**Swansea University**, Department of Civil Engineering

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**Doctor of Philosophy**

# Priming and Mining the Civil Engineering Mindset: How Personal Values and Perfectionism Shape Societal Engagement and Consideration in Design

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## Abstract

There are many ongoing calls for the integration of public welfare needs and concerns into engineering curricula and practice; for example, promoting social consciousness, human-centred design, and other socially-related frameworks. However, some engineering students still seem to devalue or resist these initiatives. This project attempts to overcome this problem by exploring a new methodology to facilitate such integrations, whilst bypassing the possible resistance. In the first intervention, this project explores to facilitate such notions via exploiting the psychology-informed approach of priming. Results of the first intervention showed that the priming initially intended to raise empathy (and by extension, social consciousness) scores unexpectedly resulted in significantly decreasing them. This initiated the second and third interventions, which explored how different key facets of the mindset (i.e., personal values and perfectionism, respectively) contribute to decision-making, particularly in contexts of human-centred designing and socially relevant initiatives, in civil engineering design. Such research on exploring the engineering mindset was to also inform the under-explored research literature on the subjective nature of sustainable decision-making in engineering. .. The second and third interventions therefore serve to fill the gap on addressing the subjective nature of sustainable decision-making in engineering, by researching to understand how the different facets of the mindset (i.e., personal values and perfectionism, respectively) dictate decision-making and facilitate (or hinder) social engagement and consideration in human-centric designing and socially considerate contexts. The influence of priming on such decision-making processes and social considerations were also observed in light of the different facets of the mindset. Results show that the majority of civil engineering undergraduates hold dominant Higher Order Values rooted in Self Transcendence (60.87%), and were categorised as perfectionists (74.48%). Findings indicate that those with Higher Order Value rooted in Self Transcendence were significantly less likely to produce what I term *Communal Designs* (i.e., designs that inform the metaphysical as well as the physical needs of the end-user), compared to those with dominant values rooted in the Higher Order Value of Openness to Change. Students were also found to transition in value towards the Higher Order Value of Conservation with time (i.e., with transition from year 1 to year 3 in a civil engineering programme), and thus transition away from their likelihood of producing Communal Designs by extension. Similarly, those categorised as perfectionists were significantly less likely to produce Communal Designs compared to those categorised as non-perfectionists. Perfectionists were later found to be associated with the Higher Order Value of Conservation when resumed back to the literature for sense-making of the present findings. Underlying common motives of Self-Protection and Anxiety-Avoidance were thus deduced to be hindering 'truthful' (i.e., intrinsically driven) engagement with human-centric initiatives, and production of what I termed Communal Designs. An intention-behaviour gap was found prominent in civil engineering undergraduates perhaps intending to, but then failing to produce Communal Designs. Further, the reversed influence of the priming was then discussed to be relative to the underlying motives of self-protection and anxiety-avoidance of the civil engineering undergraduates. Findings of the present project thus serve as a foundation for future mitigative studies or interventions promoting socially considerate initiatives or practices in civil engineering designs.

**Keywords**: Civil Engineering Design, Social Consideration, Human-Centred Design, Priming, Personal Values, Perfectionism, Empathy

## Extended Abstract

**Scope:** There has been discourse criticising the lack of non-technical competency training in engineering education, and with it, rose the demand for incorporating more sustainable and social consideration in engineering design. Since then, human-centred designing and design thinking frameworks in engineering rose to popularity. The issue is, however, that human-centred designing and design thinking involve empathy and creativity as prerequisite skills for proper engagement and execution of such frameworks, and that there have been many cases were engineering students were seen to resist such non-technical notions, and decline in their engagement with time in engineering education. Moreover, sustainable (and by extension, socially considerate) decision-making in civil engineering is known to be subjective in nature; i.e., the individuality of engineers therefore might be playing a role yet to be understood and researched.

**Arguments and Aims and Objectives:** As empathy was reviewed to be unenforceable, and the act of empathy was reviewed to be unteachable, I therefore argue that empathy should be induced in an engineering classroom, in a manner particularly designed to bypass the possible resistance. I therefore proposed characterising empathy (and by extension social consciousness) in engineering classrooms subconsciously, via exploiting the psychological phenomena of priming (i.e., subtle, unconscious induction of a cognitive schema/feeling in a person/people, by exposing them to subtle cues (primes) in their surroundings). Priming is also known to surpass disruptive behaviour, thus could be argued to help bypass the resistance of the students to such notions.

Moreover, in addressing the subjectivity of sustainable and by extension socially considerate decision-making in engineering, I propose researching the individuality of the engineer making the decision by addressing the engineering psyche, and how it associates with social consideration, human-centred designing, and the production of what I later term as *Communal Designs.*

The broad research question, and aims and deliverables for this project are therefore proposed to be:

> Priming and Mining the Engineering Mindset: 1. Can we promote empathy and social consciousness in civil engineering undergraduates via priming, and 2. through understanding civil engineering undergraduates' mindset, can we understand how receptive and engaging civil engineers are with socially considerate initiatives?

**Methodology:** Three interventions took place in this project, all involving civil engineering undergraduates at a university in Wales. All three interventions shared a similar scope: working on a human-centred designing workshop involving a real-life case of Hamra vs. Shatila of Beirut, Lebanon. The concept of the human-centred designing assignment was grounded with its usage of Max-Neefs' *Matrix of Human Needs and Satisfiers* (see Section 4.1) as a framework to aid students understand and inform their conceptual design with. The intervention varied, however, to

accommodate for different specific aims and objectives. Each intervention variation involved the research of different facets of the engineering mindset and their associations with human-centred designing and Communal Design production; each variation also carried different methods of introducing the primes into the assignments, similarly regarding their associations with human-centred designing and Communal Design production as well.

Designs submitted by the end of the interventions were qualitatively analysed to see if they match certain criteria (see **Table 4**) or not – declaring them Communal Designs or not (respectively). The declaration of Communal Designs (or not Communal Designs) has been carried out blindly, by two independent judges, that were cross-checked for verification.

The three intervention variations objectives compose of the following:

> Intervention Variation 1: Exploring the feasibility of the Priming in a Civil Engineering Human-Centred Designing Task.
>
> Intervention Variation 2: Exploring prevalent Personal Values in civil engineering undergraduates, and personal values' associations with human-centred designing and Communal Design production.
>
> Intervention Variation 3: Exploring the prevalence of Perfectionism in civil engineering undergraduates, and perfectionism's associations with human-centred designing and Communal Design production.

**Findings:** Results of intervention variation 1 showed that, opposite to what was anticipated, civil engineering undergraduates' levels of social consciousness (and by extension, empathy) significantly decreased, as opposed to increased, with exposure to the priming. To make sense of the findings, I resumed to the literature. A study (Price V. , 2016) was found referring to negative correlative associations between empathy levels and self-protecting and anxiety-avoidant motives. From this sense-making, it was suggested that the self-protecting and anxiety-avoidant motivators of the civil engineering students may have possibly been behind the reversed influence of the priming on the students, and by extension, their inhibited ability to *properly* engage with the empathy-driven human-centred designing initiatives.

In intervention variation 2, it was found that the majority (60.87%, N=92) of civil engineering undergraduates hold dominant Higher Order Values rooted in the communal Self Transcendence, followed by almost a third of them (27.17%, N=92) holding dominant Higher Order Values rooted in Openness to Change. It was also found those with dominant Higher Order Values of Openness to Change were significantly more likely to produce Communal Designs, than those with dominant Higher Order Values of Self Transcendence.

Moreover, it was found that third-year students valued Tradition (a subsidiary value to the Higher Order Value of Conservation) significantly more than first-year students. This suggested that students seem to skew more towards Conservation, with time in engineering education. As the Higher Order Value of Conservation sits in opposition to that of Openness to Change, an increase in the value of Conservation therefore suggests a decrease in the value of Openness to Change, and with it, the likelihood of producing Communal Designs, with time. On a side note, the Higher Order Value of Conservation is known to be underlying motivators of self-protection and anxiety-avoidance (see **Figure 3**).

In intervention variation 3, it was found that the majority (74.48%, N=145) of civil engineering undergraduates categorise as perfectionists, as opposed to non-perfectionists. It was also found that perfectionists were significantly more likely than non-perfectionists to not produce Communal Designs, and that non-perfectionists were significantly more likely than Perfectionists to produced Communal Designs whilst being *Primed*. According to Fermendel (2015), perfectionists are driven by self-protecting and anxiety-avoidant motives; which therefore loops back to the findings of intervention variation 1 discussed.

A theme of repetitive indications highlighting that motives of self-protection and anxiety-avoidance have been persistently interfering with human-centred designing engagement, Communal Design production, and positive perception of the priming, was hence established and reassured. Therefore, the present research project suggests that such motivators prevalent in engineering should be further researched and understood, in order to progress with the characterisation and encouragement of empathy and human-centred designing in engineering education.

Moreover, the present results show that the majority of the students (i.e., those categorised as dominantly Self Transcendent in intervention variation 2, and those categorised as perfectionists in intervention variation 3) seemed to have higher engagement with the human-centred designing initiatives (i.e., by having higher empathy, consciousness or '*prosocialness*' (as termed by Caprara et al. (2005))scores during their work on the assignment), but were simultaneously found to be significantly less likely to produce Communal Designs. This proposes the existence of a cognitive dissonance, or an intention-behaviour gap present amongst the majority of civil engineering undergraduates in human-centred designing context. Reasons to this was discussed, and notions from other studies (Cech E. , 2013; Leydens & Lucena, 2017; Mazzurco & Daniel, 2020; Nieusma, 2013; Riley, 2008; Trevelyan J. , 2010) criticising the lack of non-technical educational training in engineering were referred to.

Additionally, equations predictive of Communal Design production were developed and discussed in the present thesis. Equations were developed using the data collected on civil engineering students' personal values, perfectionism and other characteristics, paired with their production of Communal

Designs (or not Communal Designs). These equations were to show how different personal characteristics and traits are weighted in terms of their influence on Communal Design production.

Lastly, the present studies and findings shed light on the importance of further exploring the influence of the engineering mindset and characteristics on engineers' design decision-making processes, especially in the context of sustainability and social consideration. The present studies show significant associations of two facets of the mindset (Personal Values and Perfectionism) and other characteristics of civil engineering undergraduates, to the type of designs they produce, and their engagement with human-centred, public-welfare-related initiatives.

To conclude, present findings show that priming can be a useful tool to promote empathy, and influence human-centred designing and engagement, provided the engineering mindset is priorly understood. Present findings also show that two facets of the engineering mindset and decision-making motivators, are highly associated with such socially considerate initiatives. This therefore suggests further and deeper research on the topic.

**Suggested Future Work:**

Recapping on the proposed concept of Communal Designs, and its alignment with the calls proposed by the Institute of Civil Engineers (ICE Community blog, 2021) and the UK Government (HM Government; Department for Digital, Culture, Media and Sport, 2018, pp. 36-45) for implementing strategies to 'design out loneliness' and achieve 'a connected society' (respectively), I drew and made connections with it to the concept of 'Placemaking'.

*Placemaking* is a form of architectural urban design that encourages communal interaction (Project for Public Spaces (PPS), 2018). I therefore suggest that Placemaking would be a useful concept to integrate into civil engineering design modules, since it overlaps both design and social science, addressing human behaviour and interaction with structures and spaces. Placemaking could therefore be useful as a way of bringing civil engineering students' attention to social interaction needs, by aiding the understanding of social interactions, and thus bringing in more human-centred, humanitarian values into design, and considering both the metaphysical as well as the physical needs of the people, engineers are to design for. How and to what extent Placemaking should be introduced in civil engineering curricula should be further looked into.

With the present findings showing that the majority (74.48%) of civil engineers are more likely to hold perfectionistic traits (– with a high percentage of them being maladaptive) combined with the extensive, existing research on the negative associations of perfectionism to mental and physical wellbeing (Blatt, Quinlan, & Pilkonis, 1995; DiBartolo, Li, & Frost, 2008; Geranmayepour & Besharat, 2010; Molenaar, Sobin, & Antillón, 2010), this project sheds light on, and recommends, engineering curriculums and cultures to actively seek and implement strategies that would tend to their students' and other subjects' perfectionism and consequential wellbeing, and further consider mitigating perfectionism to aid with Design Thinking, engagement with human-centred, public-welfare-considerate initiatives, and Communal Design production. These recommendations also apply to other cultures and paradigms where positivism and/or perfectionism are known to be predominant. Specific strategies to such mitigations, however, were outside the scope of this project.

Based on the present findings, it is suggested the motivators of anxiety-avoidance and self-protection prevalent in engineering and engineering students, should be further understood and mitigated to allow for better human-centred engagement and designing in civil engineering. Mitigation strategies to cope with motivators of self-protection and anxiety-avoidance in engineering (undergraduates, at least) should be promoted, as the present findings suggest that such detrimental motivators are acting as inhibitors to empathy-engagement, and thus by extension, *proper* human-centred designing and Communal Design production. Specific strategies to such mitigations, however, were outside the scope of this project. Further, in future work, it is suggested to research to unpack where (such) motives are derived from, how they are being developed in civil engineering, and whether they could be mitigated at an earlier stage.

Priming, as a tool of characterising empathy, should be further looked into and researched, as it stands as a promising tool to promote empathy whilst bypassing resistance and has the potential to act as a human-centred designing 'value reinforcer', as argued previously. Priming, however, is suggested to come sequential to prior understanding of the engineering mindsets, as in this project, it has been demonstrated how influential the mindset is on the interaction and association with the priming.

**Keywords**: Civil Engineering Design, Social Consideration, Human-Centred Design, Priming, Personal Values, Perfectionism, Empathy

## Declarations and Statements

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signature: Nathalie Al Kakoun

Date: 31/03/2023

This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signature: Nathalie Al Kakoun

Date: 31/03/2023

I hereby give consent for my thesis, if accepted, to be available for electronic sharing.

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Date: 31/03/2023

The university's ethical procedures have been followed and, where appropriate, that ethical approval has been granted.

Signature: Nathalie Al Kakoun

Date: 31/03/2023

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## List of Publications from the Present Project

Al Kakoun, N., & Boy, F., & Groves, C., & Xavier, P. (2021, July), *Priming Civil Engineers Into Human-Centered Designing (and Its Unexpected Consequences)* Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. https://peer.asee.org/37600

Al Kakoun, N., & Boy, F., & Xavier, P. (2021, July), *Are Civil Engineers "Practicing What They Preach?"* Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. 10.18260/1-2--36697

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As to my parents and brother, we did it! I have said this before, and I am now putting it in writing; I may have the intelligence or the cognitive capacity to do a PhD, but if it was not for my parents, the way they raised me, and their immense support and guidance that continuously pushed me to try and go beyond my limits ever since I was a child, doing a PhD would have never occurred to me. So, Adnan and Sanaa (my beloved baba and mama), from the bottom of my heart, I thank you for always believing in me and for being who you are as people and as loving parents. As for my brother, Hamza, I would like to thank you for voluntarily signing up to be my 'sanity manager' these past few years – doing a PhD is definitely mentally challenging, thus I kept Hamza pretty busy these past few years. I thank you brother for being my rock.

Concluding, I have heard stories that writing an acknowledgement is one of the most difficult pieces of writing in a PhD, and I can now confirm it. I also can now confirm that doing a PhD is not a destination but a journey, and I thank everyone that have contributed to this journey, whether directly or indirectly. It really does take a village.

## Chapter 1: Introduction

Just recently, in February 2023, an earthquake shook the world with its devastating consequences, resulting in the loss of millions of homes, and thousands of lives (Çelik, 2023). What was interesting about this earthquake was its location. With its epicentre's located in south Turkey and near Syrian borders, the earthquake imposed devastating social impacts on the people of Turkey, Syria, and other neighbouring countries – people lost their homes, neighbours, and their lives.

The earthquake's epicentre was located between the Turkish cities of Gaziantep, Nurdagi, Pazarcik and the Syrian border, and interestingly, was approximately about 90 miles away from the Ataturk Dam; see **Figure 1**, and Robles, et al (2023). The Ataturk dam is said to be one of the world's largest clay-cored rock fill dam (as stated by Ozcan et al. (2012), and is located in a 'fault zone', i.e., in a an area well known to be surrounded by "tectonically active faults" in Turkey (see (Büyükakpınar, et al., 2021)). Early warning signs of earthquake occurrences have been detected, those resulting from the Ataturk Dam reservoir's impoundment back in 1992 (Çetin, Laman, & Ertunç, 2000). Additionally, there were other earthquake occurrences within that region of Turkey; which were also said to be associated with the dam (Büyükakpınar, et al., 2021; Jamalreyhani, et al., 2020; Soysal, Sipahioglu, Kolçak, & Altınok, 1981). Similar earthquakes (i.e., those surrounding other reservoirs) have also been observed in other parts of the world (see (Healy, Rubey, Griggs, & Raleigh, 1968; Rinaldi, et al., 2020) for example). In fact, such a phenomenon is so common, that it was given a name: reservoir-induced or reservoir-triggered seismic activity.

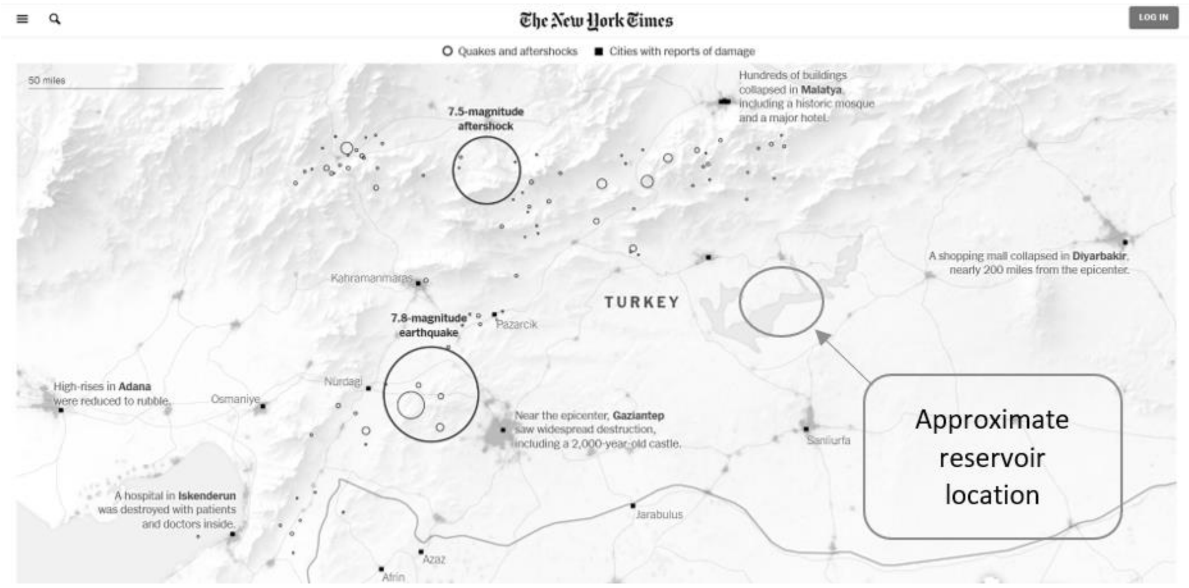


*Figure 1 - Mapping the Damage from the Earthquake in Turkey and Syria; extracted from (Robles, et al., 2023), with additional present annotations made on approximate reservoir location.*

Expanding on this topic, seismic activity has also been detected in association with other civil engineering related activities; they have been said to be triggered or induced by fluid extraction or injections, open pit and deep mining, deep geothermal power generations, carbon sequestration, fracturing, and again, artificial water reservoir impoundments (see (Byrne, Silva, Plesch, Juanes, & Shaw, 2020; Dahm, et al., 2013; Davies, Foulger, Bindley, & Styles, 2013; Ellsworth, 2013; Foulger, Wilson, Gluyas, Julian, & Davies, 2018; Improta, Valoroso, Piccinini, & Chiarabba, 2015; Juanes, et al., 2016; Keranen, Savage, Abers, & Cochran, 2013; McGarr, Simpson, & Seeber, 2002; Villaseñor, Herrmann, Gaite, & Ugalde, 2020) and (Yeck, et al., 2016)).

Starting with this very recent real-life case, and coming from an civil engineering background, I only ask one question – were the civil engineers who designed the Ataturk Dam and reservoir (or were involved with other seismic-inducing engineering practices) unaware of the potetially chatastrophic social impact of their design, or were they unaware of how socially considerate they *should* have been during the design process? – the latter implies questioning the intentions and motives for social consideration and human-centric designing and engagement, and the engineering paradigm's *allowance* for such initiatives to occur, regardless of whether they had a choice.

There have been recent updates to the Accreditation of Higher Education Programmes (AHEP 4, 2020) and the UK Standard for Professional Engineering Competence and Commitment (UK-SPEC 4, 2020) that call for more societal and sustainable consideration and in engineering practice, aligning with a rise in the research discourse calling for 'rounding' the technocentric engineering paradigm, to allow for more human-centric, empathic and considerate engineering training and education (see (Cech E. A., 2014; Kouprie & Visser, 2009; Leonard & Rayport, 1997; Leydens & Lucena, 2017; Maguire, 2001; Mattelmäki, Vaajakallio, & Koskinen, 2014; Riley, 2008; Trevelyan J. , 2010) for example). Therefore, it is no surprise that futuristic cities are calibrated against sustainable and socially considerate measures; for example:

I. THE ORBIT: INNISFIL, Canada.

The ORBIT is designed to accommodate more residents, whilst preserving green and agricultural lands and historic monuments to ensure sufficient exposure of its residents to nature and culture. It has 5 goals to achieve: 1) 15-minute neighbourhoods (i.e., neighbourhoods consisting of amenities to be found within a 15 minutes walking or biking distance) – a 'people-first approach and integrated green spaces', 2) Achieving a Sense of Place – for 'placemaking' and ensuring more social interaction, 3) Higher quality density - promoting higher density and diversity in buildings, and integrate outdoor spaces to improve living quality, 4) An insightful city – Smart cities concept to make day-to-day life easier, 5) Sustainable Community – minimising carbon emissions during design through to construction and living stage (Town of Innisfil, 2022). The ORBIT also has a 'NUCLEUS', a city centre designed to ensure social interaction, and “promote a safe and balanced community by ensuring a mix of socio-economic backgrounds exist in each neighbourhood” (Pierre Carapetian Group, 2022). It is visible that such a project has addressed the metaphysical as well as the physical needs of its residents during the design stage (see (PARTISANS + Innisfil) for more information).

II. NEOM: THE LINE, Saudi Arabia.

The Line, is a human-centric “blueprint for how people and the planet can co-exist in harmony”. It is designed to operate as 20-minute city ensuring that residents’ essentials needs are met within a maximum of 20-minute walking distance without the use of cars. It ensures the provision of renewable sustainable energy and high tech, and the intention of elevating the quality of life, health and wellbeing of its residents. The Line also flaunts its intention to prioritise the peoples’ wellbeing, and a contributing with a positive carbon footprint in achieving it; and similarly, is designed to meet the physical as well as the metaphysical needs of its future residents (see (NEOM, 2022) for more information).

III. CHENGDU FUTURE SCIENCE AND TECHNOLOGY CITY, China.

The city of Chengdu is interesting as it proposes different ‘clusters’ for different living aspects, i.e. it proposes a design incorporating a governmental cluster, a living cluster, a university cluster, a laboratory cluster, a market cluster, and a public cluster. Instead of following a generic planning model, this project observes and informs its plans with the area’s existing topographies, green landscapes and existing water systems in attempt to “combine urban and rural qualities” (OMA Office Work, n.d.). This city is also designed to be ‘car-free’ with amenities to be reached within 10 minutes. The plan also flaunts its intention to result in “a dynamic environment that will inspire innovative ideas”, and develop strategies to accommodate for “new forms of living, working, and social spaces that meet our ever-changing needs” (OMA Office Work). The design to have the physical as well as the metaphysical needs met is also visible here.

Social, thus sustainable consideration are not just to be found in futuristic designs however; in fact, below is reviewed a historic example of social consideration integration in designs, one which resulted in positive social impacts that still prevail today: the *Eixample* (literally, the ‘expansion’) project by the Spanish civil engineer Ildefons Cerdà.

“*The construction of cities, if it is not already, will soon become a true science that will require great and profound studies in all the branches of human knowledge, and most especially in the social sciences and in all the admirable advancements of modern civilization*” - Ildefons Cerdà, (1859a).

Otherwise known as the godfather of the term and study of '*urbanisation*' (Cerdà, 1859b; Cerdà, 1867), Cerdà was the original designer of Barcelona's famous grid system of expansion in the 19th century (Cerdà, 1859a; Cerdà, 1859b; Cerdà & Vicente, 2018). This system was designed to serve the need for expanding the city, but unlike others in the domain in the 19th and 20th century (see the works Georges Haussmann and Le Corbusier, respectively, for example), his plans were informed by both the physical, infrastructural needs of the citizens, as well as the metaphysical needs ones - as he conducted multiple surveys to grasp ideas of the citizens' social, environmental, economic and behavioural trends to inform his designs with (Cerdà, 1855a; 1855b; 1856). As a result of his design, Cerdà managed to indeed induce enhancement in the surrounding quality-of-life (Pallares-Barbera, Badia, & Duch, 2011) and economic prosperity (Margarit, 1994) in the area. His work was said to have "changed the way in which people thought about urban space, and introduced the idea of changing people's behaviour by modifying public space", where his innovation lies in "build[ing] a bridge between the urban roles and functions of a metropolis and a healthy population" (Pallares-Barbera, Badia, & Duch, 2011, p. 133). Cerdà's approach was exceptional, as it was clearly defined by his technical as well as non-technical, socially conscious and considerate, abilities as a civil engineer, to design and serve the community, and bestow a positive social impact in the city of Barcelona.

## 1.1 Background: Demand for Social Consideration

Recapping, in recent years, there have been an increasing number of calls for engineers and engineering students to gain a greater understanding, awareness, and consideration of social needs, impact and social value of engineering design (Cech E. A., 2014; ICE Community blog, 2021; ICE usefulprojects, 2020; Kouprie & Visser, 2009; Lawlor, 2016; Leonard & Rayport, 1997; Leydens & Lucena, 2017; Maguire, 2001; Riley, 2008), as studies (Fitton & Moncaster, 2019; Mehring, Geoghegan, Cloke, & Clark, 2018) show that social demands and needs were in fact not taken into consideration by engineers; this was also exemplified by cases of engineering-practice-related seismic activity. These calls have been reflected in the recently updated versions of the United Kingdom's Standard for Professional Engineering Competence and Commitment (UK-SPEC 4, 2020), and Accreditation of Higher Education Programs (AHEP 4, 2020), where engineers and engineering curriculums are now required to implement and display sustainable thinking in their practice, to comply with the UN's Sustainable Development Goals framework (AHEP 4, 2020; Engineering Council | Guidance on Sustainability for the Engineering Profession, 2021; UK-SPEC 4, 2020).

As a result, Chartered Engineers are now required to demonstrate an "understanding of the safety and sustainability implications of their work, seeking to improve aspects where feasible" (UK-SPEC 4, 2020, p. 31); whereas engineering curriculums now have to "have a sharper focus on inclusive design and innovation, and the coverage of areas such as sustainability and ethics" (AHEP 4, 2020, p. 7), as “sustainability of engineering practice is an issue of concern for the profession and HEIs [Higher Education Institutions] are encouraged to make use of the United Nations Sustainable Development Goals, and Engineering Council Guidance on Sustainability in programme design and delivery.” (AHEP 4, 2020, p. 11). This emphasised the assimilation of strategies and approaches driven by engineers and engineering projects to attain goals listed in the 2030 UN Agenda on Sustainable Development Goals.

To comply with the sustainable development goals and agenda of the United Nations, one should first address the frameworks and approaches employed by UN agencies to achieve their goals. Multiple UN agencies implemented frameworks of Human-centred designing and Design Thinking to solve complex and wicked problems (i.e., multifaceted, subjective, ‘difficult-to-define’, real-life problems requiring both technical and nontechnical input and thinking to solve – see Rittel and Webber (1973) for more information on ‘wicked problems’) when pursuing their Sustainable Development Goals (see (UNICEF | Human Centred Design 4 Health; UNICEF | Office of Innovation; UNICEF, 2016; Cserhati, 2019; United Nations Development Operations Coordination Office, 2016; UN Sustainable Development Goals | UNESCO Report, 2016) for more information); thus, it naturally implies that such design frameworks are to be tested in the realm of civil engineering in order to achieve sustainable and socially considerate outcomes.

Moreover, there have been other calls for a similar change on a more technical level in civil engineering project management – i.e., call for motivations to incorporate user involvement in the built environment (Whyte & Sexton, 2011), developing social principles in public procurement (Iles & Ryall, 2016), more social engagement in sustainable construction projects (Ball & Fortune, 2000; Berry & McCarthy, 2011; Broesterhuizen, Vellinga, Taneja, & van Leeuwen, 2014; Hanák & Muchová, 2015; Naoum & Egbu, 2016; Olanipekun, Xia, Hon, & Darko, 2018; Wu, Zuo, & Zhao, 2017), and a call for the incorporation of integrated delivery methods to give wider scope for sustainability and social consideration decision-making in civil engineering projects (Broesterhuizen, Vellinga, Taneja, & van Leeuwen, 2014).

Research implies that sustainable decision making is most likely prevalent in integrated, as opposed to traditional, delivery methods (Montalbán-Domingo, García-Segura, Amalia Sanz, & Pellicer, 2019) – where integrated approaches comprise of design-build (DB), public-private partnerships (PPP), integrated project delivery (IPD), construction management at risk (CRM) and their variants (Mollaoglu-Korkmaz, Swarup, & Riley, 2013); whereas the traditional ones being the design-bid-build (DBB) approaches.  Therefore, moving forward from the traditional procurement and delivery methods is crucial to achieving more sustainable consideration (Ruparathna & Hewage, 2015; Xia, Chen, Xu, Li, & Jin, 2015) in the construction industry, and sustainable outcomes (Naoum & Egbu, 2016).

The procurement method that tends to prevail in the Traditional delivery methods is said to be the *lowest-price* procurement method (Doloi, 2013; Montalbán-Domingo, García-Segura, Amalia Sanz, & Pellicer, 2019; Ruparathna & Hewage, 2015; Varnäs, 2008); whereas that employed in the Integrated delivery method is said to be the *best-value* procurement approach (Molenaar, Sobin, & Antillón, 2010; Montalbán-Domingo, García-Segura, Amalia Sanz, & Pellicer, 2019; Xia, Chen, Xu, Li, & Jin, 2015). Lowest-price procurement is exploited to maximise savings, while best-value procurement is utilised in more wicked, or 'complex' (i.e., sustainability and socially-informed) projects in construction auctions (Ballesteros-Perez, Pellicer, & González-Cruz, 2017). Although Best-value procurement allows for more social consideration (Brammer & Walker, 2011), it has been regarded that, historically, lowest-price procurement was more popularly selected, regardless of the complexity in construction projects (Korytárová, Hanák, Kozik, & Radziszewska-Zielina, 2015); i.e., indicating that the 'default' procurement is the one that does not allow for social consideration. Moreover, it has been observed that the lowest-price procurement acts as an obstacle to obtaining sustainable goals (Bruno, Gelderman, Lambrechts, & Semeijn, 2018; Hanák & Muchová, 2015; Palmujoki, Parikka-Alhola, & Ekroos, 2010; Ruparathna & Hewage, 2015; Wang, Wang, Lai, & Li, 2006; Witjes & Lozano, 2016), whilst best-value procurement acts as a facilitator to it (Molenaar, Sobin, & Antillón, 2010; Xia, Chen, Xu, Li, & Jin, 2015). Regardless, Traditional methods, have been the dominating methods of civil engineering project delivery methods (Naoum & Egbu, 2016; Montalbán-Domingo, García-Segura, Amalia Sanz, & Pellicer, 2019); and similarly, the lowest-price method has been the dominant procurement method in civil engineering, regardless of how complex or sustainability-informed the project is (Korytárová, Hanák, Kozik, & Radziszewska-Zielina, 2015).

Ruparathna & Hewage (2015) address that the reasoning behind civil engineering favouring lowest-price, as opposed to best-value, procurement method is due to the fact that engineers find it difficult in properly defining the objective, as opposed to subjective, criteria related to the project. Varnäs, (2008) agrees to this by addressing another reason for civil engineers preferring the lowest-price method as a method of avoidance to the uncertainties that surface at the preconstruction stage. Thus, it can be observed that these 'uncertainties' are the embodiment of working with less-technical, less-objective, and less-numerically-based decisions that may arise with sustainably- and socially-relater matters in civil engineering.

Risk transfer, on the other hand, also plays a notable role in such procedures. Mees et al. (2016) review that in England, a culture of "absorb, recover and adapt" – as opposed to a more involving plan – is encouraged amongst the local stakeholders of the community involved in the project. Furthermore, there exists an ideology that the involvement of local stakeholders is viable, provided they adhere to the state's frameworks (Lorenzoni, Benson, & Cook; Watson, Deeming, & Treffeny, 2009), and whilst the top-down decision making dynamics remain claimed by the state, engineers and senior decision-makers of the project (Begg, Walker, & Kuhlicke, 2015; Penning-Rowsell & Johnson, 2015). Such tactics of risk transfer may be understood as a mean to reduce the weight of the 'uncertainties' discussed above, but they highlight another tactic – authoritarian decision making in civil engineering.

Hunold & Young (1998) have highlighted such an authoritarian, 'top-down' decision-making strategy occurring in construction projects, with the influence of local stakeholders on the decision-making process being rather 'down'. Additionally, in her study, Begg (2018, p. 393) states that "although formal opportunities for participation are included in national policies in England, the examples provided by the review show that the ability of local stakeholders to influence decisions is limited", whilst others (Doorn, 2016; Edelenbos, Van Buuren, Roth, & Winnubst, 2017) reveal that locals' interests are only usually taken into consideration by the senior decision-makers provided that they comply with those of the state.  Needless to say, that such an understanding of social engagement and authoritarian decision-making, may act as hinderance to proper social consideration integration in civil engineering projects.

However, it was found that this authoritarian dynamic of decision-making, was rather remarked positively (by both engineers and local stakeholders) and as a medium to 'move the project forward' (Menzel & Buchecker, 2013). In fact, amongst Menzel & Buchecker's (2013) results was the statement that "good leaders had a clear vision, were able and willing to listen, and did not try to make everyone happy" as this (according to them) "helped to move the project forward" (p. 7). In their study, a project leader quoted: "[I learned] regarding my role as a project leader: Today I would lead more forcefully, in a more dominant manner" (p. 7). Menzel and Buchecker (2013) also revealed their observation: "participants could be satisfied by a relatively small 'objective' influence if the project leader clearly communicated which topics were subject to negotiation and which were not" (p. 10), and that "in practice, project leaders have a tendency to hide the fact that stakeholders do not have any right to influence decision-making". They also highlight the struggle and the uncertainty in the "recurring challenge for leaders and participants to find their roles in participatory settings" (p. 11) – looping back to the uncertainties accompanied with such socially considerate projects, and thus engineers' avoidance of them. This paragraph highlights how such an authoritarian and assertive dynamic of decision-making is prevalent, and is rather positively perceived, in the paradigm.

Another key contributor to sustainable decision-making in engineering is subjectivity. Havbro Faber & Rackwitz (2018) refer to a an unquantifiable, 'intuitive' aspect when it comes to sustainable decision-making in civil engineering. Montalbán-Domingo, García-Segura, Amalia Sanz, & Pellicer (2019) find that decisions related to social consideration during processes of delivery and procurement of public construction contracts are in fact subjective – i.e., different engineers may respond differently to societal consideration, and thus contribute differently to the social impact. Besides, it was also Cerdà's (subjective) mindset that informed his design with social consideration that resulted in positive social impact (Pallares-Barbera, Badia, & Duch, 2011); however, Park et al. (2015) address this subjectivity in sustainable decision making as a point of weakness in the evaluation phase in a bid selection process.

Moreover, Zavadskas, Antucheviciene, Vilutiene, & Adeli (2017) reveal that multiple-criteria decision-making (MCDM) theories have been growing in the realm of civil engineering, construction and building technology as methods to identify and measure the 'fuzzy' sustainable decisions and impacts of civil engineering projects. Multi-criteria decision-making strategies are known to be subjective in nature – and based on the decision-makers' personal humane subjective judgement, values and psyche (Eshrag, 1980).

The gap here therefore presents itself, as, to my knowledge, this subjectivity has not yet been examined in the realm of civil engineering, and especially not in the relatively new niche of sustainable- and social-consideration and human-centred design, where subjectivity characterises as a key factor in the projects and decision-making processes. In this thesis, I study two facets of the 'civil engineering mindset', i.e., drivers and influencers of decision making, and examine their associations with the engineering students' ability to engage with a human-centred (i.e., social metaphysical-needs-informed, as well as physical-needs-informed) designing initiative, and their ability to produce what I term *Communal Designs.*

### 1.2 Addressing Another Issue: Bypassing Resistance?

Despite the calls that have been ongoing for the past decade now, social consideration in civil engineering and engineering education is still at halt – this could be argued to be due to multiple reasons, and one of them being the heavy reliance of engineering education on the scientific and mathematically-driven training and problem solving (Downey & Lucena, 2003b), making it ontologically *positivistic* in nature (Erden, 2003; Morgan, 2019).

Positivism is defined as "the tendency to "take a realist position and assume that a single, objective reality exists independently of what individuals perceive"( (Hudson & Ozanne, 1988, p. 509) citing (Bagozzi, 1980; Burrell & Morgan, 1979; Morgan & Smiricich, 1980)). Such an ontology or manner of problem-solving is thus known to reject intuitive and *metaphysical* input (Ayer, 1936; Hume, 1748; Weinber, 1936). This implies that empathy-informed, non-numerical inputs, are thus rejected by extension. This is a problem, as 'human-centred designing' and design thinking' approaches utilised by UN agencies to obtain their SDGs are said to be powered by intuition and empathy (Giacomin, 2014), and creativity (Brown, 2008; IDEO U, 2022; IDEO, Design Thinking; IDEO.ORG). Moreover, human-centred designing is said to be coloured with the intention of positively impacting the lives of those designed for by putting their needs at the core of the design process (IDEO.ORG; Giacomin, 2014; Walters, 2005). These 'needs' can be argued to be both physical and metaphysical – and thus both a cognitive and intuitive engagement between the engineers/designers and local users have to be established for more effective designing and positive impact. Moreover, positivism was argued to be ‘captivating’ social consideration in engineers as it is being carried forward into practice by Johnston, Lee, & McGregor (1996).

Such resistance to incentives for social engagement and public welfare consideration has been seen in the works Niles et al. (2018; 2020); whilst Cech (2014), Bielefeldt (2018), and Bielefeldt & Canny (2016) showed results indicative of engineers’ tendency to devalue social concerns over the course of their studies and careers. Other researchers (Cech E. , 2013; Leydens & Lucena, 2017; Mazzurco & Daniel, 2020; Nieusma, 2013; Riley, 2008; Trevelyan J. , 2010) discuss how such non-numerical/non-tenhnical notions are generally devalued, belittled, or marginalised in engineering. It can be argued that such notions are devalued, belittled and marginalised due to them generally being niched and ‘boxed’, to later either be ticked or simply just ignored. Niles, Contreras, Roudbari, Kaminsky, & Harrison (2020) discuss such a resistance to be due to the engineers’ disruption or confusion of their ‘engineering identity’ and thus triggering a backlash and resistance, whilst Cech (2014; 2015) blames the depoliticised nature of engineering education which suggestively triggers such a declination in social and public welfare consideration amongst engineering students.

Therefore, with the rising call for intuitive- and empathy-informed, socially considerate initiatives in engineering, methodologies for characterising social consciousness and empathy in engineers and engineering students are a must, but how can such alienated notions be introduced into an ontologically opposing paradigm without triggering a resisting backlash from the engineers and engineering students?

The gap here also presents itself: methodologies of incorporating and characterising metaphysical social consciousness in engineers and engineering students to prepare them (mentally) for social consideration during their work on engineering projects, *without triggering resistance or a backlash*, are lacking.

In attempt to fill this gap, I research the feasibility of the psychological phenomena of Priming in the context of human-centred designing in a civil engineering curriculum. I attempt to ‘prime civil engineers into human-centred designing’ by unconsciously triggering empathy (and by extension, social consciousness (Thompson, 2001)) in the engineering students, whilst they work on a human-centred designing assignment. This was intended to fulfil a prerequisite condition to the human-centred designing approach, and for the civil engineering students to be ‘better equipped’ in addressing peoples’ needs that inform their designs – this is through their use of their empathy towards the people they are designing for. This trigger of empathy was also intended to be done subconsciously, as a mean to bypass any possible backlash from the engineering students. Moreover, studies show that empathy cannot be forced (Stein, 1970), nor can the act of empathising be taught

(Davis, 1990). This highlights another gap in the literature which indicates that empathy and social consciousness therefore have to be promoted in some other way – I argue for this to be another justification for the use of priming to promote empathy in the civil engineering, in the context of human-centred designing and social consideration and impact. More on the Priming will be discussed in the Literature Review, and in the Methodology.

## 1.3 Summary of Gaps Found in the Literature

1) Methodology to promote empathy and social consciousness in civil engineers and civil engineering students, without forcing empathy and/or triggering backlash, is needed.
2) Understanding the subjectivity of sustainable, socially considerate decision making, via understanding facets of the engineering mindset:
    a. I research the Personal Values of an undergraduate cohort of Civil Engineers, and attempt to associate personal values with empathy- and creativity-informed human-centred designing engagement, and production of what I term *Communal Designs* (more on Communal Design synopsis will be discussed later; and the conceptual basis for personal values to be related to empathy will be addressed in the Literature Review).
    b. I research the prevalence of Perfectionism in an undergraduate cohort of Civil Engineering students, and attempt to associate perfectionism with empathy- and creativity-informed human-centred designing engagement, and production of what I term *Communal Designs* (more on Communal Design synopsis will be discussed later; and the conceptual basis for perfectionism to be related to empathy will be addressed in the Literature Review).

## 1.4 Research Question and Aims and Deliverables:

Priming and Mining the Engineering Mindset: 1. Can we promote empathy and social consciousness in civil engineering undergraduates via priming, and, 2. through understanding civil engineering undergraduates' mindset, can we understand how receptive and engaging civil engineers are with socially considerate initiatives?

**Figure 2** schematically illustrates the track of thought that led this PhD project.

## 1.5 Thesis Schematic Layout

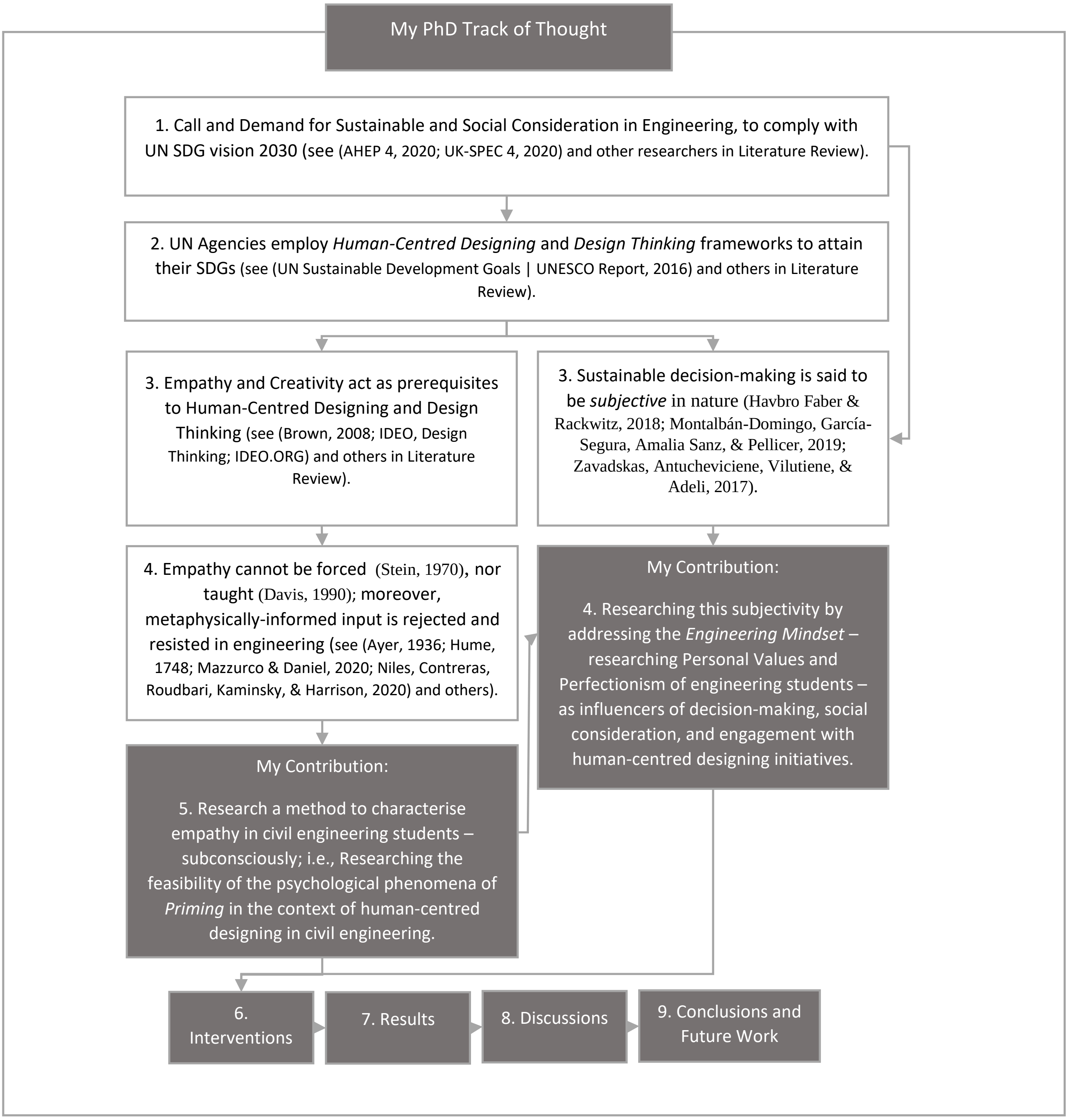


*Figure 2 - 'PhD Track of Thought' Flowchart*

## Chapter 2: Literature Review

As previously discussed, there have been calls for the integration of more empathic, socially conscious, and public welfare considerate initiatives in engineering and engineering education (see (Cech E. A., 2014; Kouprie & Visser, 2009; Leonard & Rayport, 1997; Leydens & Lucena, 2017; Maguire, 2001; Mattelmäki, Vaajakallio, & Koskinen, 2014; Riley, 2008; Trevelyan J. , 2010) for example). This has been reflected in the recently updated (Fourth Edition) versions of the UK Engineering Council's Accreditation of Higher Education Programmes (AHEP 4, 2020) and the UK Standard for Professional Engineering Competence (UK-SPEC 4, 2020).

As a result, Charted Engineers are now required to demonstrate an "understanding of the safety and sustainability implications of their work, seeking to improve aspects where feasible" (UK-SPEC 4, 2020, p. 31). Similarly, engineering curriculums now have to "have a sharper focus on inclusive design and innovation, and the coverage of areas such as sustainability and ethics. The coverage of equality, diversity and inclusion is also strengthened to reflect the importance of these matters to society as a whole and within the engineering profession" (AHEP 4, 2020, p. 7), as "sustainability of engineering practice is an issue of concern for the profession and HEIs [Higher Education Institutions] are encouraged to make use of the United Nations Sustainable Development Goals, and Engineering Council Guidance on Sustainability in programme design and delivery." (AHEP 4, 2020, p. 11).

Human-Centred Designing and Design Thinking are approaches that have been used by multiple United Nations agencies in pursuit of working for and attaining their Sustainable Development Goals (See (Cserhati, 2019; UN Sustainable Development Goals | UNESCO Report, 2016; UNICEF, 2016; UNICEF | Human Centred Design 4 Health; UNICEF | Office of Innovation; United Nations Development Operations Coordination Office, 2016) for example).

### 2.1 What is Human-Centred Designing and Design Thinking?

Giacomin (2014) describes Human-Centred Designs as the design that is "based on the use of techniques which communicate, interact, empathize and stimulate the people involved, obtaining an understanding of their needs, desires and experiences which often transcends that which the people themselves actually realized." (p.610). He further elaborates with "human centred design is thus distinct from many traditional design practices because the natural focus of the questions, insights and activities lies with the people for whom the product, system or service is intended, rather than in the designer's personal creative process or within the material and technological substrates of the artefact. Practised in its most basic form, human centred design leads to products, systems and services which are physically, perceptually, cognitively and emotionally intuitive." (p.610). Giacomin (2014), citing

Von Hipple (2007), also discusses the economic benefit of Human-Centred Designing. ATKINS, IDEO, and the UNICEF also discuss the economic benefit of implementing human-centred designing and design thinking frameworks (see (ATKINS | The Economic Benefits of Human-Centred Design; IDEO, Design Thinking; UNICEF | Human Centred Design 4 Health) for more information).

Walters (2005, p. 9) describes Human-Centred Design as “a creative exploration of human needs, knowledge and experience which aims to extend human capabilities and improve quality of life”; whilst Zhang & Dong (2009, pp. 2-3), citing HCDI Brunel University, define it as “[it is] all about putting the human user at the heart of a product, system, or process. Human-centred designers use knowledge of human capabilities and limitation across a variety of methods, combining biomechanics, psychology and engineering, to produce a solution which is safe, efficient, and satisfying to use”.

Based on contemporary research in the field by others, Zhang and Dong (2009) summarise the features of Human-Centred Designing (HCD) as:

- The central place of human beings;
- Understanding people holistically;
- Multi-disciplinary collaboration;
- Involving users throughout the design process;
- Making products or services useful, usable, and desirable; (Zhang & Dong, 2009, p. 3).

Zhang & Dong (2009) proposed a conceptual model of human-centred design that intersects Maslow’s hierarchy of needs (Maslow, 1943) and Küthe’s model of “design and society” ( (Zhang & Dong, 2009, p. 2) citing (Hauffe, 1998)). Their model demonstrates “a tendency that design evolution responds to the hierarchy of human needs” and that “nowadays design tends to care for more levels of human needs” (Zhang & Dong, 2009, p. 1).

Other than putting human-needs at the core of the design, along with the intention of positively impact on the human quality of life, and better usability of design/product produced, human-centred designing also seems to have economic benefits. Observed evidence show that such designing strategies enhance commercial success as “70% to 80% of new product development that fails does so not for lack of advanced technology but because of a failure to understand users’ needs” (Von Hipple, 2007, p. 28) as cited in (Giacomin, 2014, p. 615).

Reiterating, human-centred designing has human needs set at the core of the design or design process (Fila, et al., 2014; Hynes & Swenson, 2013), and thus has its value rooted in human needs and the intention of positively impacting human quality of life. Human-centred designing is characterised by empathy (Bruseberg & McDonagh-Philp, 2003; Giacomin, 2014; Kouprie & Visser, 2009; Walters, 2005), in attempt to properly and deeply understand human needs, and tailor the design according to the needs of those particularly involved in the project in progress (i.e., those being designed for), to therefore provide more efficient, effective products and solutions.

Furthermore, Human-Centred Designing is said to be powered by what is termed ‘Design Thinking’;

“Design thinking is a human-centered approach to innovation that draws from the designer’s toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success.”

—*Tim Brown, Chair of IDEO* (IDEO, Design Thinking)

Tim Brown (2008) describes Design Thinking as “a methodology that imbues the full spectrum of innovation activities with a human-centred design ethos” (Brown, 2008, p. 86). It is a “process for creative problem solving” and “has a human-centred core” (IDEO U, 2022). It also “encourages organizations to focus on the people they're creating for, which leads to better products, services, and internal processes.” (IDEO U, 2022).

Design thinking:

•seeks innovative solutions to complex problems;

• is an innovative approach in tackling the unknown;

• is a fast and iterative prototyping method in understanding the user’s needs, discovering the solutions and ideas;

• is a human-centered methodology; (GİRGİN, 2021, p. 217) citing (Brown, 2008).

2.2 The Role of Creativity and Empathy (and its Associates) in Human-Centred Designing and Design Thinking

The literature review  implies that empathy and creativity act as prerequisites to successful human-centred designing and Design Thinking (Brown, 2008; GİRGİN, 2021; IDEO U, 2022; IDEO, Design Thinking; IDEO.ORG). Further, Giacomin (2014) describes human-centred designing as an intuitively informed design approach. IDEO explains that Human-Centred Design “sits at the intersection of empathy and creativity” (IDEO.ORG), and that it is used to “create products, services, and experiences that improve the lives of people” (IDEO.ORG), and thus, it is coloured with the intention of positively impacting peoples’ lives.

Call it human-centred (Giacomin, 2014; Krippendorff, 1989; Maguire, 2001; Walters, 2005; Zhang & Dong, 2009), empathic (Kouprie & Visser, 2009; Leonard & Rayport, 1997; Mattelmäki, Vaajakallio, & Koskinen, 2014), compassionate (Seshadri, Reid, & Booth, 2014), humanitarian (Campbell &

Wilson, 2011; Lucena, et al., 2007), or 'socially – just' (Dombrowski, Harmon, & Fox, 2016; Leydens, Lucena, & Nieusma, 2014) designing – the value of it remains the same; that is, having the needs of the people designed for, at the core of the design or the design process.

It has been argued that this can be achieved via an attempt of *actively* empathising with the people (Giacomin, 2014; Steen, 2011) to better understand their needs and requirements (Maguire, 2001; Zhang & Dong, 2009), to *effectively define* the problem(s) (Leydens, Lucena, & Nieusma, 2014), and thus produce more effective and impactful solutions or designs, especially when that is accompanied with the intention to positively influence the peoples' living standards and quality of life (Dombrowski, Harmon, & Fox, 2016; Walters, 2005).

Empathy can be described in many different forms. Some of its most popular interpretations include (Coplan, 2011):

(A) Feeling what someone else feels;

(B) Caring about someone else;

(C) Being emotionally affected by someone else's emotions and experiences, though not necessarily experiencing the same emotions;

(D) Imagining oneself in another's situation;

(E) Imagining being another in that other's situation;

(F) Making inferences about another's mental states;

(G) Some combination of the processes described in (A)-(F); (Coplan, 2011, p. 2).

Moreover, it was found by Shen (2010) that "state empathy has unique contribution to predicting persuasion outcomes above and beyond the individual's affective and cognitive responses to the messages. In addition, state empathy also has an indirect effect on persuasion via mitigating psychological reactance". From this, it can be deduced that empathy, when used as a 'state' psychological mitigating tool (i.e., triggered or induced instantaneously and temporarily), can be powerful in persuading engineers into adopting empathy-informed and socially considerate approaches of design, in the present civil engineering context.

Recapping, Campbell and Wilson (2011) argued that in the execution of humanitarian engineering, "Care" is "not simply a nice thing for engineers to do in some cases, but, when properly invoked, makes a rich, meaningful, and needed contribution to the engineering education endeavor". 'Care' was defined as "an active, interpersonal compassion, empathy, or concern for the wellbeing of others"; and was also described as the 'neglected dimension' of humanitarian engineering. This further emphasises the weight of active empathy in such designing processes.

‘Design for social justice’, as expressed by Leydens, Lucena & Nieusma (2014) is “the design process [that] is explicitly motivated by the goal of equitable distribution of opportunities and resources in order to enhance human capabilities while reducing externally imposed risks and harms” (p. 6). They also argue that “HCD [human-centred designing] for communities brings students closer still to the social justice dimensions of their design work as it necessarily grapples with the social relationships that define an individual’s standing and opportunity structure within a given community context” (Leydens, Lucena, & Nieusma, 2014, p. 6). Leydens, Lucena & Nieusma (2014) elaborated on the link between Human-Centred Designing for communities and social justice with: “while HCD for communities necessarily attends to the social relationships that undergird the lived experiences of community members, social justice is merely another dimension of the equation considered by designers and not the principle motivator or goal” (p. 6).

Drawing on the above, this project particularly emphasises the links between prosocial behaviour, ‘socially-just’, humanitarian, and human-centred designing.

Walther, Miller, and Sochacka (2017) discuss the demand for and the role of empathy in engineering practice, and its implicit ties to the social work facet of engineering. They proposed a model for empathy as a learnable and a teachable skill in their “model of empathy in engineering as a teachable and learnable skill, a practice orientation, and a professional way of being”. The ‘professional way of being’ part being tied to the engineers’ execution of engineering ethics and moral judgement, and to the implicit bonds of engineering practice to improving society. They also suggest accompanying methods to “switch between empathic and analytic modes” in engineering education and practice (Walther, Miller, & Sochacka, 2017, p. 134). On a side note, although such a study implies that empathy can be taught, and ties it to engineering identity, moral judgement and self-consciousness, the present project however, argues and stands with the notion on empathy being a characteristic that cannot be taught, but rather is something that can ‘happen to us’ as a result of self- and emotional intelligence improvement, see (Davis C. , 1990) for more information.

Moreover, Zickfeld et al. (2017) make a more specific connection, and talk about the role of *empathic concern* (i.e., a specific from of empathy (Davis M. , 1983)) as a part of a ‘general communal emotion’. Decety and Yoder (2016) found that empathy is  “an obvious candidate in playing a critical role in justice motivation” (p. 8) and that “individual differences in cognitive empathy and empathetic concern predicted sensitivity to justice for others, as well as endorsement of moral rules” – which in essence, what is ought to be accessed, in order to via produce socially-just, communal, human-centred, humanitarian designs.

Further, a large body of research has verified that empathic concern is associated with prosocial behaviour in both children (Davidov, Zahn-Waxler, Roth-Hanania, & Knafo, 2013; Williams, O’Driscoll, & Moore, 2014) and adults (Batson C. , 2009; Miller, Kahle, Lopez, & Hastings, 2014).

Walther et al. (2017), citing (Nash & Jang, 2014), stated that “developing a whole professional persona anchored in, and simultaneously supporting, the development of other facets of empathy would also afford students with tangible opportunities to integrate personal values and beliefs with professional goals and actions”. This notion not only further emphasises the positives of encouraging empathy in engineering, but also refers back to one of the aims and objectives of this project – to research personal values and other characteristics of the engineering students, and understand how (if) they manifest in the engineering practice and designs they produce.

Moreover, in extension to empathy as a prerequisite to human-centred designing, this project observes the role of prosocial behaviour and its association with human-centred designing engagement and with the production of what I later term *Communal Design*; as this project argues that prosocial behaviour is connected to human-centred designing through principle: “prosocial behaviour refers to any action performed by one organism to alleviate another's need or improve their welfare” (Decety, Bartal, Uzefovsky, & Knafo-Noam, 2016, p. 9) citing (Cronin, 2012), and because positive correlations were found between empathy and both prosocial behaviour and “cooperative/socially competent behavior” (Eisenberg & Miller, 1987).

On another note, empathy is known to have ties with self consciousness and social consciousness. “Empathy is the precondition (the condition of possibility) of the science of consciousness” as Thompson (2001) explains it. Indeed, Bekoff (2002, p. 26) argued that “discussions of empathy necessarily include consideration of the notions of self-awareness (also referred to as self-recognition and self-consciousness)”, and Haley et al. (2017) found positive, significant associations between self-awareness and empathy. Davis (1990) agrees that with the promotion of self-awareness, empathy is developed.

Additionally, Segal (2011) explains how empathy and social consciousness are linked under the ensemble of Social Empathy. She explains (with reference to Freire (1990)) how social action is characterised by the development of consciousness – which is the “combination of the self/other-awareness and the perspective-taking components of empathy” (Segal, 2011, p. 271). Further, she elaborates on how Social Empathy embraces social responsibility and promotes social justice and well-being. Segal (2011) explains that via Social Empathy, people are better able to ‘deeply understand’ peoples’ situations and needs, and therefore be better equipped to deal with these situations. Although Segal (2011) concerned the activities of social workers, it is worth considering whether and how the framework could be extended to understanding how social empathy relates to the social impact of engineering design.

In addition to the above ties addressed, Chlopan et al. (1985), citing Mehrabian (1977), stated that “highly empathic individuals tend to show a great amount of social concern and tend to screen irrelevant environmental information less ” (1985, p. 648); in other words, those highly empathic individuals that are inclined to show/have more concern and awareness of surrounding environmental stimuli, are more likely to screen (i.e., filter out or disregard)irrelevant pieces of information found in the environment, to a lesser extent – highlighting the readiness of such individuals to be sensitive and receptive of both the relevant as well as the irrelevant pieces of information in their surroundings. This further highlights the positive association between empathy and social concern, and social consciousness.

Social consciousness is arguably particularly adjacent to the now 'called-for' *societal consideration* in engineering – as one has to be conscious about society to be considerate of it. This therefore calls for empathy, prosocialness, as well as consciousness, to be addressed and analysed in the context of human-centred designing in civil engineering and engineering education.

Moreover, Joslyn & Hynes (2016) discuss how self-awareness, social-awareness, and engagement with human-centred designing, are associated with professional engineering formation in undergraduate students. They, whilst citing Fenigstein et al. (1975), define self consciousness as "one's disposition to direct her/his attention towards her/himself", and thus "the existence of this self-directed attention produces a state of self -awareness". This state of self-awareness, they address whilst citing (Natsoulas, 1998), "represents the extent to which one has identified and can articulate the personal values, professional values, and assumptions regarding professional roles and responsibilities that inform her/his professional identity", which eventually maps onto professional formation.

Social-awareness, on the other hand, is defined as "a state of focused attention on considerations of public welfare in one's day to day life and it represents the extent to which one considers matters of public welfare" (Joslyn & Hynes, 2016, p. 2) citing (Cech E. , 2014; Cech E. , 2014b). They further state that the "ability to consider matters of public welfare is highly influenced by the professional formation process" (Joslyn & Hynes, 2016). Moreover, social consciousness is one of the four public welfare beliefs that were examined by Cech (2014) in her influential study of 'Culture of (Dis)engagement in Engineering Education'.

Joslyn and Hynes (2016) point out that design courses offer the opportunity to "integrate the development of engineering students' self and social-awareness". This, they argue, can be facilitated by engagement with user-centred, human-centred, empathic and compassionate designing, emphasising the importance of engaging with such design frameworks on supporting professional formation. Walther et al. (2019) agreeingly argue the emphasis of empathy on the development of engineering formation.

Joslyn & Hynes (2016) designed an instrument to capture and measure levels of self-awareness and social-awareness indicators (the Self-awareness and Social-awareness Assessment; SSA) of engineering students, before and after their engagement with a human-centred design project. This instrument (along with others) is adopted and to be used in the present project, will be further addressed in the methodology.

Moreover, on the motivation for human-centred designing, Young (2010) addressed the link between human-centred designing and design thinking, with sustainability, stating: "by taking a human-centred approach and placing the emphasis on user needs and motivations, design thinking has the potential to guide designers away from solutions that, while seemingly good ideas, are less likely to be useful to or adopted by end-users". This, Young argues, "is a less-documented benefit of design thinking's contribution; commentary on design thinking tends to focus on the outputs of the process – that is, innovations produced – rather than the reduction of social and natural capital waste afforded by design processes that steer designers away from sub-optimal solutions that are less likely to support their intended objectives" (2010, p. 15). Young (whilst citing Fabricant (n.d.)) then states that "empathy is an essential component of designing for behaviour change, which, as identified earlier, is a key benefit of a human-centred approach" – emphasising the key role of empathy in such design thinking or human-centred designing practices and objectives.

Moreover, Young (2010, p. 18) then elaborates with the argument: "taking a human-centred approach shifts perspective from the technical to one in which human biases and heuristics play a role, and where personal values, attitudes, beliefs, cultural settings are considered when designing solutions". Such an argument addressed by Young (2010) highlights the importance of addressing how the subjective or personal elements of the engineers, i.e., the engineering mindset, attitudes, and heuristics, play a role in such contexts and designing frameworks. This argument therefore clearly aligns with the present project, as it crosses with a present aim and objective of understanding the subjectivity of sustainable and socially considerate decision-making in engineering designing contexts, by addressing Personal Values and Perfectionism, as facets of the engineering mindset, to understand said facets' associations and influences on human-centred designing engagement and production of *Communal Designs*, in the civil engineering design context. Reasons as to why Personal Values and Perfectionism are the particular facets to be researched in the present project are to be discussed shortly in the next few sections.

## 2.3 Introducing the Setback

As previously mentioned, due to the necessity of implementing strategies to promote empathy (and by extension, social consciousness (Thompson, 2001)) in engineering, and the findings on empathy being unenforceable (Stein, 1970), nor the act of empathising can be taught (Davis, 1990), this project introduces a methodology to promote empathy via exploiting the psychological phenomena of *Priming*. This project assesses the feasibility of priming empathy in the context of human-centred, socially considerate designing. Through *Priming*, this project also argues it to be a methodology to promote empathy whilst simultaneously bypassing the possible resistance or backlash from students that may result from enforcing such under-valued and non-technical notions in a technocentric engineering setting. More on the students' 'resistance' and 'rejection' of such non-technical notions will be discussed in the following few paragraphs.

Non-technical, metaphysically (and thus, empathically) informed initiatives are likely to be devalued and belittled, resisted and even rejected by engineers and engineering students; this is arguably to be due to the heavy reliance on positivistic (Downey & Lucena, 2003b; Erden, 2003) and technocentric (Cech E. A., 2014; Kouprie & Visser, 2009; Leonard & Rayport, 1997; Leydens & Lucena, 2017; Maguire, 2001; Mattelmäki, Vaajakallio, & Koskinen, 2014; Riley, 2008; Trevelyan J. , 2010) values characterised in the engineering paradigm and curriculums.

Niles et al. (2020) investigated how engineering students respond to the non-technical notions of public welfare engagement and working with public welfare related issues in an engineering classroom. They found that although students seem to get excited for working on public-welfare-related work, they also seemed to resist it. Niles et al. found that the challenges that often lead to students' resistance to public welfare issues are the following:

(a) defining and defending students' identities as engineers;

(b) justifying the value of nontechnical work and relevance to engineering;

(c) redefining engineering expertise and integrating community knowledge into projects; and

(d) addressing ambiguous questions and ethics. (Niles, Contreras, Roudbari, Kaminsky, & Harrison, 2020, p. 6).

Niles et al. (2020, p. 6) explain the struggles engineering students experience when public welfare related assignments are "foregrounded". They explain how that disrupts the "technical/social dualism in engineering", which eventually leads to the complications of the students' understanding of "what it means to be an engineer, what engineers do, and what constitutes engineering knowledge and expertise". Niles et al. realise how this "created difficulties for students as they contended with conflicting conceptions of engineering knowledge and practice".

Niles, Roudbari, & Contreras (2020) derive examples on how ""social" aspects have been brought into engineering in a depoliticized manner that limits engagement with political and social justice goals". Linking these examples to Cech's three pillars of 'culture of disengagement in engineering', they find that "reframing engineering as sociotechnical addresses the first pillar, the social/technical dualism, but does not necessarily include the second and third pillars" – namely, meritocracy (the second) and depoliticization (the third pillar). They suggest that "all three pillars can be addressed through integrating explicit attention to political engagement and social justice in efforts to reframe engineering as a sociotechnical field. Doing so can increase engineers' capacity to contribute to social justice and peace".

Langus et al. (2018) study the reflection in integrating political and social dialogue in engineering classrooms. They found two emerging themes: "political awareness" and "future-self impact". They found that students demonstrated awareness of current political events at the local, national and global levels, and identified personal and social impacts that these events may inflict on friends, family members, and the society. The students, however, were found "unsure of how to interpret political dialogue as it relates to policy in engineering disciplines and practices. This uncertainty led students to question their future-selves or careers in engineering". Langus et al. further explain that "as participants continued to discuss their uncertainty, they expressed a desire to make explicit connections between politics and STEM and their eventual careers in STEM", suggesting that "depoliticization in the classroom results in engineering students having limited consciousness of how political issues are relevant to their field". They propose that "by re-politicising STEM classrooms in a way relevant to students' futures, educators can better utilize important dialogues to help students understand how their role as engineers influence society and how the experiences of society can influence their practice of engineering".

On another note, Swift, Godwin, & Shealy (2018) examine the how gender difference influences 'sustainability beliefs' in engineering undergraduates. They found that "women are significantly more likely to want to address water supply, food availability, and opportunities for woman and/or minorities in their careers than their male peers", whilst reciprocally, "men were significantly more likely to want to address energy and terrorism and war in their careers than their female peers". Swift, Godwin and Shealy's results therefore identify the different perspectives from which engineering undergraduates regard sustainability outcomes and expectations in their careers. They further elaborate that "this work begins to let us understand certain topics and pathways that may support women in engineering as well as provides comparisons to prior work on early career undergraduate students".

Recapping to the obstacles of characterising of empathy in engineering, one is argued to be the engineering ontology, or in other words, the engineers' nature of *being*. Engineering paradigms are known to be ontologically positivistic in nature (Downey & Lucena, 2003b; Erden, 2003) – i.e. following the approach of "tak[ing] a realist position and assume that a single, objective reality exists independently of what individuals perceive" (Hudson & Ozanne, 1988, p. 509) citing (Bagozzi, 1980; Burrell & Morgan, 1979; Morgan & Smiricich, 1980).

Moreover, Morgan (2019), whilst referencing Downey & Lucena (2003b), states that "the dominant learning paradigm within schools of engineering is the positivist paradigm of engineering science, as articulated through the teaching of core engineering science subjects". Erden (2003) found confirming results that show that “engineering students are more positivist (more technocratist, more elitist, more rationalist) than social science students.” (p.121).

Positivism is known to reject metaphysics (Ayer, 1936; Hume, 1748; Weinber, 1936), and thus by extension, it is hypothesised to reject empathy. From this, it can be theoretically deducted that engineers tend to reject empathy and other metaphysical stances, due to their positivistic training and education. This is critical, as for engineers and engineering students to be more socially considerate in their line of work and design, they are encouraged to adopt human-centred designing and design thinking frameworks to allow for and incorporate more societal consideration in the design process – both of these frameworks require empathy as a prerequisite entity, which is now discussed and hypothesised to be most likely rejected, due to the positivistic nature of the engineering paradigm or curricula.

As previously mentioned, positivism is the dominant problem-solving paradigm in engineering education, due to the engineering education’s dominant reliance on scientific and mathematical learning (Downey & Lucena, 2003b; Erden, 2003). Positivism is also argued to be ‘captivating’ engineers from social consideration as it is carried forward into practice, as it is resulting in a “serious limitation in engineers' capacity to examine the social meanings and effects of their work and to self-consciously reflect upon their practice and professional identity” (Johnston, Lee, & McGregor, 1996).

Moreover, in a review of Haskamp, Paul, Stöckli, de Paula, & Uebernickel (2020, p. 2), they stated that "while DT [Design Thinking] comes with great promises, the implementation is much harder as the underlying values of DT challenge existing organizational cultures (Elsbach & Stigliani, 2018). In particular, it is known that especially “cultures based on the values of productivity, perfectionism, and siloed specialization are likely to impede the implementation of design thinking in an organization” (Elsbach & Stigliani, 2018, p. 2295)”, elaborating with “these values are especially prominent in manufacturing firms (Kortmann, 2012). Embodied through employees that are working in these environments, especially non-designers in firms cultures that do not rely on the values of user focus, collaboration, experimentation and risk-taking seem to have problems in adopting DT (Elsbach & Stigliani, 2018).” Haskamp et al. then point out to the gap in literature on implementing Design Thinking in such work environments (such as those in engineeering), by refering to Elsbach & Stigliani (2018, p. 2296) questioning of “the reasons why non-designers may resist design thinking tools”. Again, this is interesting as it aligns with the current project on perhaps contrinuting to reasons, by researching how (if) different facets of the engineering mindsets or characteristics may be influencial to human-centred deisnging engagement, and thus by extension, design thinking.

Lastly, Love (1999) addresses this issue with respect to academic engineering paradigms. Stating that “engineering design education both presumes and depends upon theories of design cognition”, Love clearly highlights the dilemma at present by saying: “until recently, most theories of design cognition have been based on the application of positivist research perspectives. This poses a contradiction. Positivist research perspectives exclude human subjective issues, but designing is essentially a subjective human phenomena" (Love, 1999, p. 33) citing (Coyne & Snodgrass, 1993; Franz, 1994; Goldschmidt, 1994; Holt, 1997; Petroski, 1992; Reich, 1995; Valkenburg & Dorst, 1998). Love therefore contributes to the current (and carried) issue of resisted implementation and proper engagement with design thinking and human-centred designing in engineering, still spoken of today.

Overall, the studies discussed above on the dilemmas faced when implementing design thinking in engineering, and those that

To sum up, a few of the studies that described how engineering paradigms are heavily rooted in, prioritising technocentrism (Cech E. , 2013; Cech E. , 2014; Elsbach & Stigliani, 2018; Leydens & Lucena, 2017; Nieusma, 2013; Riley, 2008), positivism (Downey & Lucena, 2003b; Erden, 2003), and consumerism and financial profit (Turnbull, 2019), paint the picture that characteristics other than of those outlined (i.e., empathic, human-centred, humanitarian, and social characteristics of engineering) are often devalued or belittled (Trevelyan J. , 2010; Mazzurco & Daniel, 2020) and/or resisted (Niles, Contreras, Roudbari, Kaminsky, & Harrison, 2018; Niles, Contreras, Roudbari, Kaminsky, & Harrison, 2020).

Summarising, empathy, i.e., an important character of human-centred designing and design thinking, is known to be unenforceable (Stein, 1970), and the act of empathising cannot be taught (Davis C. , 1990). This, therefore, presents the gap in which a methodology of characterising empathy in engineering, in an undisruptive manner, is yet to be addressed. This is in response to the called for social consideration in engineering, and proper implementation of the continuously disrupted human-centric and design thinking frameworks in engineering. A review of how others in the field have addressed this problem is presented in the next section, followed by how this project addresses this problem. This project argues that the characterisation of empathy (and its relevant frameworks, like human-centred designing and design thinking) should be done in a subconscious manner to bypass resistance – therefore, this project proposes doing so via the exploitation of the psychological phenomena of priming, to promote empathy subconsciously in a civil engineering human-centred designing classroom context. This will be discussed further in the upcoming sections – Section 2.5 will provide an in-depth review and examples of priming.

### 2.4 Reviewing how others in the field addressed the problem of characterising empathy, social consciousness or consideration, design thinking, and/or human-centred design in engineering classrooms.

This section is to review how others in the field have conducted interventions to promote empathy, consciousness, design thinking or human-centred designing in undergraduate engineering classes -

i.e., to view how others have attempted to overcome the ‘setbacks’ or solve the problems mentioned earlier.

Therefore, as it arguably being one the most leading conferences on the aforementioned topics and interventions in engineering education, the American Society for Engineering Education (ASEE) conference proceedings was the database from which the literature review for this section was extracted; as this conference proceedings' database can be argued to be on the most internationally updated on the latest, new, and creative methods researched by others in the field, on overcoming this exact same, specified problem, whilst holding a degree of ‘flexibility’ (in the use of wording, communication, and interaction with the authors) that would not necessarily be present in a stricter journals – this makes it ‘closer to our classrooms’, in terms of the proposed attempts, ,methodologies, and findings. To narrow the search, keywords and publication date restrictions have been applied. The keywords were “"implementing" & "integrating" & "EMPATHY" & "Social" & "Design" & "CLASSROOM" & "lecture" & "INTERVENTION" & "university"”, and only the papers published after 01/01/2015 were considered, to obtain more relevant and contemporary and research results (this was intended to review – and build upon – the latest and most contemporary prevalent methodologies on the subject and proposed problem, on the start of the present PhD project, which was in 2018). The webpage from which the obtained papers (discussed in **Table 95**) have been extracted is: ASEE PEER - Search Results [for online access of the document].

Ninety-two papers were therefore reviewed (see **Table 95**), and have been discussed as relevant or not relevant – relevant is when it provides methods or interventions designed to explicitly promote empathy, consciousness (self or social), design thinking and/or human-centred designing skills in engineering undergraduate students. **Table 95** can be viewed in Appendix A, and a summary of the papers found most relevant to the present project and literature review section (that is, on reviewing how others have conducted interventions explicitly to promote or cultivate empathy, consciousness, human-centred designing and/or design thinking, in engineering students), can be viewed below. A more in-depth, detailed review of the following most relevant studies can be found in **Table 95**, in Appendix A.

Hempel, Blowers, & Kiehlbaugh (2019) study can be argued to contribute to notions of metacognition, and can thus be argued to be characterising a growth mindset, metacognition and belongingness within engineering education, which may overlap with the aforementioned characteristics and human-centric design thinking approaches. However, this study does not address an intervention that explicitly promotes empathy, consciousness, design thinking or human-centred designing.

Hoople & Choi-Fitzpatrick (2017) addressed an approach to explicitly promote empathy in students by having engineering students work collaboratively with peace study students, to put forward a collaborative design for a drone. Schuman, McNair, Gray, & Ozkan's (2021) study implements an intervention to explicitly promote consciousness via employing a pedagogical strategy of critique: "The critical response Process".

Andrade & Tomblin's (2018) study implements interventions to explicitly promote social consideration and consciousness, by intentionally surfacing such notions in discussions and other practices in the classrooms. Ruiz, Trageser, & Lutz (2021) explicitly fostered empathy in engineering students by guiding them to understand their personal values and identify their connection with the course content (i.e., understanding how the values of the course resonate with their [students'] personal values, and motivation for the engineering work or practice).

Erickson, Caussen, Leydens, Johnson, & Tsai's (2020) study attempts to explicitly promote social consideration by implementing strategies of exposing students to real-life examples in engineering classes. Dodson, et al.'s (2017) study discusses an intervention designed to explicitly promote human-centred designing, design thinking, empathy, and other skills associated with achieving sustainable development goals in engineering students. This was achieved through students' exercise of role-playing and reflective writing.

Smith, Teschner, & Bullock (2018) promoted socially considerate, human-centred designing skills by exposing students to a human-centred designing project infused with stakeholder engagement; this intervention was said to inspire "deeper insights" in students, thus indicating the characterising of empathy as well. Frow, Smith, & Ankeny's (2017) study successfully promotes social consideration and wicked (real-world) problem solving, despite the limitation of students being unable to meet with the end-user. This was done via guiding groups of students through a biomedical device design, whilst encouraging them to reflect, self-evaluate their ability to work in a team, and self-identify how well they comprehend different aspects of the design process.

Hammond, et al. (2021) promoted notions of social consciousness and consideration through training engineering educators on how to introduce related topics in classrooms; and by holding weekly meetings for engineering students to meet and discuss matters of race and inclusivity, and methods to integrate such socially-considerate and inclusive notions in engineering classrooms. Allen & Chen's (2018) study explicitly promotes empathy and human-centred designing skills in biomedical engineers by allowing for direct engagement with the patients that students are designing for, or by shadowing and interviewing clinicians of the patients.

DiBiasio, et al.'s (2017) study promotes empathy by providing enough context for the designers (students) to imagine and role-play the characters that would be of concern in the design process; the intervention was found to promote empathy in some engineering students. Favaloro, Mantey, Petersen, & Vesecky's (2018) paper addresses an intervention to foster an entrepreneurially-minded learning, and not an intervention designed to explicitly promote empathy, consciousness, design thinking or human-centred designing.

Eskandari, Karanian, & Taajamaa's (2015) study develops an intervention to explicitly promote empathy in engineering students; this was done via storytelling and audience engagement. DiBiasio, et al.'s (2018) promote empathy in engineering students through transdisciplinary collaboration (with humanities students and faculty) and in-class role-playing, in contexts of engineering human-centred designing. Gomez & Svihla's (2019) paper develops a tool that was found to aid with engineering students' contextualising and understanding of real-world problems, and enhancing students' ability to empathise with the communities they are designing for.

Turpen, et al. (2018) addresse an intervention designed to promote design thinking in engineering classrooms – this was done via educating the learning assistance (to transfer the knowledge), and by choreographing role-playing activities for students. Bosman & Arumugam (2019) address a framework that would cultivating creativity (which is a prerequisite to design thinking) and human-centred designing thinking, during phases of a 4-step framework that would ultimately reach business model development.

Cavanagh & Tranquillo (2017) address a method of characterising student human-centricity in design and empathy through gaining information using "flow-chart diagrams, written summaries of disease processes, rubrics for evaluating interventions, and dialogs between a patient and a physician or a family member", and through "consider[ing] the individual patient perspective of innovations in health care alongside the broad technical, economic, and business perspectives"; this method is also said to enhance student's innovation. Koehler, et al. (2020) address a methodology to cultivate virtues (which are associated with social consideration and empathy) in engineering education.

Ritz, Bodnar, & Montalbo-Lomboy (2022) designed an intervention to expose students to narratives of a case through mediums of testimonies, biographies, photos, and data related to the design case, in a 'story-like format'. Student were also encouraged to reflective writing and discussion to enhance students' curiosity and critical thinking skills; the findings of this paper suggested that exposure to such narratives concludes in enhanced social consciousness and consideration in engineering education settings.

Tomblin & Mogul's (2022) study addresses a method designed to explicitly promote empathy in engineering students in a human-centred designing context. It addresses the use of a techno-ableism intervention, instructing engineering students to wear bracelets to remind them of stay conscious of the experience an imaginary disable host might encounter in their surrounding place. This method is ultimately to remind students to stay conscious (i.e., enhancing societal consideration) and empathic (by putting themselves in the shoes of that imaginary visitor). Tomblin & Mogul declare this method as promising and have helped expose “challenges around teaching students not simply how to have empathy, but to practice cultivating situations in which they will gain empathy”.

Castaneda, Merritt, & Mejia (2022) successfully designed an intervention to cultivate and address empathy with reference to the Carlson et al.’s (2006) 4-stage understanding of Critical Consciousness. Although students were later found to have displayed superficial empathy engagement, this study is relevant to this literature review section, as it is explicitly designed to promote or influence empathy in engineering students, in human-centred designing contexts.

Newland, El-Shebiny, & Alsop (2022) address an initiative that was found to have successfully promoted students’ societal and sustainable considerations, and grasp the concept of social justice. Community engagement and reflections were common practices in this initiative. This characterisation of consciousness was also in the context of human-centred designing in engineering.

Caratozzolo, Friesel, Randewijk, & Navarro-Duran’s (2021) paper reviews an initiative designed to cultivate engineering ‘global citizenship’ in engineering students – which implies cultivating social consciousness and consideration. This was done via holding ‘hands-on’ online international collaborative sessions, which would give space for students to cultivate skills of “international cooperation, negotiation, leadership, empathy and broad perspective”.

Bielefeldt’s (2022) study promotes emotional responses in students via exposing them to personalised stories in ethics education, with the intent to heighten ethical reasoning and awareness in engineering education. Oerther’s (2017) study promotes communal value in engineering by integrating the Florence Nightingale’s Environmental [i.e., a nursing] Theory in the engineering context, and by allowing for engineers and nurses to co-work and both learn from each other’s approaches and expertise.

Goodman, Underwood, & Bennett (2016) addresses an intervention that explicitly promotes empathy, design thinking, and human-centred designing skills in engineering education, and is therefore relevant to the present literature review section. Such a characterisation was achieved through implementing a multidisciplinary approach contributing to such notions, and working on relevant assignments, and by creating the space (literally) for people across disciplines to meet and work on ‘things that matter’ to human society.

Mativo, Sochacka, Youngblood, Brouillard, & Walther’s (2017) study promoted wicked problem solving skills (associated with design thinking skills) via exercising collaborative efforts of educational researchers, instructors, and industry partners in preparing real-life cases for student to work on. Guerra, Guerra, Gallardo, & Ubidia’s (2022) paper addresses a successful mechanism said to enhance students’ development of ‘soft skills’ (i.e., communication and teamwork skills, and empathy), and understanding of others’ perspectives; the latter can also be argued to be hinting towards exercising empathy; this was done via organising collaborative team working (between students of architecture and civil engineering) on infrastructure projects.

Fiss, Meadows, Raber, Henquinet, & Berkey's (2019) study addresses an intervention designed to explicitly promote consciousness (of the self) in engineering students; this was done via exercising a strategy rooted in Robert Kegan's theory of adult development (1994), reflective writing, collaborative working efforts, and students' assessment against Bloom's Taxonomy framework of educational objectives – both in cognitive and affective contexts. Students were found to be able to articulate their feelings, values, and goals", established "intrinsic motivation, a driving force for deep learning", and were said to be more encouraged to "think beyond their majors, and even their careers, in defining their goals", as a result of this intervention.

Schulte Grahame, Freeman, & Levi (2019) address an intervention that was found to have influenced or promoted students' communal engagement skills. This was said to be done by bringing them closer to the community, both emotionally and cognitively, in a mandatory public-serving programme. Radcliffe & Pilotte (2018) address a successful mechanism found to have promoted social consciousness and human-centric designing skills in students. This was done via proposing a "novel Study abroad programme" where students were set to experience a 'socio-technical laboratory' which is suggested to imitate 'an experience of global engineering fieldwork'. Students' reflective writing was also encouraged in this programme.

Mogul, Tomblin, & Reedy's (2019) study assesses and analyses students' ethics assignment proposals and outcomes of a story telling assignment (where students wrote "context for a decontextualized problem" – i.e., for identifying the strategies students used to construct context, and their difficulties in doing so); the latter was thought of a "scaled down approach to adding context". Mogul, Tomblin, & Reedy's findings show that such practices have enhanced students' understanding of the professional identity and the "real world application" and empathy.

Telang, Annaluru, Julien, & Santacruz's (2023) addresses the results of implementing diversity, equity and inclusion (DEI) modules in an engineering classroom. The objective was to "ensure that engineering undergraduate students, who are not historically exposed to DEI content, are introduced to these important topics in the context of their technical coursework and that they understand the relevance of DEI to their careers". Modules were implemented to inform students on "history of computing and algorithms, identity and intersectionality in engineering, designs from engineering that have high societal impact, the LGBTQ+ experience in engineering, engineering and mental health, and cultural diversity within engineering". Students were given the option to "(1) watching a relevant video; (2) reading and annotating a provided article; (3) responding in a written reflection to a set of specific prompts relevant to the module; and (4) conducting an interview with a peer or community member using a list of suggested questions about the module's contents", as a mean to interact with such topics, and were thereafter requested to explain what they've learnt through submitting a deliverable to be graded and evaluated. Feedback from the students was collected to be later fed into the process of the development and further promotions of such notions in engineering education. This paper designs a methodology to explicitly integrate notions (associated with empathy) to expand and promote the understanding of diversity, equity, and inclusion in an engineering classroom; however, it does not provide a methodology designed to explicitly promote empathy in contexts of design thinking or human-centred designing, in an engineering classroom, but it is still worth noting in the present literature review section.

Arguing that "lecture-based approaches are the least effective pedagogical method for ensuring concept retention, changes in empathetic thinking, and recognition of personal implicit biases", Lego (2023) overcomes this issue by implementing "a skills-based approach to its DEI learning modules within all capstone courses". This was done via implementing "a variety of pedagogical techniques including interactive video-based bystander training; self reflections on microaggressions and implicit bias; and in-class team exercises and discussions on the intersection of power dynamics, team interactions, and discrimination, as well as strengthening empathy though a recognition of societal privilege and economics factors"; ensuring that students develop "concrete action that will promote and ambiance of "an inclusive, collaborative, and psychologically safe environment for all members" when working in teams. Although this remains still as a "work in progress" intervention, the present paper has promising positive impacts. This paper remains a work in progress, however it addresses an intervention designed to explicitly promote empathy in contexts of diversity, equity, and inclusivity; however, said intervention was not designed to explicitly promote empathy in contexts of human-centred designing or design thinking; however, it remains as relevant to the present section, as in explicitly promotes empathy) in an engineering classroom.

Ely, Hill, & Sparks's (2023) work-in-progress paper reviews a methodology to promote "unique collaborations between engineering and non-engineering students in a user-centered design course and humanitarian engineering project work". It assesses "the professional formation of engineers by examining how engineers apply social attributes (namely those identified by the Social and Emotional Learning (SEL) framework) to user-centered design in a multidisciplinary project", asking "What key social attributes do undergraduate students identify as significant factors within service-learning engineering projects?" and "How does participating in a user-centered design curriculum impact students' identification of key social attributes associated with service-learning projects?". As this is an ongoing project, this paper only reviews the implementation process, however, discusses promising positive socially consideration influence on students. Although this paper is a work-in-progress, it reviews an intervention designed to explicitly promote user-centred designing (i.e., can be argued to be relevant to human-centred designing); and is therefore, relevant to the present literature review section. It does not presently present solid results; however it displays an array of positive potential influence.

Buzzanell, Eddington, & Zoltowski's (2023) paper's objective is to "understand better how facilitators work with DT participants in particular spaces and engineering cultures regarding sensitive ethical issues like DEI, and to provide guidelines for developing facilitation expertise for DEI in DT sessions". This paper then drew findings on how facilitators extract "participants' understandings and explanations of marginalization and inclusion"; this was done by the facilitators' "attending to design session participants' own expressions of causality and hopes for the future". This study addresses how design facilitators can promote further design thinking in engineering education, and is therefore relevant to the present literature review section.

Lastly, Rhoads & Schrock's (2023) work in progress reviews the modifications made to the Multidisciplinary Design Capstone (MDC) course at The Ohio State University. This involved the enhancement of four major learning strategies and theories (sense of belonging, stereotype threat, calibration and retrieval) in the course, in addition to the instructors integrating empathic decision making into the design process. Triangulation feedback (i.e., between students, MCD instructors, faculty advisors, and capstone project sponsors) was analysed to evaluate the changes. The methods implemented in the current development of the course show promising positive influence on students, where students showed skills of working in diverse teams, developed team value, inclusivity and efficiency and empathic decision making in the design process, skills of calibration between their 'perceived' and 'actual' performance and knowledge of cognitive level, and lastly, trained students to "to reflect and modify their problem identification as they gain knowledge progressing through the design process" and avoid 'jumping to conclusions'. This paper addresses a change made to a curriculum that resulted in cultivating empathic design thinking in a Multidisciplinary Design Capstone course, by attending to the enhancement of the listed skills like sense of belonging, stereotype threat, calibration and retrieval, in the course. This paper is therefore relevant to the present literature review section.

## 2.5 How this project addresses the problem of characterising empathy, social consciousness and social consideration; Introducing Priming.

Recapping, empathy, i.e., an important character of human-centred designing and design thinking, is known to be unenforceable (Stein, 1970), and the act of empathising cannot be taught (Davis C. , 1990). This, therefore, presents the gap in which a methodology of characterising empathy in engineering, in an undisruptive manner, is yet to be addressed. This is in response to the called for social consideration in engineering, and proper implementation of the continuously disrupted human-centric and design thinking frameworks in engineering. Others have addressed methodologies to implement such frameworks, but non (to my knowledge) have addressed them with an intent to bypass possible resistance. This project argues that the characterisation of empathy (and its relevant frameworks, like human-centred designing and design thinking) should be done in a subconscious manner (as opposed to enforcement) to bypass resistance – therefore, this project proposes doing so via the exploitation of the psychological phenomena of priming, to promote empathy subconsciously in a civil engineering human-centred designing classroom context.

### 2.5.1 What is Priming; and how can it be linked to Human-Centred Designing?

The priming effect is an unconscious prompt that occurs as a result of a subtle, contextual cue (a prime) that activates an existing semantic association in the mind of the receiver. This has been proven to have an effect on behaviour (Bargh J. , 2002; Bargh, Chen, & Burrows, 1996), perceptions (Higgins, Rholes, & Jones, 1977), performance on a cognitive task (Dijksterhuis & van Knippenberg, 1998), and attitudes and values (Kawakami, Dovidio, & Dijksterhuis, 2003). Priming has been also proven to affect decision making (Kusev, van Schaik, & Aldrovandi, 2012), ethical decision making (Welsh & Ordóñez, 2014), and moral judgement (Zarkadi & Schnall, 2013; Zhong, Strejcek, & Sivanathan, 2010).

The idea of priming was initiated based upon the fact that most of human behaviour (and thus its associate – decision-making (Robbins, Judge, & Campbell, 2017)); and by extension to decision-making, problem-solving (Saitis & Saiti, 2018)) is rather ‘nonconscious’ in nature (Alba, 2000; Loewenstein, 1996), making an unconscious, *automatic* trigger towards a targeted behaviour change viable (Bargh & Chartrand, 1999; Bargh & Chartrand, 2000).

The semantic association from priming occurs as follows: When an individual has to give a fast response on Topic A, whilst subject to the unconscious influence of Topic B (through exposure to a prime associated with Topic B), the schema (set of memories, understandings, and experiences) of both Topic A (conscious) and B (unconscious) are thus activated. This process is automatic, unconscious, and passive, and allows the experiences and mindset associated with Topic B to influence the solution produced consciously for Topic A – thus, allowing for the final solution to be informed by semantic schemas of both Topics A and B, unconsciously; see (Bargh J. , 1994; Bargh, Chen, & Burrows, 1996; Higgins, 1989; Wyer & Srull, 1989) for more information.

Any form of sensory trigger that has the ability to trigger a semantic schema has potential to be a prime, though olfactory (Smeets & Dijksterhuis, 2014), auditory (Schacter & Church, 1992), and/or visual (Bar & Biederman, 1998) are most commonly adopted. When the prime is above the conscious detection threshold it is termed supraliminal, and when is below this threshold it is termed subliminal. Subliminal priming is usually characterised by the flashing of a prime, quick enough to influence, but to also remain undetected by the human consciousness (Bargh & Chartrand, 2000); whilst in supraliminal priming, exposure to primes can be longer in duration (Bargh & Chartrand, 2000), but its' intention still has to remain undetected, for the effect to be feasible (Bargh & Chartrand, 2000). Supraliminal visual priming is considered to make a 'longer-lasting' effect than subliminal (Cave, 1997).

Priming has been a known persuasive technique used widely in Politics (Weinberger & Westen, 2008), Marketing and Advertising (Packard, 1957) and in the educational process of autistic children (Koegel, Koegel, Frea, & Green-Hopkins, 2003), as it is also shown to surpass 'disruptive transition behaviour' (Schreibman, Whalen, & Stahmer, 2000). Moreover, there have been many studies where visual priming affected behaviour and decision making, for example;

- A study by Latu et al., (2013) showed that female participants who were primed with pictures of powerful women ('role models') demonstrated better speech delivery and leadership skills.
- A study by Fitzsimons et al. (2008) shows that behavioural traits such as 'creativity' was triggered when participants were exposed to priming imagery logos of Apple; and 'honesty' when exposed to Disney logos.
- And finally, the famous experiment by James Vicary in 1957 showed that people consumed more popcorn and drank more Coca Cola when they were visually primed to do so, whilst watching a movie in a theatre hall. Although some accused this to be a hoax, Karremans et al., (2006) conducted a similar study, and found aligning results.

Priming has also been proven to induce emotions like happiness and anger (Skandrani-Marzouki & Marzouki, 2010), and induce empathy (Hodges & Wegner, 1997) in a prosocial behaviour related context (Calvet Christian & Alm, 2014), and in a 'feel others' pain' context (Cameron, Spring, & Todd, 2017; Song, Wei, & Ke, 2019). It has also shown to influence *empathic responding* (Johnson, Olivo, Gibson, Reed, & Ashburn-Nardo, 2009) and empathy related to personal value (Price, 2016).

Besides, using images of the people being designed for have been found influential on designers' understanding of user need and subsequent designs, as it was found that "images of users are a powerful means to represent results of user studies to design teams" (Sleeswijk Visser & Strappers, 2007). It was also seen that user images trigger designers' empathy (with the user) (Sleeswijk Visser & Strappers, 2007) and creativity, as it triggers an 'extrapolation' from the limited information provided to the designers (Grudin & Pruitt, 2002). Moreover, images of the users can act as mental 'anchors' to the designers, where they can act "as a reference point through the process of receiving the information and calling upon it later in the design process" (Sleeswijk Visser & Strappers, 2007) citing (Bruce & Green, 1985; Pruitt & Adlin, 2006).

Based on the above, it appears that priming could have a role to play in engineering design processes, in cases where a particular mindset or set of values has relevance to a design task. This is particularly true in the case of mindset and values that are not already being strongly associated with engineering schema within the mind of the student (or even often being resisted and/or devalued). For example, in the case of inducing a mindset compatible with human-centric design frameworks for public-welfare and engagement of social consciousness, the use of primes could possibly facilitate empathy, and by extension, social consciousness (as empathy is the 'precondition of consciousness' (Thompson, 2001)).

In addition to facilitating or inducing empathy in engineering students towards the people they are instructed to design *for*, this project argues that the priming pictures could hold the potential of aiding the students into visualising and thus better understanding the situations they are to design for. Therefore, it is argued that priming civil engineering students during a human-centred designing assignment workshop could hold the potential of producing more 'communal' designs by inducing empathy towards the people students are designing for. This is argued to also facilitate students' imagination and understanding of the peoples' situations and needs; and is thus argued to facilitate a *proper definition of the problem(s)* (as the previous literature already pointed out), and better identification of peoples' needs to be put at the core of design or design process.

Moreover, the main reason for the use of priming was to induce subtle change (as opposed to sudden, obligatory change) to bypass possible resistance coming from students when suddenly *forced* (as one would in a typical top-down teaching dynamic) to engage with relatively 'foreign' non-technical, public welfare related work and design strategies.

Finally, as targeted behaviours via priming have shown to have increased over time as a result of using primes (Koegel, Koegel, Frea, & Green-Hopkins, 2003), it is thus predicted that repeated application of priming (and even on a larger scale – not just restricted to a classroom intervention/workshop) is argued to be of potential to act as a 'human-centred' mindset and value reinforcer in engineering settings, over time. Additionally, the priming pictures are argued to act as 'reminders' for the students on the impact of their designs, and their responsibility as engineers, to produce designs and solutions intended to elevated people's quality-of-life.

Primes used in this project are visual – supraliminal pictorial cues were used to intentionally trigger certain schemas and internal responses (specifically, empathy and 'understanding') in the students, during their human-centred designing assignment workshop. Supraliminal pictorial primes were used as they are argued to be the most convenient form of sensory priming interventions to be set in an in-class, or online assignment workshops (as this was the case in the present project), and is longer lasting in effect compared to subliminal visual priming (Cave, 1997). Moreover, *Supraliminal* visual priming (happening above consciousness detection threshold), as opposed to *subliminal* visual priming (happening below consciousness detection threshold), has a more pronounced contact with the parieto-frontal area of the brain (Kouider, Dehaene, Jobert, & Le Bihan, 2007). Rizzolattin & Sinigaglia (2010) state that there are “several mechanisms” to understand the behaviour of others, however, “the parieto-frontal mechanism is the only one that allows an individual to understand the action of others ‘from the inside’ and gives the observer a first-person grasp of the motor goals and intentions of other individuals”. This explanation appears to be quite (literally) resonating with empathy and its understandings addressed earlier by Coplan (2011) – empathy being addressed along the lines of “(A) Feeling what someone else feels; (B) Caring about someone else; (C) Being emotionally affected by someone else’s emotions and experiences, though not necessarily experiencing the same emotions; (D) Imagining oneself in another’s situation;(E) Imagining being another in that other’s situation; (F) Making inferences about another’s mental states; (G) Some combination of the processes described in (A)-(F)” (Coplan, 2011, p. 2).

Details on the mechanism of use of Priming as tool to promote empathy in the context of human-centred designing is discussed further in the Methodology.

### 2.5.2 Reviewing how others conducted priming interventions in contexts of engineering or sustainability in general.

This section is to review how others in the field have conducted priming interventions in the contexts of engineering or sustainability in general. For this being a relatively broad notion, Google Scholar was used as the database from which the literature review for this section was extracted – Google Scholar was used here for the efficiency of collecting as much relevant data and publishes as possible, across multiple (or all) relevant databases at once. To narrow the search, keywords and publication date restrictions have been applied. The keywords were “"sustainability" & "Social" & "INTERVENTION" & "priming" & "nudges" & "human-centred"”, and only the publications published between (and inclusive of) 2015 and 2023 were considered, to obtain more relevant and contemporary and research results. The webpage from which the obtained papers (discussed in **Table 96**) have been extracted is: "sustainability" & "Social" & "INTERVENTION" & "priming"... - Google Scholar [for online access of the document].

Fourteen publications were therefore reviewed (see **Table 96**), and have been remarked if found not relevant– relevant is when it provides methods or interventions of nudging or priming in contexts of characterising human-centred designing or sustainability (not necessarily just in engineering). This is to view how others may have used the different methods of priming to promote sustainable consideration and goals or human-centred designing practices in engineering or other disciplines. **Table 96** can be viewed in Appendix A, and a summary of the papers found most relevant to the present project and literature review section (that is, on reviewing how others have conducted nudging or priming interventions in contexts of human-centred designing and in pursuit of sustainability) can be viewed below. A more in-depth, detailed review of the following most relevant studies can be found in **Table 96**, in Appendix A.

Liu, et al. (2023) tested methods of nudging adolescent girls and young women in contexts of accessing preventive sexual and reproductive health (SRH) services, in sub-Saharan Africa. Nudging was used as an 'encouraging' manipulative tool, in an empathic intervention, to motivate the girls and women to pursue contraception and HIV self-test kits. The nudging intervention was set out as: adolescent girls and young women were set on a default membership gift of an HIV self-test kit (with an opt out option), as a method for encouraging HIV self-testing and consideration of contraceptives. Liu et al, then found positive outcomes of the nudging, as hypothesised. The authors then suggest that "integrating human-centered design and behavioral economics [i.e., nudging] was effective for developing an innovative and effective intervention that simultaneously met the different needs of economic actors in support of public health priorities".

Hunter, et al. (2021) explore the use of human-centred designing to create drug shops where young women could access contraceptives and HIV self-testing, in Tanzania; the authors also use nudges to enhance and encourage such a procedure. The nudging intervention was set out in the form of a gifting free HIV self-test kits (with the option to opt out) to girls and women, upon their signing up to a loyalty membership of the 'Malkia Klabu' (translates to 'Queen Club'). Such a club was designed to facilitate 'discreet request' for "free SRH products, including HIV self-test kits, by pointing at symbols on loyalty cards". They found that with the nudging strategy incorporated within the human-centred designing framework proposed, the authors conclude that "[their] HCD approach increases the likelihood that the intervention will address the specific needs and preferences of both drug shopkeepers and young women".

Kacha (2016) addresses how behavioural policy is normally driven by cost-efficiency and effectivity; therefore, tests to analyse how intervening with autonomy supportive framing and normative framing (both are forms of nudging) could influence motivation towards sustainable behaviours. The nudging was set in experiments that took place online, where participants were requested to respond to weekly assignments whilst undergoing two forms of nudging (separately). The assignments were set to "encouraged participants to engage in one of four sustainable behaviours (supporting local producers, saving electricity, supporting less fortunate individuals, and waste recycling, in the stated order)". Surveys were set to track participants' change in responses over time (i.e., before and after engaging with assignments). Assignments were composed of three parts regarding the assigned task:

(1) A title – (e.g. "Your challenge on the following week is: Saving electrical energy");

(2) A description; this was also where the the nudging took place; and

(3) Four examples of the endorsed sustainable behaviour (e.g. "Prefer using stairs instead of an elevator").

The two types of nudges tested were:

(i) Autonomy supportive framing – where the description of the task provided a justification for engaging in the sustainable behaviour, accredited participants' perception, and used a “non-controlling language”.

(ii) Normative framing – where the description consisted of ‘norms’ deduced from previous responses made by the participants. Such descriptions were informative of the statistics of the ‘norms’ deduced from earlier responses – for example, "8 of every 10 asked participants of this study try to save electricity and water on a regular basis. For the following seven days, limit your electricity consumption at your home, employment and other places that you regularly visit."

As a result of Kacha’s study, it was found that normative framing, in encouraging motivation towards sustainable behaviour, maybe hindering individuals’ “conscious valuing of a promoted behaviour” (i.e., their intrinsic drive behind the motive), and rather making them “pursue the promoted behaviour for adaptive reasons (going with the crowd yields social benefits)” – i.e., the latter hinting towards encouraging extrinsic drive to such motives and sustainable behaviours. The findings therefore suggest that “individuals who internally value sustainable behaviours more engage in these”; and, to a smaller extent, are happier in their life. The autonomy supportive framing, on the other hand, was found encouraging of the intrinsic drive (i.e., the “development of internal valuation of promoted sustainable behaviours”) for sustainable behaviour and motivation.

Grocott (2022) addresses nudging as a supportive form to continuous learning, and “learning from and adapting to a rapidly changing world”. The book offers practical design approaches to elevate reflective, critical and globalised problem-solving skills, inviting the designers to ‘revise the stories they tell themselves, unlearn old habits and embrace new practices’. The author therefore claims that this book is “an essential read for design and social innovation researchers, facilitators of community engagement and co-design workshops, design and arts educators and professional learning designers”. The author also questions “how the cognitive, constructed, relational, personal, experiential and imaginative nature of design might amplify our engagement in the unsettling of long-held meaning structures and the remaking of new constellations of knowing and being”. Grocott concludes by recommending adopting creative design thinking, nudge design and human-centred designing as frameworks for transformative learning to yield positive impact through design that align with sustainability agendas.

Harvey (2015) addresses the issue of irrational thinking and irrational thinkers’ (in)ability to make decision assisting steady financial savings or managing money; this study addresses such an issue in the context of economic sustainability, in particular. Harvey's thesis combined practices of behaviour science (i.e., nudging and priming) with human-centred designing strategies to create a device application (app) to trigger for a long-term economic sustainability. The nudging was conducted in the following format: using an app focussing on the automatic process of thinking, and due to the "always-with-you nature" of the apps on the mobile phone, the phone would therefore allow "behavioural self-helpers such as nudges, reminders, and personal incentive" to be more readily effective (p.29). An app, 'Digit' was suggested to be "building skills" that would "employ behavioural techniques that change 'mindsets' along the way". The nudging technique of Automation was addresses. Under "Automation: manage money well day-to-day and prepare for life ahead with automated saving", the app Digit then does the work (of saving money) for the user. The app's "algorithms calculate money available to save based on users account history, current balance and salary and upcoming bills", and then the app "proactively saves that money, by transferring an amount a user will not miss into a saving account". In discussing the successful research findings, Harvey remarks that "an automated process such as this [the nudge in the app] could mean students forget money is leaving the account and it takes them by surprise". The author then elaborates with that it is thus "important that the 'app' is communicative and open about what is happening to the users' money ahead of time. The theory at this point was to make communication via text message, not through app notifications as texts is more salient and also more personal and when dealing with money it is important the message gets through".

De Villiers (2017) addresses "how wellness-related personal informatics (PI) systems can be effectively designed to better promote lasting behaviour change and sustained wellbeing". With the current unsupportive health care that does not support and address "the complex challenges modern lifestyle diseases and behavioural disorders", a new model (the System Medicine Model) has emerged. The new system incorporates PI systems that acknowledges and triggers shifts towards pre-clinical, patient-centric, behavioural focus in healthcare. Moreover, it was argued that "PI systems can therefore incorporate a balance of persuasive and reflective strategies to cultivate a necessary balance of mindful attitudes which include elements of curiosity, present-centred awareness, attentiveness and recognition of patterns and correlations in a constantly changing internal and external environment" (p.50-51). This study therefore argues that efficient design and incorporation of PI can encourage behaviour change and sustain health outcomes strategies like "persuasive and mindful experience (UX)". This research provides a prototype design of a "PI system design that balances persuasive and mindful strategies and aims to promote lasting behaviour change and enduring states of wellbeing more effectively"; nudges were also tested as means for triggering behavioural change. "Strategies applied in design play an important role in ensuring that feedback is delivered in a style likely to promote meaningful, lasting change". Therefore, this research studies 2 categories of strategies opposing in style of promoting such a lifestyle change: persuasive and mindful. It was said that “both approaches are effective in encouraging change; however, each presents concerns and barriers”. Semi-structured interviews on the different ways in which the PI systems are experienced by users were qualitatively analysed. This was to feed the PI design process, and influence behaviour change tactics, to “support more lasting shifts and sustainable states of wellbeing”. Additionally, an online survey was distributed to establish a PI tracking method (i.e., via the user’s usage of personal tracking methods and apps), and allow for the persuasion (i.e., the nudge or priming) to take place; the survey was to “gain insight into effective persuasive and reflective UX design elements”. Results of this study revealed that the use of an influence of the PI tracking activity on wellbeing was promising. It was also shown that the wording of the survey content and the introduction of the face-to-face interviews, may have primed responders into responding according to a desirable outcome. The wordings and subsequent responded were discussed to may have also influenced the users’ views on tracking activity in the period between the survey and interviews. Overall, it was found that the persuasion specifically, the authoritarian and coercive nature of the persuasion) integrated in the PI system was shown to have a negative effect on the users: “the relationship is often strained and experienced as punitive and often unfair or inaccurate. This leads to low levels of trust and display of characteristics such as rebellion, cheating and undermining behaviours. Focus is on external validation through incentives such as physical rewards, competitive measures and numerical goals while little attention is paid to the connection with personal wellbeing and effects of resulting activities on wellness and how to improve. Self-reflection and intrinsic motivation is therefore seen to be low. As such, the system experience can be interpreted as dictatorial, policing and partial, adding volatility and complexity to the pursuit for sustained wellbeing” (p.72).

Afterwards, a few other discreet, miscellaneous papers were randomly found quasi-relevant to the present section of the literature review – relevant here is when publications mentioned the use of cues (images or other – also not necessarily referred to as primes or nudges) in contexts of engineering, human-centred designing, or sustainability characterising interventions. These publications have been reviewed and summarised. A more in-depth review and discussion of these papers can be viewed in **Table 97**, in Appendix A

As previously stated, **Table 97** displays a few other miscellaneous papers have been reviewed when found relevant to the present section of the literature review – relevant here is when publications mentioned the use of cues (images or other – also not necessarily referred to as primes or nudges) in contexts of engineering, human-centred designing, or sustainability characterising interventions. **Table 97** can be viewed in Appendix A, and a summary of the papers found most relevant to the present project and literature review section can be viewed below. A more in-depth, detailed review of the following most relevant studies can be found in **Table 97**, in Appendix A.

Hi, Shealy, & Milovanovic (2021)'s study involved designs produced by first- and senior year engineering students, where half of the designs were informed with sustainability-related concepts or 'dimensions' as forms of prompts. Students' designs and neurocognitive activation were then recorded. Hi, Shealy and Milovanovic found that first-year students generated significantly more solutions compared to the senior year students – without the additional sustainability requirements. First-year students were shown to have had higher activation in the cortical region of the brain, which is associated with cognitive flexibility, and divergent and convergent thinking; whilst senior year students were shown to have higher activation in the region mostly associated with uncertainty processing and self-reflection. When additional sustainability dimensions were requested, first-year students then produced fewer solutions, whereas senior students produced a similar number of solutions as before. This was thought to be associated with the senior students' "less cortical activation to generate a similar number of solutions"; and that this changing pattern of cortical activation determines how engineering students grasp and manage information during the design process. From these findings, the authors suggest that "this paper offers potential opportunities for interventions to help improve sustainable design outcomes. For example, future research could explore whether priming the recruitment of activation in the dlPFC [i.e., the dorsolateral prefrontal cortex] or through transcranial direct current stimulation (tDCS) to the dlPFC, can improve senior engineering students' ability to generate more novel design solutions". The authors then suggest that "future studies can begin to test the effectiveness of novel design methods and tools, for example, concept mapping or priming, to overcome fixation and enhance engineering students' ability to develop engineering design solutions". These findings are interesting as they address a notion that requires further research: analysis of cognitive responding to sustainability and sustainability-related designing.

She, Seepersad, Holtta-Otto, & MacDonald (2018) address two design methods that "actively prime designers to exhibit or accentuate certain skills during the conceptual design process". This study tests two forms of priming to "help designers generate design features that communicate sustainability to customers". The authors use the five human senses (i.e., sight, sound, touch, smell, and taste) in combination to the sustainability concepts for priming. 2 studies were tested in this chapter/paper – one with the use of implicit (i.e., low-immersion) priming, and the other using an explicit (i.e., high-immersion) form of the priming. The first was to test the feasibility of priming to influence the generation of more concepts and solve problems more efficiently, whilst the second was to induce sustainability semantics in the designer, and enhance the communication on products' sustainability with the user. Both priming activities (low-immersion and high-immersion) were hypothesized to "enhance designer performance in a later conceptual design task in terms of the number of concepts generated by the designer and the extent to which the concepts' features are beneficial in communicating a product's sustainability". Study 1 (implicit priming) involved the following methodology: “Designers were primed implicitly with the mindset of sensory perceptions and sustainability by answering two simple questions or finishing a collage activity” – this was the low-immersion priming activity. Subjects were primed via their responding to a questionnaire in which subjects were asked to give answers to describe: (1) “three examples of things that they have done to reduce their environmental impact” and (2) “the sponge or cloth they use at home [i.e., the focal design] to clean dishes using some or all of the five senses [i.e., sight, sound, touch, taste, and smell]”. Study 2 (explicit priming) was intended to “help designers generate more unique, user-centered concepts”. In the second study, subjects were primed by their working on a collage activity. This activity was designed to develop “sustainable product semantics” and establish “a set of design recommendations for sustainable designers with collage activities”. Subjects were requested to position images of sponges [i.e., the focal product] and sensory words on a “white background with two axes: one tracked preference, from “dislike” to “like”, and the other tracked environmental impact, from “high impact” to “low impact””. There were eight images in total to be arranged, and 28 sensory descriptors like “dim, smooth, soft, musty, disgusting” (etc.) to be matched with. This, the authors stated, would subsequently influence the design produced by the designers as “when subjects are working on a collage activity, not only specific cognitive orientations but also relevant cognitive procedures become activated. Effects on subsequent design tasks may then be driven by both the orientations and procedures”. Findings of study 1 showed results aiding designers in generate more ideas and concepts; however, it did not show “significant effect on the quantity of concepts generated in total”. The high-immersion prime (i.e., Study 2) was found to have led subjects to better “communication of sustainability through the design”. Subjects in Study 2 were found to “generate design concepts with higher levels of originality and more innovative features targeting product-user interactions, without loss in feasibility”. High-immersive priming was also found and were found to aid in generating more concepts in general, compared to the low-immersive priming. Building upon these findings, the authors conclude that both forms of priming are “promising techniques that can be used to enhance design skills”. Remarking on this study, it is interesting to observe that such a priming methodology influences the quality and not necessarily the quantity of creative ideas generated. This therefore calls for further research, to specifically address this in contexts of the ‘rapidly-changing’ world and the updated (more creativity-requiring) demands of engineers.

Sleeswijk Visser & Strappers (2007) examines the use of visual representations of a person’s face in designing processes, as “images of real people trigger designers to empathise with users”. The authors argue that the representation of the user is vital, however, the way in which the users are represented is tricky – and is therefore a “a design problem in itself”. They found that “images of the users have impact on the way designers interpret the result and are inspired by them”. Different studies exposed designers and designer students to images of the users in different formats, quantities and sizes. The images were placed on cards for designers to read when building user need information to inform the designs with. The authors find that, indeed, "images of users are a powerful means to represent results of user studies to design teams". One study showed that the combination of a photo and user's name was most informative to the designers, when presented with cards of the users . Additionally, when sketches of users as opposed to photos of fictional characters were exposed on cards to the designer, it was found that the fictive photos were more effective than sketches, indicating an empathic enhancement in the designers. Similarly, a combination of sketches and photos gave the designers a 'feeling of satisfaction' due to the "richness of the presented materials"; however, sketches alone were found unsatisfactory as they lack detail, and were less convincing, and therefore result in "a lesser emphasis on real people". Moreover, designers preferred additional information to accompany the images, and the combination of sketches and photos (i.e., 'abstract representations') helped designers to "quickly step into the shoes of the user". Lastly, the size of the visual representation played a role, as it was found that a size smaller than a 'letter size' would be most preferred by designers exposed to visual representations of the end-user; and so were the quantities of the images – it was found that showing designers multiple but smaller images were more preferred than presenting them with one but bigger image of the user(s). This is very relevant to the present literature review section and project, as they address (in their novel way) the influence of using pictures of end-users in the design process.

Earle, Nishimura, Smith, & Small (2021) examine the influence of emotional priming and meeting with cancer patients (i.e., those who are impacted by biomedical engineers' or engineering students' designs and research) on the enhancement and the receptivity of biomedical engineers' ethics and ethics education. This study hypothesises that "having a personal and emotional interaction with people impacted by research decision would impact interest in ethics or influence decision making toward more ethical or inclusive behaviours". Another strand of the study examines "whether the timing of the emotional intervention in relation to the ethical education would impact the student outcomes". Students' reflections on a time when students "may have acted unethically", and survey data on ethical tendencies and moral expansiveness were analysed in relation to the interventions. The study was carried out as follows: The control group attended a research ethics seminar then met with cancer patients (i.e., those influenced by the research or the design of biomedical engineers/engineering students), whilst the "treatment group" were "primed with the emotional experience [i.e., meeting and engaging with the cancer patients] then received the research ethics seminar". In Phase I, all students received "formalized instructions on research ethics in a didactic seminar", but the "treatment group" (i.e., the primed group) were set to meet the patients before the research ethics seminar. Students were given the choice to meet with the patients. In Phase II, all students were obliged to meet with the patients, but half of them were set to meet with the patients before the seminar (i.e., emotionally primed before the seminar), whilst the other half met with the patients after the seminar. Results showed that in phase I of the study (where students were given the choice to meet with the cancer patients), it was found the there were no "statistically significant changes in situational ethics response, moral disengagement, perspective taking, or moral expansiveness". Students' ethical leanings remained the same despite the interventions. The authors suggested that "it is possible that the brevity of these interventions was insufficient to lead to a significant change in response to the [bioethics] survey questions". Moreover, it was interesting to observe that "the group that self-selected to see the cancer patients scored statistically lower on the situational ethics and moral disengagement elements of the survey instrument". Primed students, however, were found to have engaged in "deeper reflective practices". In Phase II, it was found that the students who met with the patients before the seminar (i.e., the primed) compared to those who engaged with the patients after the seminar, showed "no change in the ability of our students to clearly describe and analyze an example of ethical/unethical behavior from their own lives". Overall, it was found that those primed with the engagement with the patients before the seminar were found "nearly twice as likely to mention the downstream consequences of their actions, an emotional response to the actions they took, or to take responsibility for their actions". These results, the authors suggest, imply that those who chose to engage with the patients (i.e., primed) possibly encouraged "deeper self-reflection and possible deeper integration of the ethics instruction". Although Earle, Nishimura, Smith, & Small's study does not involve pictorial priming, it was mentioned in the current literature review sections, as it is relevant in the intent of using priming for promoting empathic design thinking in engineering students.

Buffardi & Rahn (2020) review an adopted 'Tech Startup" intended to cultivate entrepreneurship and intrapreneurship in software engineering education. This was to encourage collaboration on novel software ideas (between engineering and entrepreneurship students), and leveraging of entrepreneurship students to provide feedback, and change requirements whilst learning *Lean Startup methods*, and understanding students' motivation for generating innovative, entrepreneurial ideas in software engineering. Buffardi & Rahn's study hypothesized (H1): "after priming students with a presentation on emergent technologies, software engineers would be more likely to propose entrepreneurial project ideas". Students were primed by exposing them to a ten-minute presentation on innovative technologies – specifically, VR (virtual reality), AR (augmented reality) and Iot (internet of things). The hypothesis was: "after priming students with a presentation on emergent technologies, software engineers would be more likely to propose entrepreneurial project ideas". After priming students with a presentation on emergent technologies, it was found that "only 3% of software engineering students took the initiative to propose their creative ideas among their peers and business students". However, when compared to entrepreneurship students, it was found that "software engineers' pitches increased more than sevenfold in semesters when the emergent technology intervention was applied" - therefore supporting the study's first hypothesis (H1). Additionally, it was found that "engineering students identified that a desire to learn a new programming language, framework, or technology was the most common motivation for project selection. Students also reported motivation from how interesting they find the problem and whether they would personally use it". Remarking on the study: the latter finding is interesting, as it highlights the agentic nature of motivation in engineering students and/or innovation. Similar to the study mentioned above, Buffardi & Rahn's study is worth mentioning as it involves the use of priming for innovation (and thus creativity) promotion in engineering.

Ritz, Bodnar, & Montalbo-Lomboy (2022) research the association between narrative-based interdisciplinary case study and engineering students' entrepreneurial mindset. Their proposed methodology was the following: exposing engineering students to "narratives that included testimony, biography, photos, and data related to the Holocaust in a story-like format", and engaging them with the narrative through "reflections, discussions, and other activities used to promote students' curiosity and critical thinking". Amongst this study's findings was that "the interdisciplinary narrative case study increased students' perception of their altruism, ideation skills, interdisciplinary skills, and recognizing disciplinary perspectives to the point of statistical significance". Exposure to such narrative therefore is concluded to enhance social consciousness and consideration in engineering education settings. Although this study does not explicitly prime engineering students, it does use imagery in a process to influence students' consciousness (i.e., extension of empathy (Thompson, 2001)) which makes it relevant to the present PhD project.

Tomblin & Mogul (2022) developed a new framework for students to encounter intellectual problems with emotions. This was done by conducting a so-called *techno-ableism* intervention. In this techno-ableism intervention, engineering students were instructed to wear bracelets for 24 hours to remind them to "imagine they are hosting a friend from high school that day, and the friend is using a knee scooter to get around because of a sports injury". This was essentially to trigger empathy towards that imaginary individual, and acknowledgement of how surrounding areas might be problematic for that person. Acknowledging that students and professors "need continual practice to embody any habit or skill", this method was argued to be the "most successful". As a result, the techno-ableism module, the authors discuss, "has helped reveal to [them] challenges around teaching students not simply how to have empathy, but to practice cultivating situations in which they will gain empathy". Arguing that "empathy itself is not the destination", the authors reiterate on them wanting students "to be able to design their own experiments to change perspective and cultivate empathy". Remarking, although this study does not explicitly prime students to express empathy, it does employ a mechanism that acts as inducers and 'reminders of empathy'; this therefore makes it loosely relevant to the present project, as the priming pictures are argued to also induce empathy and act as reminders of the students' social impact via design (and subsequent responsibility).

DiBiasio, et al. (2017) implement role-playing in an interdisciplinary design course choreographed by faculty from engineering and humanities departments. The course attempted to target and engage students' empathy when designing a waste management solution for residents in the 19th century. In characterizing empathy, this paper states that "by digging deeply into their roles and thinking of the course content through the persistent lens of their character role, students learn what it means to identify with another person, even a person at some considerable historical remove. But they must identify not only with their own roles; to do well in this game they must also learn to listen well". In the study, all student teams were informed on the case to be designed for, with the same information, photo, and brief scenario when considering a solution. Students were then instructed to "determine what they could about the conditions of this family [the family they are designing for] in order to recommend interventions that would improve their lives". Roleplaying was also part of this intervention, as this was a method for students to immerse themselves in the case study (or scenario) they are solving for. The intervention was purposely left open-ended to encourage students' creativity. It could also be deduced by the exposure of students to photos and information, this was also an attempt to induce a 'deeper understanding', which in essence relates to empathy. As a result of the role playing game, the findings revealed "a strong grounding in collaboration for all teams and individuals; strong evidence of empathy among some (but not all) teams and individuals; and varying degrees of learning that integrates the humanities and engineering". The findings indicated that the role playing game yielded an induction of empathy and interpersonal skills in (some) engineering students. Remarking, although this study does not explicitly specify the use of the photo as a prime, it does use imagery (and other documents) with the intention to induce empathy and deeper understanding. This makes it worthy of note in this project, as it loosely ties with the motivation or intention of using photos to induce empathy, and other characteristics that relate to human-centred designing or design thinking.

Gaver, Dunne, & Pacenti (1999) address the use of Cultural Probes in the process of context mapping (i.e., addressing the context to be designed for) as a method to work with the users – i.e., codesign with those to be influence by the design (which happen to be elderly people in diverse communities). Cultural probes, in this study, were information packages that included postcards, maps, camera, photo album and media diary, which were set up to be prepared by user-end, and used by the designers to inform their design. The probes were "designed to provoke inspirational responses from elderly people in diverse communities", and were to "pursue experimental design in a responsive way". The probes were to "address a common dilemma in developing projects for unfamiliar groups". The authors explain that "understanding the local cultures was necessary so that our designs wouldn't seem irrelevant or arrogant, but we didn't want the groups to constrain our designs unduly by focusing on needs or desires they already understood. We wanted to lead a discussion with the groups toward unexpected ideas, but we didn't want to dominate it". Probe boxes were given to volunteering members of the elder groups in a series of meetings, and were requested to be filled and returned later to the designers. The authors (designers) stated that "the probes were not designed to be analyzed, nor did we summarize what they revealed about the sites as an explicit stage in the process. Rather, the design proposals we produced reflected what we learned from the materials". The designers therefore emphasizes that although the probes were vital to their understandings of the sites, they "didn't directly lead to our [their] designs"; indicating that the designs were also informed with other information anecdotal data. The authors further elaborate that the probes were successful in informing and familiarizing the designers with the sites, allowing them to base their design in the "detailed textures of the local cultures". As a conclusion, the authors (designers) address that "the real strength of the method was that we had designed and produced the materials specifically for this project, for those people, and for their environments".

Remarking, although this methodology is different to the one in the present PhD project, this popular study was mentioned here as personal pictures (in the form probes) were used to inform the designs with; and although the probes were not explicitly addressed in the sense of inducing empathy in the designers (to further understand the contexts they are designing for), they can be argued to be used as such. This use of probes was also argued to be "a type of empathic design" by Steen (2011). See also Mattelmaki (2006) on the use of probes to induce empathy in designers and "enrich designs".

Moreover, the work of Sleeswijk Visser (2009) tests and addresses the use of probes as a method to prepare and help designers to gain 'rich' (i.e., multilayered, complex and emotionally informed) information on the users' needs (through personification, imagination, immersion, curiosity and connection, for example) – this clearly addresses the characterising of empathy in such a design process. In similar contexts, Mattelmaki (2006) shows that the way in which the probes have been designed (i.e., what documents have been requested from the volunteering users/to be returned to the designers), and have been communicated (requested from or addressed to the volunteering users) has the potential to boost sensitivity for the users, and eradicate possible biases that may inform the design. Therefore, it can be deduced that such a framework also characterizes empathy in such design frameworks. Such use of probes is supportive of codesigning and more socially considerate designing frameworks.

### 2.5.3 Contribution 1: A novel approach to characterising empathy and social consciousness, whilst bypassing resistance; via the exploitation of the psychological phenomena of Priming

Due to the demand and the call for more socially considerate and empathy-informed designing strategies in engineering, it implies that empathy and social consciousness should be increasingly promoted in engineering. An obstacle to that would be that empathy and other non-technical notions seem to be resisted and even rejected by engineers and engineering students. The gap for a mechanism to promote empathy without causing a 'backlash' therefore is highlighted. This project introduces the concept of exploiting the psychological phenomena of priming as a tool to '*Prime Civil Engineers into Human-Centred Designing'* (– see paper (Al Kakoun, Boy, Groves, & Xavier, 2021) on this), where empathy (and by extension, social consciousness (Thompson, 2001)) is promoted subconsciously in engineers, rather than consciously enforced. Through priming, this project also attempts to promote empathy whilst crucially bypassing the possible resistance that may arise to it.

The present project stands with the ongoing calls for characterising empathy and encouraging more human-centric initiatives, but simultaneously criticises how the efforts paid into researching and acknowledging the issue (on the presence of a 'resistance' to such non-technical, empathy-informed notions in engineering education), are not yet matched with research and acknowledgement of methodologies to overcome it; i.e., highlighting that research to acknowledge a way or methodology to promote such non-technical notions, whilst bypassing the resistance in engineering classrooms, are yet to be researched and addressed.

This project's first aim and objective is to yield results contributing to the gap of that latter spectrum of research, by testing a methodology of -promoting empathy (and social consciousness and consideration) in civil engineering students during a human-centred designing workshop, whilst simultaneously bypassing, and being conscious of, its possible rejection. By recognising that empathy cannot be forced (Stein, 1970), nor can the act of empathising be taught (Davis, 1990), it was therefore essential to research and examine a new methodology to promote empathy without forcing it, and whilst being conscious of the possible consequences of enforcing it – i.e., its resistance.

## 2.6 Sustainable (and thus by extension, Socially Considerate) Decision-making in Engineering – and the role of Subjectivity.

Recapping on the apparent subjectivity exercised in design decision-making, especially in the contexts related to sustainability in engineering, I attempt to tackle this problem by understand this subjectivity through identifying facets of the engineering mindsets known to influence decision making, and their links to social consideration and human-centred designing. I research two facets of the 'Engineering Mindset' (i.e., two facets of the drivers/influencers on human decision making made by engineers/engineering students) that contribute to that subjectivity: Personal Values and Perfectionism, and their link to social consideration in engineering design. The following few sections of the Literature Review will inform the reader on how Personal Values and Perfectionism influence decision making (and thus, problem solving), which will then lead to the present project's hypotheses made on their link to social consideration in engineering.

2.6.1 Contribution 2: Identifying engineering personal values and their links to empathy, social consideration, and human-centred designing.

### *2.6.1.1 What are Personal Values?*

According to Schwartz (2012, p. 3), values are what “we think of what is important to us in life” and that “each of us holds numerous values (e.g., achievement, security, benevolence) with varying degrees of importance”. Personal values are known to have significant influence on decision-making and behaviour (Schwartz S. , 1992; Schwartz S. , 1994; Schwartz S. , 1996; Schwartz S. , 2012; Schwartz, et al., 2012).

Schwartz’s value system (2012, p. 12), consists of 19 values which all people hold, but in varying rank or order according to personal relevance, importance and priority. This “tradeoff amongst the relevant values”, Schwartz states, within the value system of a person, is what classifies which dominant category (named Higher Order Value) of the human value system this person resides in, and therefore how this person’s motivation and decision-making processes are driven. This “tradoff” or categorising process can be achieved using the PVQ-RR 57 questionnaire (Schwartz S. , 2012; Schwartz, et al., 2012) which will be discussed further in the Methodology.

Based on the “tradeoff” of the 19 values (see **Table 1**), a person is then categorised into dominant Higher Order Values categories (Schwartz, et al., 2012). The Higher Order Values are listed in **Table** 2. Calculated PVQ-RR scoring (Schwartz S. , 2016) of the different 19 values of **Table 1**, map onto the four different Higher Order Values shown in **Table** 2. Visually, all values and Higher Order Values eventually map onto Schwartz et al.’s Circular motivational continuum (Schwartz, et al., 2012, p. 7), shown in **Figure 3.**

An intervention variation in this research project will examine the personal values of civil engineering students using this personal value system and instruments, as they can be argued and regarded as the most profound, popular, and updated means and instruments for personal value research.

*Table 1 - The 19 values of the Schwartz value system with their definitions in terms of motivational goal(s); extracted from (Schwartz, et al., 2012, p. 7)*

| Values | Conceptual definitions in terms of motivational goals |
|---|---|
| Self-direction – thought | Freedom to cultivate one's own ideas and abilities |
| Self-direction – action | Freedom to determine one's own actions |
| Stimulation | Excitement, novelty, and change |
| Hedonism | Pleasure and sensuous gratification |
| Achievement | Success according to social standards |
| Power – dominance | Power through exercising control over people |
| Power – resources | Power through control of material and social resources |
| Face | Security and power through maintaining one's public image and avoiding humiliation |
| Security – personal | Safety in one's immediate environment |
| Security – societal | Safety and stability in the wider society |
| Tradition | Maintaining and preserving cultural, family, or religious traditions |
| Conformity – rules | Compliance with rules, laws, and formal obligations |
| Conformity – interpersonal | Avoidance of upsetting or harming other people |
| Humility | Recognizing one's insignificance in the larger scheme of things |
| Benevolence – dependability | Being a reliable and trustworthy member of the ingroup |
| Benevolence – caring | Devotion to the welfare of ingroup members |
| Universalism – concern | Commitment to equality, justice, and protection for all people |
| Universalism – nature | Preservation of the natural environment |
| Universalism – tolerance | Acceptance and understanding of those who are different from oneself |

*Table 2 - Higher Order Values; extracted from (Schwartz, et al., 2012)*

| Higher Order Value: | Achieved by combining the means of the following Values: |
|---|---|
| Self -Transcendence | Universalism – nature, universalism – concern, universalism – tolerance, benevolence – care, and benevolence – dependability |
| Self – Enhancement | Achievement, power – dominance and power – resources |
| Openness to Change | Self-direction – thought, self-direction – action, stimulation and hedonism |
| Conservation | Security – personal, security – societal, tradition, conformity – rules, conformity – interpersonal. Humility and Face may also be included in Conservation. |

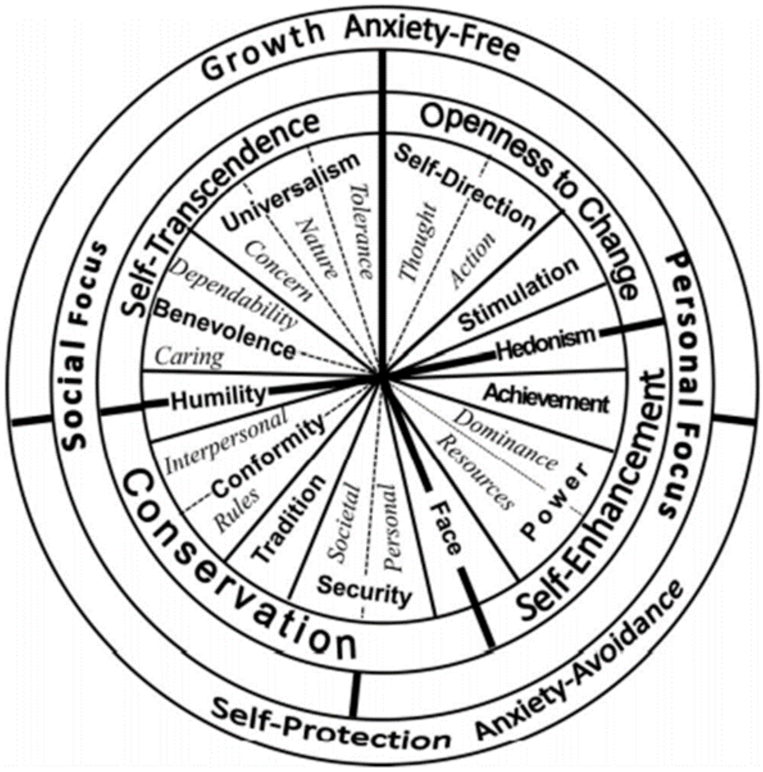


*Figure 3* **-** *Circular Motivational Continuum; extracted from (Schwartz, et al., 2012, p. 7)*

It is important to note that on Schwartz's value system, the Higher Order Values of Self Transcendence and Self Enhancement are generally adverse in nature, and are thus are mutually exclusive, irrespective of context (i.e., generally, at all times); hence, one cannot be categorised (or ranked highly) in both polarised categories simultaneously. Similarly, the Higher Order Values of Openness to Change and Conservation are adverse in nature and are thus are mutually exclusive; hence, one cannot be categorised (or ranked highly) in both polarised categories simultaneously, and so, as one increases in value, the other, by default, has to decrease (Schwartz, et al., 2012). This can also be easily visualised on the Circular Motivational Continuum (see **Figure 3**)**,** as the Higher Order Values of Self Enhancement and Self Transcendence are set across from each other, and so are the Higher Order Values of Conservation and Openness to Change.

Values are linked to various aspects of human life, for example beliefs, standards, and action. Schwartz summarises these aspects and their ties to personal values; these ties are listed in **Table 3.**

*Table 3 - Concepts of Values; extracted from (Schwartz S. , 2012, pp. 3-4) citing (Allport, 1961; Feather, 1995; Kluckhohn, 1951; Morris, 1956; Rokeach, 1973; Schwartz S. , 1992; Schwartz S. , 2006).*

| |
|---|
| (1) **Values are beliefs** linked inextricably to affect. When values are activated, they become infused with feeling. People for whom independence is an important value become aroused if their independence is threatened, despair when they are helpless to protect it, and are happy when they can enjoy it. |
| (2) **Values refer to desirable goals** that motivate action. People for whom social order, justice, and helpfulness are important values are motivated to pursue these goals. |
| (3) **Values transcend specific actions and situations**. Obedience and honesty values, for example, may be relevant in the workplace or school, in business or politics, with friends or strangers. This feature distinguishes values from norms and attitudes that usually refer to specific actions, objects, or situations. |
| (4) **Values serve as standards or criteria**. Values guide the selection or evaluation of actions, policies, people, and events. People decide what is good or bad, justified or illegitimate, worth doing or avoiding, based on possible consequences for their cherished values. But the impact of values in everyday decisions is rarely conscious. Values enter awareness when the actions or judgments one is considering have conflicting implications for different values one cherishes. |
| (5) **Values are ordered by importance** relative to one another. People's values form an ordered system of priorities that characterize them as individuals. Do they attribute more importance to achievement or justice, to novelty or tradition? This hierarchical feature also distinguishes values from norms and attitudes. |
| (6) **The relative importance of multiple values guides action**. Any attitude or behavior typically has implications for more than one value. For example, attending church might express and promote tradition and conformity values at the expense of hedonism and stimulation values. The tradeoff among relevant, competing values guides attitudes and behaviors (Schwartz S. , 1992; Schwartz S. , 1996). Values influence action when they are relevant in the context (hence likely to be activated) and important to the actor. |

In the present project, the Schwartz personal value system framework, and the Schwartz Personal Value Questionnaire (PVQ-RR 57) (Schwartz, et al., 2012; Schwartz S. , 2016), are to be utilised to collect data on personal values, and therefore, the questionnaire will be addressed further in the Methodology. This is because the PVQ-RR 57 is the most updated version of the PVQ-R questionnaire to date. Moreover, the Schwartz personal value system is utilised in the present project (as opposed to other personal value systems) was due to the following reasons:

Schwartz's circular model has been supported in large studies (i.e., of over 127 samples) in over 70 countries (Schwartz & Rubel, 2005) – i.e., showing high reliability of profound usage in research. Schwartz's system was found to show strong predictions of value-relevant reasoning (Bernard, Maio, & Olson, 2003a; 2003b) , and strong associations between value and behaviour (Bardi & Schwartz, 2003; Garling, 1999; Judge & Bretz, 1992). Moreover, Schwartz's system of values was developed to fill in the voids of the shortcomings found in other personal value systems – for example, it was designed to overcome the shortcomings of Allport et al.'s (1951) value system, which was found failing to identify how values change over time (Iscoe & Lucier, 1953), and Rokeach's (1973) value system, which did not show how different values (of said system) related to each other (see (Rokeach, 1973)). Finally, other than efforts to overcome the limitations identified in other (aforementioned) personal value systems, Schwartz worked to address a system consisting of multiple values (as opposed to single value systems – i.e., consisting of subsidiary/basic values, as well has higher order ones), across different cultures (as opposed to basing research off a single culture), and contextualised research of values with broader theory of human motivations, behaviour and relations (see (Schwartz S. , 1992; 1994; 1996; 1996b) and (Schwartz & Bardi, 2001; Schwartz, Sagiv, & Boehnke, 2000; Seligman, Olson, & Zanna, 1996)).

*2.6.1.2 Linking Personal Values to empathy, creativity, and human-centred designing.*

As now established, empathy and creativity are critical characteristics to be practiced in design thinking and human-centred designing. This section then highlights the links between personal values with empathy, creativity and those this project argued to be associatory (for example, consciousness, and prosocial behaviour).

Schwartz (2010) found predictive associations between the Higher Order Value of Self Transcendence and moral consideration in decision-making and self-pride; and associations between the Higher Order Value of Openness to Change and behaviours related to freedom, creativity, curiosity and pleasure. Sanderson & McQuilkin (2017) found positive associations between the Higher Order Value of Self Transcendence and prosocial behaviour – i.e., behaviours of "everyday kindness, political activism, pro-environmental behaviour and participation in organised groups that work in the interest of others"; they also found negative associations between such prosocial behaviours and the Higher Order Value of Self Enhancement, and particularly, its subsidiary basic value of Power.  Meanwhile, Benish-Weisman et al. (2019) found positive associations between prosocial behaviour the Higher Order Values of Self Transcendence and Conservation, and negative ones between prosocial behaviour and the Higher Order Value of Self Enhancement in children;  they also found an interesting association between the Higher Order Value of Openness to Change and prosocial behaviour – when these were seen negatively associated at a younger age (i.e., young children), but such association switched to a positive one as they grew older. Heilman & Kusev

(2020) found that only the Higher Order Value of Self Transcendence associated positively with prosocial behaviour.

Agreeingly, Bayram (2016) argued that prosocial behaviour can be traced back and predicted by basic human values, and found that Self Transcendence and Openness to Change values are reliable predictors of support for "foreign development assistance". This is relevant to the present context, as it touches upon prosocial-behaviour in relevance to working on real-life, human-centred designing initiatives intended for development. Franco et al. (2017) also found that subsidiary basic values of the Higher Order Values of Self Transcendence and Openness to Change, were positively associated with valuing and practicing corporate social responsibility (CSR), in a cohort of business undergraduates; with women being more inclined to do so, and increasing in inclination with time.

On the other hand, Campbell and Wilson (2011) (agreeing with Lucena et al.'s (2007) concept of humanitarian engineering as "an important dimension of engineering practice that deserves clearer ethical articulation and curriculum development") discuss how humanitarian engineering is accentuated by particularly exercising engineering ethics and "care" (- which could be denoted as empathy or feeling with others) whilst developing a model under the name "Humanitarian Engineering as a Matrix of Care and Ethics" (p. 5). Building upon this, personal values and notions on ethical practice and judgement, and 'care', shall be addressed in the following paragraphs.

On the link between Personal Values and ethical practice and judgment, Finegan (1994) found that peoples' rank for the instrumental value of honesty was the best predictor of judgement (about the morality of a behaviour), whilst the terminal value of ambition was the best predictor of behavioural intentions, in the workplace. The Rokeach Value Survey (Rokeach, 1973) was used to determine personal values in this study.

Fritzsche & Oz (2007) investigated "personal values' influence on the ethical dimension of decision making". They examined personal values relation to five types of ethical dilemmas – namely, *Bribery*, *Coercion*, *Deception*, *Theft*, and *Unfair Discrimination*. They found "a significant positive contribution of altruistic values to ethical decision making and a significant negative contribution of self-enhancement values to ethical decision making". Values in this study were those of Stern, Dietz, & Guagnano (1998) adaptation of the Schwartz's Personal Value System (Schwartz S. , 1994). Altruistic Values in this study meant "a world at peace; free of war and conflict; social justice; correcting injustice; care for the weak; equality; equal opportunity for all"; whilst Self -Enhancement ("or Egoistic") Values meant "authority; the right to lead or command; influential; having an impact on people and events; wealth; material possession; money".

As for linking the aspect of "care" (denoted by Campbell & Wilson (2011)) and empathy in humanitarian designing, a study by Oriol et al. (2020) found a "strong relationship between self-transcendent aspirations, gratitude, and cognitive and affective empathy". This study employed the

Aspiration Index (Kasser & Ryan, 1996) to assess intrinsic ("personal growth, close relationships, community involvement, and physical healthy") as opposed to the extrinsic ("popularity, financial success, ad image") aspirations of their participants.

Oriol, et al. (2020), basing their literature off Grouzet et al.'s (2005) concept of "self transcendent goals are intrinsic aspirations that are considered prosocial, and they imply connecting with others and going beyond selfish concerns", found "a strong relationship between self-transcendent aspirations, gratitude, and cognitive and affective empathy". These results therefore supported Kasser and Ryans' (1996) statement of "self-transcendent aspirations as community involvement focus people's interest not only on themselves, but also on others".

Mashlah (2015) discussed and illustrated the sequential links between personal values and other aspects like attitudes, behaviour, characteristics, decision-making, perceptions, motivation, morals/ethics and spirituality. Mashlah's illustration demonstrates that personal values are fed by peoples' beliefs, principals, faith and quality; and are key contributors to the consequential outputs of choices, priorities, judgements, preferences and relations people make (see **Figure 4**).

**The Role of people's Personal Values Model**

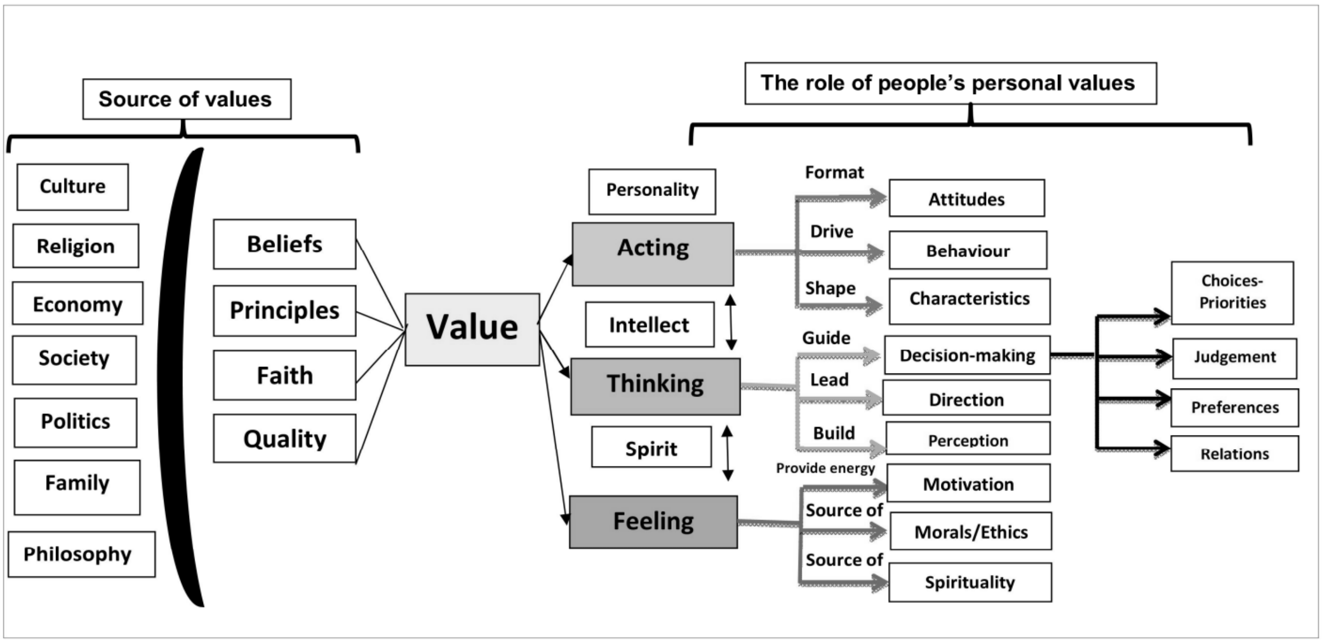


*Figure 4 - Mashlah's Schema of Value Influence. Source: Figure designed by Mashlah (2015) based on the literature and data collected by Mashlah (2015); figure directly extracted from (Mashlah, 2015, p. 162)*

On the link of personal values to consciousness, Ahmad et al. (2020) found that the Higher Order Value of Self Transcendence, when intersected with high environmental consciousness, displayed more pro-environmental attitudes whereas when values of Self Transcendence were intersected with low levels of environmental awareness, people displayed less pro-environmental (or pro-social) attitudes. These findings supported the notions presented by Ajzen & Fishbein (1980). These findings are interesting as they hint towards the role of the intent towards practicing prosocial and/or pro-environmental attitudes and behaviours. Similarly, Liobikienė & Juknys (2016) found that "stronger self-transcendence value orientation, which are guided by normative goals, are more perceptive of environmental problems and are more inclined to assume responsibility and behave in a more environmentally-friendly way" – in other words, those with dominant Self Transcendent values and intent to act in a pro-environmental manner, were more conscious of their surroundings, and were more inclined to take responsibility for it. Karp (2016) also found supporting findings, showing the positive associations between pro-environmental behaviour and both Higher Order Values of Openness to Change and Self Transcendence, and the inverse with the Higher Order Values of Self Enhancement and Conservation. Prosocial behaviour can be argued to be inclusive of pro-environmental behaviour (see Sanderson & McQuilkin (2017)).

As for creativity, it was generally found negatively associated with the Higher Order Value of Conservation or its subsidiary basic values (Arsenijević, Bulatović, & Bulatović, 2012; Dollinger, Burke, & Gump, 2007; Kasof, Chen, Himsel, & Greenberger, 2007; Kurt & Yahyagil, 2015; Lebedeva, Schwartz, Van De Vijver, Plucker, & Bushina, 2019; Rice G. , 2006; Sousa & Coelho, 2011; Zhou, Shin, Brass, Choi, & Zhang, 2009), and with the Higher Order Value of Self Enhancement (Kurt & Yahyagil, 2015), and its basic value of Power (Dollinger, Burke, & Gump, 2007; Rice G. , 2006). Moreover, a negative association between Conservatism (or its subsidiary values) and both creativity and pro-environmental behaviour (independently) was reviewed by Sagiv & Schwartz (2022).

On the other hand, the basic values of self-direction and stimulation (i.e., subsidiary to the Higher Order Value of Openness to Change), as well as the basic value of universalism (subsidiary to Self Transcendence) were found positively associated with creativity (Dollinger, Burke, & Gump, 2007). Studies (Curşeu, Schruijer, & Fodor, 2022; Lebedeva, Schwartz, Van De Vijver, Plucker, & Bushina, 2019; Liu, Wang, & Zhu, 2020; Park, Song, Lim, & Kim, 2014) showed supportive, positive association between openness to change and creativity; and, Xu et al. (2021) showed a strong positive association between both openness to change and openness to experience (the personality trait (Costa & McCrae, 1985)), and creativity.

Moreover, Zhang (2002) studied the association of personality traits to thinking styles and found that the personality trait 'Neuroticism' was significantly positively associated with executive (i.e., being confronting) and conservative (i.e., using traditional ways to deal with tasks) thinking styles. Neuroticism is defined by its holders' tendency to over-worry, and experience negative emotions such as sadness and anxiety (Costa & McCrae, 1985), and was found to be positively associated with the Higher Order Value of Conservatism (Anýžová, 2017; Fischer & Boer, 2015). Meanwhile, the majority of engineering students were found scoring high on Neuroticism scales (Cárdenas Moren, et al., 2020), as there has been discourse criticising the inadequate teaching of creativity in engineering classrooms, where creativity is not being encouraged or praised (Atwood & Pretz, 2016).

Furthermore on thinking styles in engineering, Gridley (2006) found that concrete thinking styles (i.e., thinking styles that enable people to "to grasp and mentally register data through the direct use and application of the physical senses" (Gregorc, 1982)) were preferred by 98% of woman engineers. This hints towards the over-reliance on positivism for data input and problem solving in engineering. Later, Gridley (2011) compared the thinking styles of engineers to those of artists, and found that "artists preferred less external input in their work than engineers preferred, and engineers were more inclined to prioritize their thinking. Artists preferred devising their own plans significantly more than did engineers". This, in relation to social consideration and community engagement in engineering design process, emphasises why such socially considerate interventions are not abundantly practiced in engineering (see Introduction), thus, emphasising the reason for the call for more community-engagement and socially considerate input addressed earlier.

*2.6.1.3 Current Literature of Personal Values in engineering and in the general professional setting*

Munson and Posner (1979) discussed the importance of understanding engineering 'profiles' back in 1979. They evaluated and understood engineering personal values in the workplace, and further suggested that a better understanding of personal values is "critical to an organisation's effective performance" (p. 99), as they may hold an impact on organisational decisions, regarding: "job placement, promotion, formation of special groups, and in the design of employee motivation and incentive programs" (p. 94).

Using the Rokeach Value Survey (RVS) (Rokeach, 1973) to collect engineers' and managing engineers' instrumental and terminal values, Munson and Posner found that engineers and engineering managers have significant differences in personal values, and so do "below-average- success" and "above-average success" engineers. Munson and Posner (1979) categorised the engineers' perceived "above-average-success" and "below-average-success" using an 8-item Likert scale they developed; examples of such items include: "Compared to other people your age and who have the same job classifications, how successful do you feel you are?", "How do you feel your career is progressing compared to your peers?", and "Among your peers, how influential do you consider yourself?" (p. 95). Munson and Posner (1979) found the following:

• "In terms of instrumental values, engineering managers attach significantly less importance to the values "cheerful," "independent," and "loving" than do engineers" (p. 95);

• "Engineering managers attach significantly greater importance to the terminal value of "pleasure" than do engineers and less importance than engineers to "wisdom"" (p. 95);

• “The below-average-success engineers attach significantly greater importance than the above-average-success engineers to “a comfortable life,” “world at peace,” “true friendship,” “cheerful,” and “courageous.” – (Terminal values) (p. 95);

• “The above-average-success engineers attach significantly more importance to “a sense of accomplishment” and “responsibility” than the below-average-success group.” – (Instrumental values) (p. 95).

For context, instrumental values are those involving “preferable modes of conduct (e.g., ambition, being logical and cheerfulness)”, and terminal values are those to do with “desirable end states of existence (e.g., an existing life, family security, and social recognition)” (Munson & Posner, 1979, p. 95).

Another school of value systems include the Agency versus the Communion value system – otherwise known as the *fundamental dimensions* (Abele, Cuddy, Judd, & Yzerbyt, 2008; Judd, James-Hawkins, Yzerbyt, & Kashima, 2005), or the *Big Two* (Paulhus & Trapnell, 2008). This dichotomous framework of personal value (and subsequent motivation) was initially proposed by Bakan in 1966 and was designed to categories people into two sets of “human existence” (Bakan, 1966) – the Agentic (i.e., those who prefer “getting ahead” (Hogan, 1983)) versus the Communal (i.e., those who prefer “getting along” (Hogan, 1983)). On that note, Diekman et al. (2010) argued that “STEM careers are perceived as less likely than careers in other fields to fulfil communal goals (e.g., working with or helping other people)”. They then indeed found results showing that “STEM careers, relative to other careers, were perceived to impede communal goals” and that “communal-goal endorsement negatively predicted interest in STEM careers, even when controlling for past experience and self-efficacy in science and mathematics”.

Findings by Ramsey (2017) supported those of Diekman et al.’s (2010). Ramsey took on the case study of students and faculty members of a science department in a university, and found that “both faculty and students, regardless of gender, perceived agentic traits as more important for success in science than communal traits”, which indicate that such traits and motivators are thus likely to be encouraged in STEM fields.

To ‘tie’ value systems together, Trapnell and Paulhus (2012) conducted a study and found that agentic values are more corelated to the Higher Order Value of Self Enhancemnet of Schwartz’s Personal Value system, whilst communal values were found to be more correlated with the Higher Order Value of Self Transcendence. Similarly, the Higher Order Value of Conservation was found to also mostly correlate more with communal values; whilst the Higher Order Value of Openness to Change was slightly correlated to agentic values. These findings were obtained during Trapnell and Paulhus’s development of the ACV (Agency/Communion Value) Scale. Their exact findings were: “high loadings for achievement, power, hedonism, and stimulation: This factor clearly represents a superordinate agency dimension. The second rotated factor corresponds to a very broad communal dimension, combining vertical collectivist values such as conformity, tradition, and security, with horizontal collectivist values, such as universalism and benevolence. These results parallel the preceding findings for life goals by documenting superordinate A & C dimensions within the Schwartz value taxonomy" (Trapnell & Paulhus, 2012, p. 42). To better visualise these findings, the values of the Circular Motivational Continuum (see **Figure 3)** which were declared to be more communal in nature by Trapnell and Paulhus are shaded in grey, whilst those declared to be more agentic in nature are circled with black rings (see **Figure 5**).

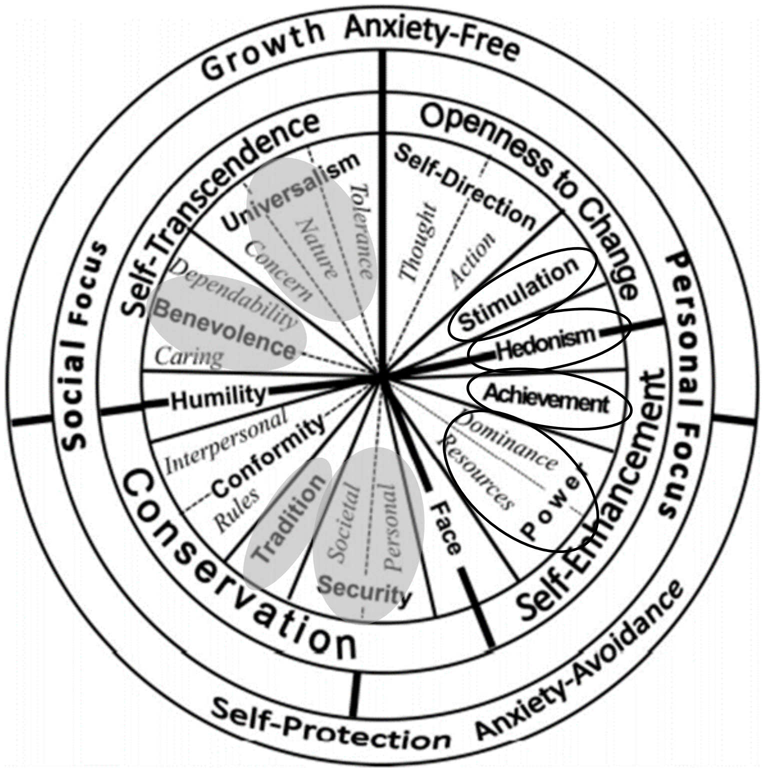


*Figure 5 - Circular Motivational Continuum; extracted from (Schwartz, et al., 2012, p. 7); Informed by Trapnell & Paulhus's (2012) Findings.*

Moreover, Mejia, Chen and Chapman (2020a; 2020b) took an approach to comprehend engineering students' personal values, in ASEE's 2020 conference proceedings. After evaluating students' discourse of what is considered "important to their [students'] vocation", they found and discussed the following:

- "Preliminary results indicate that engineering Discourses may influence the conceptualizations of status, power, and solidarity in relationship to their values and vocations" (Mejia, Chen, & Chapman, 2020a);
- "Top values selected by students included: family, health, purpose, friendship, adventure, and growth" (Mejia, Chen, & Chapman, 2020b);

- “Community and society were included or considered in the students’ actionable values in very few cases” (Mejia, Chen, & Chapman, 2020b); and
- “Engineering Discourses may contribute to the students’ tendency to simplify or narrow down social aspects of engineering activity” (Mejia, Chen, & Chapman, 2020b), arguing, “now, more than ever, as engineering educators we need to explore and analyze how students’ core values may clash with engineering Discourses” (Mejia, Chen, & Chapman, 2020b).

### 2.6.2 Contribution 3: Identifying engineering perfectionism and their links to empathy, social consideration, and human-centred designing.

The second facet of the Engineering Mindset I research to address and understand the subjectivity in engineering decision-making, is perfectionism. In the following study, I assess whether perfectionism in civil engineering students influences design decision-making and engagement with human-centred and public welfare considerate initiatives, and subsequent production of *Communal Designs.* The reason to exploring perfectionism as the second facet of the engineering mindset is the following:

This research argues that:

(i) Perfectionism – i.e., “the tendency to believe there is a perfect solution to every problem, that doing something perfectly (i.e., mistake-free) is not only possible, but also necessary, and that even minor mistakes will have serious consequences” (OCCWG, 1997)) and,

(ii) Positivism – i.e., the tendency to “take a realist position and assume that a single, objective reality exists independently of what individuals perceive”( (Hudson & Ozanne, 1988, p. 509) citing (Bagozzi, 1980; Burrell & Morgan, 1979; Morgan & Smiricich, 1980)),

highly resonate in definition and manner of problem-solving; they both pursue *the* single, unflawed, correct solution.

Given that engineering paradigms are predominantly positivistic in nature (Erden, 2003; Downey & Lucena, 2003b), this study, therefore, hypothesises that engineering students are more likely to be perfectionists, as opposed to non-perfectionists, and proceeds to test for it. This study also tests for the association of perfectionism to empathy, consciousness and prosocialness (i.e., characteristics that are known to be positively associated with human-centred designing ethos), and subsequent production of what I term *Communal Designs* (more on that in Methodology).

*2.6.2.1 What is Perfectionism?*

Perfectionism has been defined as "the tendency to believe there is a perfect solution to every problem, that doing something perfectly (i.e., mistake-free) is not only possible, but also necessary, and that even minor mistakes will have serious consequences" (OCCWG, 1997).

Perfectionists were described as those "constantly on the alert for what is wrong and seldom focuses on what is right. He looks so intently for defects or flaws that he lives his life as though he were an inspector at the end of a production line" (Hollender, 1965, p. 95), and who "set unrealistically high standards, rigidly adhere to them, interpret events in a distorted manner, and define themselves in terms of their ability to achieve their goals" (Burns, 1980). Hollender (1965, p. 94) also described a perfectionist as one who is "not likely to be a creative person who changes the world in which we live, he is likely to be a painstaking worker who performs services and turns out products we value".

Perfectionism is said to be *multidimensional* (Hewitt & Flett, 1991; Hewitt P. , Flett, Turnbull-Donovan, & Mikail, 1991), and with positive (*adaptive)* and negative (*maladaptive)* sides to it (Slaney & Ashby, 1996; Slaney, Rice, Mobley, Trippi, & Ashby, 2001).

Hewitt et al. (1991; 1991), the creators of the *Multidimensional Perfectionism Scale (MPS),* discuss perfectionism in terms of its *multidimensions*: *Self-Oriented Perfectionism, Other-Oriented Perfectionism,* and *Socially Prescribed Perfectionism.* They define these dimensions with regard to the motives and drivers for such consequential perfection. Thus, from such understandings, they are also indicative of whether the strive for perfection is intrinsic or extrinsic. Self-oriented perfectionism is defined by a person's high self-standards and high motivation to achieve perfection. Other-oriented perfectionism is defined by a person's expectations of others to perform in a perfectionistic manner, and socially prescribed perfectionism is defined by one's belief that others are imposing their perfectionistic standards upon them, expecting them to be perfect (Hewitt & Flett, 1991; Hewitt P. , Flett, Turnbull-Donovan, & Mikail, 1991).

Slaney et al.'s (2001) *The Almost Perfect Scale* (APS-R) differentiates the perfectionists from the non-perfectionists, and then identifies the nature of the responders' perfectionism – i.e., it then differentiates *maladaptive* perfectionists from the *adaptive* ones. Adaptive perfectionism is defined by a person's strive to be perfect and perform perfectly, accompanied by said person's belief that they can or are able to reach said perfection – it is known to be a rather 'healthy' form of perfectionism; whereas maladaptive perfectionism is defined by a person's strive for perfection and perform perfectly, however it is accompanied by said person's disbelief of reaching said perfection – this is known to be associated with a rather 'unhealthy' form of perfectionism (Bieling, Israeli, & Antony, 2004; Blankstein, Dunkley, & Wilson, 2008; DiBartolo, Li, & Frost, 2008; Enns & Cox, 2002; Rice & Ashby, 2007; Slaney, Rice, Mobley, Trippi, & Ashby, 2001). Rice, Richardson, & Ray (2015) describe adaptive and maladaptive perfectionism as “two sides of the same (high) standards coin”. Said differentiations are made using responders’ self-reported scores on the *Standard* and *Discrepancy* scales of the APS-R. According to the responders’ scores on the said scales, those who rankly highly on the *Standard* scale are said to be perfectionists, whereas those who do not rank highly on the *Standard* scale are considered non-perfectionists – perfectionists thereafter can be categorised into two groups (i.e., the *Adaptive* or the *Maladaptive* perfectionists) based on their *Discrepancy* scale scores. Those who rank highly on the *Standard* scale but low on the *Discrepancy* scale are considered to be adaptive perfectionists, whilst those who rank highly on both the *Standard* and *Discrepancy* scales are considered to be maladaptive perfectionists.

*2.6.2.2 Linking Perfectionism to empathy, creativity and human-centred designing.*

With regard to how perfectionism manifests in the social context (to regard traits indicative of prosocial behaviour, empathy and consciousness), it was found that perfectionists (both adaptive – i.e., the ‘healthy’form of perfectionism; and maladaptive – i.e., the ‘unhealthy' form perfectionism; see Section 2.6.2.1 for more information) showed higher social perspective taking scores (i.e., “the ability to judge a situation from the perspective of another person”) compared to non-perfectionists (Gilman, Rice, & Carboni, 2014); this indicated that perfectionists showed higher measures of empathy (as perspective taking is a form of empathy (Davis M. , 1983)) compared to non-perfectionists. Moreover, adaptive perfectionists, followed by maladaptive perfectionists and non-perfectionists, were also found to have higher positive interpersonal relationships (Gilman, Adams, & Nounopoulos, 2010); i.e., adaptive then maladaptive perfectionists showed better social skills than non-perfectionists. Gilman, Adams, & Nounopoulos (2010) further state that “peers rated both perfectionism groups as more prosocial and less disruptive than nonperfectionists”, and that “adaptive perfectionists were more liked than maladaptive perfectionists”.

On the other hand, Hewitt et al. (2006; 2017) address a positive association between perfectionism and interpersonal hostility, and social disconnection; although this was critiqued by Stoeber et al. (2017), when found that only other-oriented and socially prescribed perfectionism showed associations with signs of hostility and social disconnection, and that self-oriented perfectionism contrastingly showed associations with signs of social connection and low hostility (particularly regarding physical aggression and spitefulness). Moreover, higher levels of *aggression behavior* (i.e., “anger, hostility, physical aggression, and verbal aggression”) were found reported by adolescent maladaptive perfectionists, compared to non-perfectionists and adaptive perfectionists, respectively (Ruiz-Esteban, Méndez, Fernández-Sogorb, & Álvarez Teruel, 2021). Hostile and non-hostile behaviour here is referred to, to understand reflections of the social connection (i.e., by extension in concept, the demonstration of social consciousness, empathy and prosocial behaviour) in perfectionists as opposed to non-perfectionists.

In relating positivism and perfectionism to social consideration and human-centred designing, and the necessity of creativity in human-centred designing and design thinking frameworks (Brown, 2008; IDEO.ORG), the prevalence of perfectionism in engineering therefore proposes an obstacle. This obstacle, this project argues, is predicted to be the engineering undergraduates' interrupted engagement with human-centred designing frameworks, to solve wicked, sustainable, socially considerate problems – reasons to this are explained in the upcoming few paragraphs.

As previously mentioned, positivism is the dominant problem-solving paradigm in engineering education, due to its dominant reliance on scientific and mathematical learning (Downey & Lucena, 2003b; Erden, 2003), and is argued to be 'captivating' social consideration in engineers as it is carried forward into practice (Johnston, Lee, & McGregor, 1996). This is because positivism tends to reject metaphysical input (Ayer, 1936; Hume, 1748; Weinber, 1936), and thus by extension, empathy-informed ones, during phases of problem solving and decision-making. It is therefore clear how positivism may stand in the face of the empathy-informed human-centred designing.

Furthermore, creativity is said to be hindered by perfectionism (Goulet-Pelletier, Gaudreau, & Cousineau, 2021); although the association of creativity and perfectionism was said to be dependent upon the subcategory of perfectionism; as adaptive perfectionism was found to associate positively with creativity, whilst maladaptive perfectionism either associated negatively, or not at all, with creativity (Wigert, Reiter-Palmon, Kaufman, & Silvia, 2012). It is therefore clear how perfectionism too may stand in the face of design thinking and human-centred designing.

Moreover, in addressing the difficulty of incorporating design thinking in fields like engineering, Elsbach & Stigliani (2018, p. 2295) state that "cultures based on the values of productivity, perfectionism, and siloed specialisation are likely to impede the implementation of design thinking in an organisation" – reasons for this, however, are still yet to be addressed; hence the scope of the current study to address how (if) engineering mindsets and traits (particularly personal values and perfectionism) may be determinant of design solution decision-making and judgement in spaces of societal considerations, and human-centred designing engagement.

*2.6.2.3 Current Literature of Perfectionism in engineering and in the general professional setting*

Adaptive perfectionists were found to have better career decision-making self-efficacy compared to maladaptive perfectionists and non-perfectionists (Ganske & Ashby, 2011), and socially prescribed perfectionism (i.e., one's belief that others are imposing their perfectionistic standards upon them, expecting them to be perfect (Hewitt & Flett, 1991; Hewitt P. , Flett, Turnbull-Donovan, & Mikail, 1991)) was found to associate with inferior problem-solving orientation (Flett, Hewitt, Blankstein, Solnik, & Van Brunschot, 1996). Maladaptive perfectionism positively associated with cognitive test anxiety, and thus negatively with academic performances in university students (Eum & Rice, 2011);

whilst in STEM disciplines, “low-stressed adaptive perfectionists followed by moderately stressed maladaptive perfectionists” were found to have relatively higher GPA scores than their peers (Rice, Ray, Davis, DeBlaere, & Ashby, 2015).

On a side note, within the context of engineering education, Louis & Kumar (2016) found that there exists a “significant number of maladaptive perfectionists” in engineering, and that “they [maladaptive perfectionists] experienced higher levels of personal and societal demands leading to a negative emotional well-being in comparison to the adaptive perfectionists”. These results highlight the prevalence of maladaptive perfectionism amongst engineering students; reasons to the prevalence of perfectionism may be due to the students’ birth order (in their families), and/or due to their parental/social demands for perfectionism, according to Louis & Kumar (2016).

Reflections of poor mental wellbeing seem to be continuously emerging when addressed in relation to decision-making and perfectionism. This is interesting as it may call for future research of understanding the dynamics of decision-making and empathy and consciousness engagement in perfectionists, within contexts of the ambiguous, sustainable and socially considerate practices of engineering, especially if perfectionism was found to be abundantly prevalent (which what will be examined in this project) in engineering undergraduates.

## 2.7 Recap of Gaps Found

1) Methodology to promote empathy and social consciousness in civil engineers and civil engineering students, without forcing empathy and/or triggering backlash, is needed.
2) Understanding the subjectivity of sustainable, socially considerate decision making, via understanding facets of the engineering mindset:
    a. I research the Personal Values of an undergraduate cohort of Civil Engineers, and attempt to associate personal values with empathy- and creativity-informed human-centred designing engagement, and production of *Communal Designs* (more on Communal Design synopsis will be discussed later)
    b. I research the prevalence of Perfectionism in an undergraduate cohort of Civil Engineering students, and attempt to associate perfectionism with empathy- and creativity-informed human-centred designing engagement, and production of *Communal Designs* (more on Communal Design synopsis will be discussed later).

## 2.8 Recap of Present Project's Contributions

To my understanding, research conducted on personal values in engineering have been mostly addressed within engineering management context – for example, managerial style, and measures of success. Personal values, however, have not yet been addressed in terms of its association to social consideration and human-centred designing and engagement in civil engineering; further, they have not yet been addressed in the context of human-centred designing and social consideration in engineering education. I intend to yield results that reflect the personal values prevalent in engineering, and observe the associations of personal values with empathy, self- and social-consciousness of the engineers, and their production of what I later term *Communal Designs.*

Similarly, and to my knowledge, perfectionism in STEM and engineering have been addressed in relation to mental wellbeing and academic achievement of its members. Identifying the prevalence of perfectionism within the engineering atmosphere and how it associates with human-centred designing, is therefore yet to be examined and calls for further research; as discourse on the identification of the prevalence and association of perfectionism, particularly in engineering classrooms, within the context of sustainability and social consideration, is yet to grow. Via this project, I intend to yield results that reflect the prevalence of perfectionism in engineering, and observe the associations of perfectionism with empathy, prosocial behaviour, self- and social-consciousness in engineers, and their production of what I later term *Communal Designs.*

I will also be examining these findings and associations in relation to the Priming methodologies I shall execute to tackle the issue of characterising empathy and social consciousness in engineering classes, bypassing the possible resistance, as introduced earlier. More on this will be discussed in the Methodology.

## Chapter 3: Addressing the Research Question(s) and Aims and Deliverables Proposed:

Priming and Mining the Engineering Mindset:

1. Can we promote empathy and social consciousness in civil engineering undergraduates via priming, and,

2. Through understanding civil engineering undergraduates' mindset, can we understand how receptive and engaging civil engineers are with socially considerate initiatives?

Below are the specific hypotheses and research questions targeted for this project.

### 3.1 Intervention Variation 1 (V1): Exploring the feasibility of the Priming in a Civil Engineering Human-Centred Designing Task.

3.1.1 Intervention Variation 1 Proposed Hypotheses

*V1-H1. Based on the literature promising a positive induction of empathy in responders via the use of priming, it is hypothesised that primed civil engineering undergraduates are to show higher scores of empathy-correlated characteristics (i.e. consciousness) compared to those non-primed.*

*V1-H2. By extension to Variation1-Hypothesis1 (V1-H1), it is hypothesised that the primed groups are therefore more likely than the non-primed groups to produce more Communal Designs (which, in this research, are considered more metaphysically informed forms of human-centred designs).*

3.1.2 Intervention Variation 1 Proposed Research Questions

*V1-RQ1. What effect does engaging with the Human-Centred Designing Task have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) of the Primed (P3) and Non-Primed (P1) groups? (Before vs After engagement with HCD).*

*V1-RQ2. What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) before engaging with the Human-Centred Designing Task?*

*V1-RQ3. What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) after engaging with the Human-Centred Designing Task?*

*V1-RQ4. How does Communal Design production associate with the priming?*

### 3.2 Intervention Variation 2 (V2): Exploring prevalent Personal Values in civil engineering undergraduates, and personal values' associations with human-centred designing and Communal Design production.

#### 3.2.1 Intervention Variation 2 Proposed Hypotheses

*V2-H1. With existing literature indicating that members of the STEM community (and therefore, engineers and engineering students) are more likely to hold Agentic Values, as opposed to Communal ones, it is hypothesised that civil engineering undergraduates are most likely to hold dominant Self Enhancement and/or Openness to Change Higher Order Values as opposed to Self-Transcendence and/or Conservation values.*

*V2-H2. Based on the literature associating positively the Self-Transcending and Openness to Change Values to prosocial, altruistic, empathic traits, with Self Transcendence being the most aligned to Communal Value traits and outcomes, it is hypothesised that those with dominant Higher Order Values rooted in the communal Self Transcendence (as opposed to the agentic Openness to Change) are the most likely to engage (empathically and consciously) with the proposed Human-Centred Designing assignment (i), and subsequently, produce more Communal Designs (ii).*

*V2-H3. By extension to Variation2-Hypothesis2 (V2-H2), it is therefore hypothesised that those with dominant Higher Order Values rooted in the communal Self Transcendence to be most likely to positively engage with (or respond to) the priming (compared to those with dominant values rooted in the agentic Openness to Change).*

### 3.2.2 Intervention Variation 2 Proposed Research Questions

*V2-RQ1. What is the most common proclaimed Higher Order Value amongst civil engineering students?*

*V2-RQ2. How do the Higher Order Values associate with Communal Design Production?*

*V2-RQ3. How do the Higher Order Values associate with other characteristics (like communal/agentic values (thus intentions), empathy, and consciousness) that are known to be positively associated with human-centred designing engagement and Communal Design production?*

*V2-RQ4. How does Communal Design production and Higher Order Value associate with Social Desirability scores – thus, with intrinsic and/or extrinsic motives of the students for the design?*

*V2-RQ5. What is the effect of the Priming on the engagement with the Human-Centred Designing assignment (i.e., empathy, consciousness) and Communal Design production, in light of Higher Order Values?*

*V2-RQ6. Reiterating on V2-RQ2 and V2-RQ3 for self-cross-check – Intervention Variation 2.*

*V2-RQ7. What are the differences in characteristics of those who produced Communal Designs as opposed to those who did not produce Communal Designs? – Intervention Variation 2.*

*V2-RQ8. How (if) does the intention-behaviour gap manifests in light of the Civil Engineering Undergraduates' Personal Values?*

*V2-RQ9. Finally, can an equation be developed (via computing a Logistic Regression) to predict students' likelihood of Communal Design production given students' personal values and other characteristics' scores?*

### 3.3 Intervention Variation 3 (V3): Exploring the prevalence of Perfectionism in civil engineering undergraduates, and perfectionism's associations with human-centred designing and Communal Design production.

#### 3.3.1 Intervention Variation 3 Proposed Hypotheses

*V3-H1. Based on the notions addressed in the literature review, linking the positivistic manner of problem solving to that of perfectionism, it is therefore hypothesised that civil engineering undergraduates are more likely to be Perfectionists, as opposed to Non-Perfectionists.*

*V3-H2. Due to the existing literature on positivism rejecting metaphysical input (i.e., empathy-informed ones) to problem solving methodologies, and perfectionists being less likely to be display creative attributes in nature, it is therefore hypothesised that Perfectionists are less likely than Non-Perfectionists to 'fully' engage with Design Thinking approaches and thus with the human-centred designing assignment (i), and subsequently, are less likely to produce Communal Designs (ii).*

*V3-H3. By extension to Variation3-Hypothesis2 (V3-H2), it is therefore hypothesised that Perfectionists to be less likely than Non-Perfectionists to positively engage with (or respond to) the priming.*

### 3.3.2 Intervention Variation 3 Proposed Research Questions

*V3-RQ1. How common is perfectionism amongst civil engineering students?*

*V3-RQ2. How does perfectionism associate with Communal Design Production?*

*V3-RQ3. How does perfectionism associate with other characteristics (like prosocial behaviour and intention, empathy, and consciousness) that are known to be positively associated with human-centred designing engagement and Communal Design production?*

*V3-RQ4. How does Communal Design production and perfectionism associate with Social Desirability scores – thus, with intrinsic and/or extrinsic motives of the students for the design?*

*V3-RQ5. What is the effect of the Priming on the engagement with the Human-Centred Designing assignment (i.e., empathy, consciousness, and prosocial behaviour) and Communal Design production, in light of perfectionism?*

*V3-RQ6. Reiterating on V3-RQ2 and V3-RQ3 for self-cross-check – Intervention Variation 3.*

*V3-RQ7. What are the differences in characteristics of those who produced Communal Designs as opposed to those who did not produce Communal Designs? – Intervention Variation 3.*

*V3-RQ8. How (if) does the intention-behaviour gap manifests in light of the Civil Engineering Undergraduates' Perfectionism?*

*V3-RQ9. Finally, can an equation be developed (via computing a Logistic Regression) to predict students' likelihood of Communal Design production given students' perfectionism and other characteristics' scores?*

## Chapter 4: Methodology

### 4.1 The Concept of Shatila and Hamra Intervention, the Use of Max-Neef's *Matrix of Human Needs and Satisfiers,* and the *Priming.*

Campbell & Wilson (2011, p. 4) proposed that:

"When one has: 1) a specific location or people in mind; 2) involved those people in the design and decision-making process; and 3) together reached a consensus on solutions that are in the people's best interest; one is much closer to the economic, environmental, global and societal issues and one can better understand their importance".

Aligning with the above framework, and given that the civil engineering students could not have made contact with the people they are to design for (for health and safety reasons), this project proposes the following take on a human-centred designing assignment workshop:

A workshop was set for an undergraduate cohort of civil engineers to work on a human-centred designing assignment. The assignment involved a case study of two neighbouring districts in Beirut, Lebanon – Hamra and Shatila. Hamra is a prosperous area of Beirut with adequate infrastructure and planning and is considered a 'cultural hub', and Shatila is a refugee camp that was initially designed for 3000 people but is now accommodating 40000 (Sharif, 2018). The workshop ranged in duration and method of delivery according to the different intervention variations; more on intervention variations will be discussed in the next few sections.

Ultimately, students were expected to deliver a conceptual design that accommodates for the needs of Shatila's residents. Given that the engineering student could not have met with the Shatila residents in person (for health and safety purposes – especially during times of COVID-19), they were given other forms of informatic basis to work with; those of which, this project argues, would aid them in their identifications of the needs and problems to be dealt with and designed for later on.

Although Hamra and Shatila are geographically adjacent, they are distinctly different in terms of structural mapping, integrity and planning. These differences were made visible as their consequences were reflected in the statistical quality-of-life reports provided (i.e., numerical data on the healthy versus the ill, the educated versus the uneducated, the employed versus the unemployed, for example) of the residents of either district. The quality-of-life reports were intended to provide an indication (in the form of numerical data) reflecting the wellbeing and life satisfaction of the residents of either district.

The engineering students were given plans, maps, residential listings and forms of occupation (i.e., domestic or business), along with quality-of-life reports of both districts. The intention was for the maps, plans, information on structural integrity, and building form of occupation (domestic or business) of either district – which are all the resulting works of engineers and designers – to show how engineers may have influenced (either helped or inhibited) some of the residents' needs from being met, and therefore affecting their quality-of-life, which was then reflected in their quality-of-life statistical reports.

The students were also given a *Matrix of Human Needs and Satisfiers* (Max-Neef, Elizalde, & Hopenhayn, 1991), to ensure that all students have a common and objective baseline of the human needs that generally need to be met for people (particularly those designed for) to live a satisfactory life. This was to objectively generalise and eliminate, as much as possible, the students' biases and impositions of their personal norms, on the idea of what a 'satisfactory living standard' ought to look like – as these standards differ across geography, cultures, backgrounds and upbringings. The *Matrix* therefore conveniently acts as framework that informs the engineering students with an objective baseline of all human-needs to work with, consequentially aiding them with identifying the needs lacking in real-life scenarios (such as the case proposed here), and bypassing possible subjective bias on what a 'normal standard of living' ought to be.

Further, another reason for the use of the *Matrix* is to escape the pre-set order of needs to be met; this project argues that via the usage of the *Matrix of Human Needs and Satisfiers* in human-centred designing, as opposed to *Maslow's Hierarchy of Needs* (Maslow, 1943) (as seen in Zhang & Dong's (2009) study of a human-centred design), would nudge the engineering students into considering and regarding all human needs (both physical and metaphysical) in a more lateral and inclusive manner, as opposed to the pre-prioritised, hierarchal, and less liberally inclusive manner seen in *Maslow's Hierarchy of Needs*.

Moreover, via using the *Matrix of Human Needs and Satisfiers*, this project challenges the expectation of civil engineering students being more considerate of psychological needs (i.e., air, water, food, shelter, sleep etc. (Maslow, 1943)); this is argued to be due to civil engineering undergraduates' natural gravitation towards focusing on constructing varied structures and infrastructure (thus, due to the nature of the profession) that would essentially serving the basic needs, Moreover, using the *Matrix of Human Needs and Satisfiers*, as opposed to the *Maslow's Hierarchy of Needs*, students are argued to be set, by default, in a position to be equally considerate of the so-called 'higher-end' needs (i.e., safety needs, love and belonging, esteem and self-actualisation; i.e., the more metaphysical, psychological, social needs (Maslow, 1943)), just as well as physiological needs, marking that metaphysical human needs are just as important as basic physical needs when considering human-centred design in engineering settings. Exposing students to this notion would then prompt them to actively design for both physiological and psychological needs equally, and not rely on the expectation of metaphysical needs' satisfactions to later manifest with time as result of addressing and actively designing for the physical needs exclusively.

On another note, the usage of Max-Neef's *Matrix*, as opposed to Maslow's *Hierarchy of Needs,* would also allow the researchers and evaluators of the designs produced by the engineering students, to understand how the students' individualities, characteristics, values, and priorities may have been translated and reflected in the designs they produce, and how/what values and needs are prioritised or disregarded, in the students' designs.

4.1.1 Recap on the Hamra/Shatila Human-Centred Designing Workshop Objectives and Outline:

Prior to working on the human-centred designing task, a class discussion was held – discussing the topics of social impact, social awareness and social responsibility in the civil engineering paradigm.

Students discussed how, and to what extent, they think civil engineers and engineering designs impact society and peoples' quality-of-life (for example health, happiness, and satisfaction), and what their responsibilities are towards bettering them. They were also encouraged to think about and analyse their privileged encounters with such civil engineering designs, and imagine how different their lives would have been, had they not been exposed to such designs and solutions. This is a necessary stage of triggering the initial stage of empathy (relating to those who have not been exposed to such engineering solutions, and understanding how such encounters (or the lack thereof) affect their lives and needs), setting the goal and platform for the empathy priming to initiate its influence.

It is also important to note that the students were also first presented with the concept of 'designing for the people' then (during the intervention(s)). They were introduced to the notions of social impact, and properly defining human needs (by properly understanding, with the use of empathy) to therefore effectively and successfully design solutions for the purpose of bettering peoples' quality of lives.

Following the discussion, students were instructed to commence working on the human-centred designing task. The human-centred designing task was composed of two segments, Part A and Part B.

During Part A of the assignment, the engineering students were instructed to compare the two districts' plans, maps, and information, to distinguish how human needs have already been met and addressed in either district, and identify how that has been reflected in the quality-of-life reports. Part A was done to prepare the students for Part B of the assignment, which was to define the needs not being met in Shatila, essentially guiding the student into identifying the issues present in Shatila, those of which to be resolved by them as civil engineers, and then proceed to propose a conceptual design to do so. No detailed design was required in this assignment, as the idea was to observe what notions, needs, and importance(s) engineering students give value to, when designing and solving for the enhancement of quality-of-life.

During Part B of the assignment task, the students were encouraged to include as many of the human needs (from the Matrix of Basic Human Needs and Satisfiers) that the people of Shatila ought to have currently missing. The students were also encouraged to look for the 'root' of the problems and solve for the 'root' instead of providing 'plaster' or temporary solutions for Shatila's current situation. 'Creative solutions' were also encouraged by prompting students to try to solve multiple issues per solution or design. They were continuously encouraged to 'put themselves in the shoes' of those living in Shatila that they are designing for, in attempt to help them understand what the 'true' problems are and what they, as people, would need, to therefore produce more effective (and empathic) human-centred designs.

Following the delivery of Parts A and B of the task, students were requested to fill in different questionnaires to finish off the workshop.

Note that both Parts A and B of the assignment, and questionnaires that followed, are referred to as 'Phase II' in intervention variations 2 and 3 (see **Figure 8** and **Figure 9**, respectively)– more on the different variations to be addressed in the following few sections.

Note that filling in the questionnaires (either before or after working on design solution) was voluntary in all intervention variations.

## 4.2 The Proposed Concept of *Communal Designs*

Communal Designs are considered a specific form of human-centred, human-need based design, characterised by the particular attention to needs that involve and encourage end-users' communal engagement and interaction, sense of 'togetherness', and social identity. They are, therefore, the result and manifestation of the empathy, social consciousness, prosocialness, and communal values proclaimed to be present (via questionnaires responses) in the engineering students. Communal Designs are therefore human-centred designs that revolve around both physiological and metaphysical needs of those designed for.

In this project, the characterisation process of Communal Designs is simple: two independent judges blindly qualitatively analyse the designs provided by the students, declaring them to be Communal Designs if they were inclusive of needs related to those specified in **Table 4**, or declared 'Not Communal Designs', if they do not include the criteria addressed in **Table 4**.If a design considered and addressed peoples' needs but did not address the interaction needs in **Table 4**, it will be discounted as a Communal Design. Communal Designs are thus inclusive of both metaphysical human needs as well as physical ones (e.g., shelter and sanitation), and are distinguished by the intention explicitly expressed in the design for people to meet and interact and obtain a social identity as a result of the solution or design provided. Communal Design declarations of the two blinded independent judges were cross-checked for verification.

**Table 4** is composed of extracts from Max-Neef et al.'s *Matrix of Human Needs and Satisfiers* (1991, pp. 32-33), of needs that are strictly communal and interaction-oriented. Via the inclusion of the specified interaction-oriented needs, it is thereby indicated that the students value communion, and prioritise the metaphysical as well as the physical needs to elevate the quality-of-life of those designed for. Communal Designs are therefore interpreted to be the manifestation of the students' communal orientation and value, in the designs they produce.

The concept of Communal Designs aligns with the calls proposed by the Institute of Civil Engineers (ICE Community blog, 2021) and the UK Government (HM Government; Department for Digital, Culture, Media and Sport, 2018, pp. 36-45) for implementing strategies to 'design out loneliness' and achieve 'a connected society', respectively.

*Table 4 - Criteria for Communal Design; extracted from (Max-Neef, Elizalde, & Hopenhayn, 1991, pp. 32-33).*

| Needs according to axiological categories: | Needs according to the existential category: "Interacting" |
|---|---|
| "Protection" | Box 8: "Living Spaces, social environment, dwelling". |
| "Participation" | Box 20: "Setting of participative interaction, parties, associations, churches, communities, neighbourhoods, family". |
| "Idleness" | Box 24: "Privacy, intimacy, spaces of closeness, free time, surroundings, landscapes". |

Social desirability, i.e., "the need of Ss [subjects] to obtain approval by responding in a culturally appropriate and acceptable manner" (Crowne & Marlowe, 1960, p. 353), will also be tested in civil engineering students during the interventions. This is to observe the students' intrinsic as opposed to extrinsic, or the *truthfulness* of the motives for the responses and designs produced.

4.3 This project's exploitation of the psychological phenomena of Priming, in a civil engineering human-centred designing workshop.

Civil engineering undergraduates were primed by exposing them to visual primes of those they are instructed to design for, during their work on the human-centred designing assignment. The primes were composed of pictures of Shatila residents carrying day-today activities. The pictures were chosen to induce empathy in the students, as they were pictures clearly presenting the less fortunate living standards of the Shatila residents – they were of children playing in unfit places like dumpsters, people walking down narrow streets with electrical cables dangling above their heads, and waste bags lying on either side, for example. They were meant to show the unsafe, unhealthy status of living, and to thus induce empathy (cognitively – in further understanding their mode of living and needs, and affectively – in further aiding the compassionate designing) in the students exposed to them. Those primes were thus argued to act as facilitators of imagination and visualisation for the students, to better picture and more ‘deeply’ understand the situations and problems they are designing to solve, especially when they were casually verbally encouraged, repeatedly, to ‘put themselves in the shoes of the people they are designing for’, during the assignment workshops.

Primes used in this project were all visual (as opposed to any other form of sensory priming). The primes were supraliminal (i.e., were not flashing, and were above threshold of detection; as opposed to subliminal) pictorial cues, used to intentionally trigger certain schemas and internal responses ( specifically, empathy and ‘understanding’) in the students, when exposed to them during their work on their human-centred designing assignment. The primes, however, were intentionally positioned on the sides (of the walls or screen – see different variations below) for them not to be a primary focus of the students, i.e., they were placed on the sides for the students unconsciously detects, but not necessarily intentionally cognise or make a focal address of them.

Supraliminal pictorial primes were the chosen form of priming, as this was the most convenient and inexpensive form of sensory priming to be set in an in-class/online intervention (see variations below), and is shown to be longer lasting in effect, comparative to subliminal visual priming (Cave, 1997).

Note that the primed students were not made aware of the primes, nor were they made aware of which priming cohort they were assigned to. This was done to allow for the feasibility of the priming influence to occur, as making the primed aware of the priming inhibits the influence of the priming (Bargh & Chartrand, 2000). Discourse on the ethics of carrying priming interventions (i.e., not debriefing the primed students on the priming stimulus and/or their cohort assignment) is outside the scope of the present project, as the priming here was used and as a tool (with methods and regulations to follow) to promote empathy in an engineering classroom, with the intention of doing so whilst bypassing the predicted resistance from the students. The priming interventions were approved by the College Ethics Committee before taking place.

## 4.4 Addressing the different Intervention Variations

The Hamra/Shatila human-centred designing workshop was varied to test different hypotheses and specific research questions – i.e., the first was to test the feasibility of the priming, the second was to examine the engineering undergraduates’ personal values and their associations with human-centred designing and communal design production, and similarly, the third was to examine the engineering undergraduates' perfectionism and its associations with human-centred designing and communal design production. The latter two intervention variations were also examined in light of the priming.

Corresponding to the different specific research questions of each of the intervention variables, the instruments used (questionnaires) were different, and so was the method of priming – as the latter two intervention variations were held during times of COVID-19, during which, the assignments and workshops were forced to be held online, as opposed to in-class (which was the case in the first intervention variable only).

The scope of the human-centred designing assignment objectives (i.e., delivery of Parts A and B – see above), the information distributed (i.e., the Hamra/Shatila maps, information brief, the quality-of-life reports of those living in Shatila and in Hamra), the class presentation and scope of discussions held, remained the same across the three intervention variables.

Before and after the delivery of solutions for Parts A and B of the assignment, students were requested to fill in different questionnaires, according to the different study objectives of each intervention variation. Note that filling in questionnaires was voluntary in all cases, as well as delivering solutions for Parts A and B of the assignment in intervention variation 1 (only). Note that in all intervention variations, the primed cohorts worked on the assignment as well as responded to (some) questionnaires under the influence of the priming; more on when the influence of priming initiated within each intervention variable will be explained (and illustrated) in the next few sections.

With regards to the priming, note that the students were not made aware of the primes (on the walls or screens), nor were they made aware of which priming cohort they were assigned to. This was done to allow for the feasibility of the priming influence to occur, as making the primed aware of the priming inhibits the influence of the priming (Bargh & Chartrand, 2000). Moreover, had any of the students questioned the presence of the pictures (on the walls or in their documents), the intention was to respond with "for aesthetic purposes", but there were no questions regarding the presence of the pictures in any of the intervention variations.

In all intervention variations, the designs were collected and qualitatively analysed to be declared as Communal Designs or 'Not Communal Designs', according to their inclusivity of the criteria specified in **Table 4** – see *The Proposed Concept of Communal Designs* section above for more information on the declaration of Communal Designs.

4.4.1 Intervention Variation 1 (May 2019) – Exploring the feasibility of the Priming in a Civil Engineering Human-Centred Designing Task.

*4.4.1.1 Brief Overview of Variation*

Intervention workshop lasted for four continuous hours, in-person, in a lecture hall that is 22mx10m wide.

Students were pre-set in 20 groups of 5 or 6 (by the module coordinator, based on similar GPA scores – which was outside of this project's control). The student groups of 5 or 6 were sat on oval-like shaped tables, spread across the hall; see **Figure 6.**

Lecture presentation and class discussions were held in person. Questionnaire responses and designs were collected in hardcopy form at the end of the intervention workshop.

Questionnaire(s) responses were digitalised (converted to excel spreadsheets) by myself, using the codes provided with the questionnaires' technical manuals. Questionnaire response data was also analysed according to the technical manuals. The designs submitted were a result of the group work (of students sat on the same table), whilst survey data was individual.

The primed cohort and the control (non-primed) cohort were sat in the same lecture hall, and were taking part in the same discussions, and receiving identical information regarding the assignment at all times.

The primed students groups (i.e., P3 group; see **Figure 6**) were sat on one end of the hall, with the priming pictures placed on their surrounding walls, relatively at eye-level whilst seated; whilst the non-primed student groups (i.e., P1; see **Figure 6**) were sat on the opposite end of the hall – i.e., across the other end of the 22-meter wide hall (see **Figure 6**), as this cohort could not have been placed in a separate room due to schedule and room availability restrictions (see Limitations). Designs and questionnaires' responses from the student groups that were sat in the middle (i.e., P2 – those in between the primed and the non-primed groups; see **Figure 6**) were disregarded, given that they may or may not have been affected by the primes on the walls.

Note that in this intervention variation, as the primes were set on walls surrounding the primed cohort, the influence of the priming can then be deduced to have been effectively affective from the very beginning of the workshop – i.e., the influence of the priming may have had an affect on the primed cohort during their phases of working on the human-centred designing assignment (providing solutions and designs), and during their responding to the SSA instruments both before and after providing the solutions and designs (see **Figure 7**); this was not the case in intervention variations 2 and 3, were, due to the different aims and objectives of those variations, the influence of priming was effectively affective during the primed cohort's work on the human-centred designing task, and during their responding to the questionnaires that followed, i.e. during Phase II, only; see **Figure 8** and **Figure 9,** respectively. More information on this will be addressed in the next sections regarding the intervention variation overviews.

Moreover, note that the students were not made aware of the primes on the walls, nor were they made aware of which priming cohort they were assigned to. This was done to allow for the feasibility of the priming influence to occur, as making the primed aware of the priming inhibits the influence of the priming (Bargh & Chartrand, 2000). Additionally, had any of the students questioned the presence of the pictures on the walls, the intention was to respond with "for aesthetic purposes", but there were no questions regarding the presence of the pictures.

The designs were collected and qualitatively analysed to be declared as Communal Designs or not Communal Designs, according to their inclusivity of the criteria specified in **Table 4** – see *The Proposed Concept of Communal Designs* section above for more information on the declaration of Communal Designs.

#### *4.4.1.2 Form of Priming*

The primed cohort (P3) was primed with A5 (148 × 210 millimetres) pictures of the residents of Shatila – as it was found visual representations' most preferred sizes was a size smaller than that a letter size (Sleeswijk Visser & Strappers, 2007). The pictures were hung at the students' eyelevel whilst seated, on their surrounding walls (see **Figure 6**). The pictures were of Shatila residents carrying day-to-day activities, clearly presenting their disadvantaged standards of living. They were pictures of children playing in unfit places like dumpsters, and people walking down a street with waste lying on either side, and improper electrical cables instalment, dangling just above their heads. They were meant to show the unsafe, unhealthy status of living, and to thus induce empathy (cognitively – in further understanding their mode of living and needs, and affectively – in further aiding the compassionate designing) in the students exposed to them.

The non-primed group (P1) acted as the control group (as they were seated reasonably far away from the priming pictures – see **Figure 6**), and data collected from the middle group (P2) will be disregarded in the analyses, as students in the middle group (P2) may or may not have been influenced by the priming (See **Figure 6**).

Had any of the students questioned the presence of the pictures, the intention was to respond with "for aesthetic purposes", and that the reason they were not scattered across the whole lecture hall, would simply be "due to shortage of time" – but there were no questions regarding the presence of the pictures.

The students primed were not briefed or informed of the priming, for the feasibility and technicalities of such experiments, as for priming experiment to work, primes have to remain undetected (Bargh & Chartrand, 2000).

All students (of the primed (P3), non-primed (P1), and middle (P2) cohorts) were requested to fill in a Self-awareness and Social-awareness Assessment (Joslyn & Hynes, 2016)), directly before and directly after, their provision of a solution and a design for the people of Shatila (i.e., providing solutions for Parts A and B of the human-centred designing task); see **Figure 7**. Note that the primed cohort worked on the assignment and filled in the questionnaires (before and after working on Parts A and B of the assignment) under the influence of the priming.

*4.4.1.3 Participants*

This case study involved third year civil engineering students at Swansea University, Wales.

127 third year civil engineering students were involved in this study (16.5% of them were female, and 43.3% were international students).

*4.4.1.4 Procedure*

The students were pre-set (prior to this intervention) in groups of 5 or 6, based on their academic averages – groups of High, Medium, and Low academic averages. These groups were evenly spread across a 22m x 10m lecture hall, making sure that each ‘zone’ (of the P1, P2, P3) of the hall had an identical number of High, Medium, and Low grade-point average groups; see **Figure 6**. The diversity of each student group was not controlled.

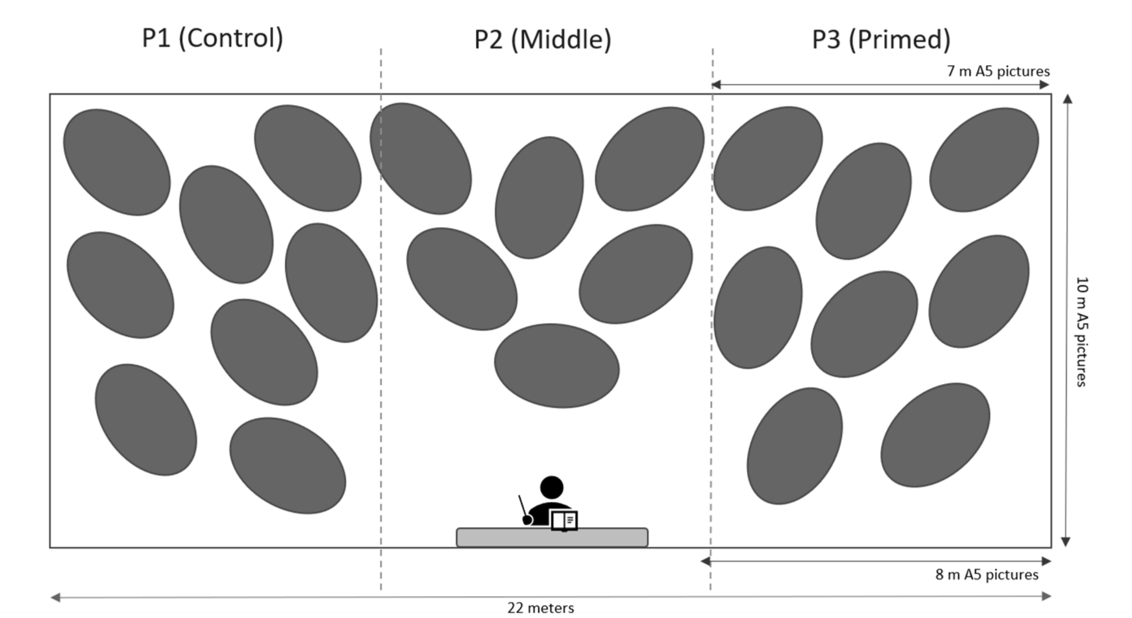


*Figure 6 - Room and Group Layout (Ovals Represent Student Group Tables)*

Prior to working on the human-centred designing task, a class discussion was held – discussing the topics of social impact, social awareness and social responsibility in the civil engineering paradigm.

Students discussed how, and to what extent, they think civil engineers and engineering designs impact society and peoples' quality-of-life (for example health, happiness, and satisfaction), and what their responsibilities are towards bettering them. They were also encouraged to think about and analyse their privileged encounters with such civil engineering designs, and imagine how different their lives would have been, had they not been exposed to such designs and solutions. This is a necessary stage of triggering the initial stage of empathy (relating to those who have not been exposed to such engineering solutions, and understanding how such encounters (or the lack thereof) affect their lives and needs), setting the goal and platform for the empathy priming to initiate its influence.

It is also important to note that the students were also first presented with the concept of 'designing for the people' then (during the intervention). They were introduced to the notions of social impact, and properly defining human needs (by properly understanding, with the use of empathy) to therefore effectively and successfully design solutions for the purpose of bettering peoples' quality of lives.

Just before their work on the human-centred designing task commenced, relevant information packs and documents were distributed to all student groups (of 5 or 6), all students (of P1, P2, and P3 groups) were requested to fill SSA Instrument (Joslyn & Hynes, 2016) questionnaires. This was to collect data on Self- and Social-Awareness and Consciousness of Students prior to their engagement with the Human-Centred Designing Task. The students were also requested the fill in an another (identical) SSA Instrument directly after their provision of a solution and a design (after their engagement with the human-centred designing task); see **Figure 7**. Self- and Social-Awareness/Consciousness have been shown to have associations with empathy (see Literature Review, and (Thompson, 2001)), which is a known requisite facet to human-centred designing.

The human-centred designing intervention workshop lasted for a total of 4 continuous hours (see **Figure 7**). Note that it was the same cohort of students that underwent all phases of the intervention, at different times – i.e., not different students undergoing the different phases of the procedure shown in **Figure 7**.

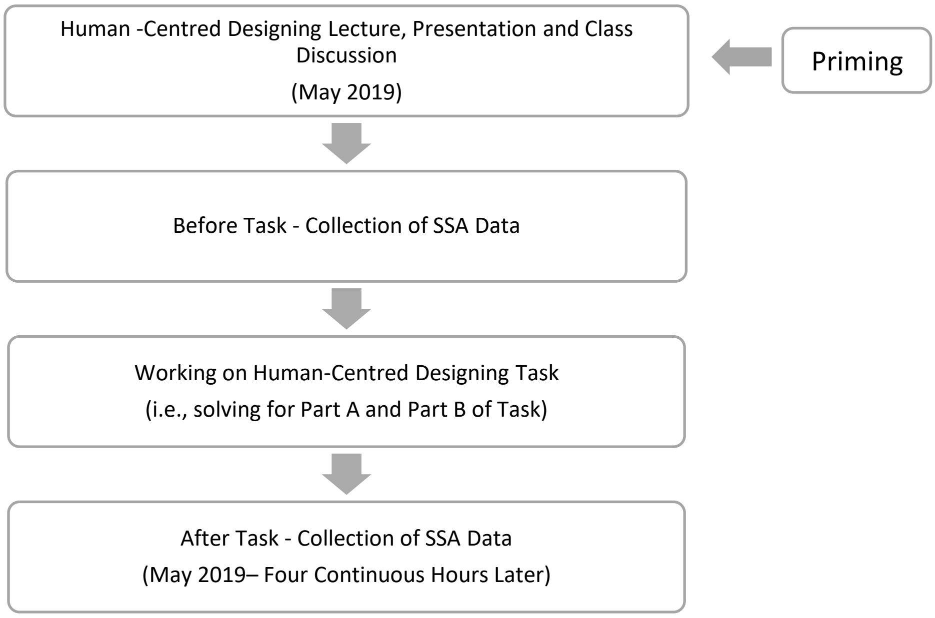


*Figure 7 - Intervention Variation 1 Procedure Layout*

*4.4.1.5 Instruments Used*

1. <u>Self-awareness and Social-awareness Assessment– SSA Instrument</u>

The *Self-awareness and Social-awareness Assessment (SSA)* was designed by Joslyn & Hynes (Joslyn & Hynes, 2016) and is based on Scheier and Carver's (Scheier & Carver, 1985) *Revised Self-Consciousness Scale*, for measuring the *Self – Awareness Indicators*, and Cech's (Cech E. , 2014) *Measures of (Dis)Engagement*, for measuring the *Social – Awareness Indicators* of students, before and after engaging in a human-centred designing project (Joslyn & Hynes, 2016).

The SSA Instrument is composed of two parts – the first measures the *Self-Awareness Indicators,* and the second measures the *Social-Awareness Indicators.*

The first section is composed of 22 items, which measure three subscales of Self-awareness (Public Self Consciousness, Private Self Consciousness, and Social Anxiety). For each item, respondents are requested to rate how much the person described is like them. Responses ranged from 0 *(Not like me at all)* to 3 *(Very much like me)*. Examples of these items include: "I know the way my mind works when I work through a problem", "I'm constantly thinking about my reasons of doing things", and "I feel nervous when I speak in front of a group".

The second section, that measures *Social-Awareness Indicators* as means of public welfare beliefs and social consciousness, is composed of three subsegments:

The first subsegment is composed of three items, and asks the respondents to rate their personal importance of multiple public welfare beliefs. Students are asked to respond to the question: "What, in your opinion, makes a successful engineering career?" by rating "Professional and ethical responsibilities", "Understanding the consequences of technology", and "Understanding how people use machines" according to their considered importance.  Responses range from 1 (*Very Unimportant*) to 5 (*Very Important)*.

The other two subsegments, composed of three items each, address and rate the respondents' (personal, and their engineering program's) importance of other public welfare beliefs, which are grouped as *social consciousness*. Students are asked to respond to the question: "Please indicate the personal importance to you of:" by rating "Improving society", "Promoting racial understanding" and "Helping others in need" according to their personal importance. The other question asks students to "Please indicate the importance to your engineering program of:" by rating "Ethical and/or social issues", "Policy implications of engineering", and "Broad education in humanities and social sciences" according to their engineering program's importance.  Responses for this subsegment range 1 (*Very Unimportant)* to 4 (*Very Important*).

### 4.4.2 Intervention Variation 2 (May 2020) – Exploring prevalent Personal Values in civil engineering undergraduates, and personal values' associations with human-centred designing and Communal Design production.

#### *4.4.2.1 Brief Overview of Variation*

Due to the sudden COVID-19 implications on teaching, instead of holding the human-centred designing workshop in person (i.e., in the same set-up as that of intervention variation 1), this workshop had to be transferred to take place online, and in the form of a Canvas assignment that student could download the information pack from, and log in and out of, over the course of two weeks. All solutions, designs and instrument responses were individual this time; solutions, designs and questionnaire(s) responses were uploaded on Canvas (all in a single MS Word Document) before the deadline was due.

The lecture presentation and discussions were held once on Zoom; this was done before the assignment went live on Canvas, and before students could commence their work on their assignments or go through the information pack.  The information pack contained all the information brief, the maps, the quality-of-life reports and the Matrix of Human Needs and Satisfiers, as well as a word document containing the assignment task questions and the questionnaires to be answered and uploaded when done. Note that there were two assignments set up on Canvas – one for the control group (where the information pack, assignment tasks document and questionnaires had no priming pictures), and the other for the primed cohort (where the information pack, assignment task document and questionnaires contained priming pictures); each student could only access one form of the assignment pack and word documents, according to their priorly allocated priming cohort set up.

The class discussion (regarding topics of social impact, social-awareness and social responsibility) took place during an hour-long Zoom lecture, at the beginning of the two-week assignment duration (before the Canvas assignment went live). To compensate for the lack of supervision (as in intervention variation 1, supervision was continuous all throughout the 4-hour workshop), the students were also provided two one-hour consultation Zoom lectures, to address any difficulties or questions, over the period of two week. In the present variation, students also had the liberty to log in and out of the assignment over the course of two weeks, provided the word document (containing their individual solutions and designs, and questionnaire responses) was submitted/uploaded on Canvas before the deadline was due.

Questionnaire responses was digitalised (converted to excel spreadsheets, from the word document submitted) by myself, using the codes in the questionnaires' technical manuals. This data was also analysed according to the technical manuals.

Individual designs were submitted (in an MS Word document) in this variation, unlike the group work design submitted as a hardcopy in intervention variation 1.

Only half of the students were primed, the other half acted as the control group. Both the primed and control (non-primed) cohorts were given identical documents and lecture presentation and discussions, except that the primed cohort had the priming pictures (identical to those used in intervention variation 1) scattered around the task questions, questionnaire items, and in the information brief, set all in one word document. The non-primed cohort did not have any of the priming pictures in their word document or information pack. Both the primed and non-primed students engaged in the same Zoom lecture presentation and discussion prior to their commencement of work on the assignment, took part in the same discussions, and received identical information regarding the assignment at all times.

The primed and the control (non-primed) cohorts were split quasi-randomly, in attempt to maintain an equal home to international, and male to female student ratios, in both cohorts – i.e., for both the primed and non-primed group to have a relatively similar number of female and international students. This was done prior to setting-up the assignment on Canvas, as students were to be assigned to access only one of the two information packs and documents (according to the priming cohort allocations) on Canvas, after the assignment goes live.

The primes were only added to the word document encompassing the assignment brief, the task questions and the questionnaires that followed; they were scattered on the page (screen) around the task questions and questionnaires, and were therefore not added to the maps, quality-of-life reports, not the Matrix of Human Needs and Satisfiers. One, or a combination of priming pictures were observed on the screen at a time. The primes occupied a range of 2.17% to 5.44% of the visible screen area, at a time. To my knowledge, the percentage of primes to screen size in supraliminal priming interventions is not typically necessarily addressed, however this study addresses the specific percentages tested, arguing that such sizes were convincingly adequate enough to influence, yet small enough to not take a focal point of attention and cognition, in the present study. As for the positioning of the primes around the main object (i.e., the text and questions), it was in line with a popular study by Maljkovic & Nakayama (1996) showing that “position priming is largely object- or landmark-centred”.

Note that in this intervention variation, the priming influence was effectively affective during phase II of the workshop only (see **Figure 8**), i.e., during the students’ work on the human-centred design and solutions, along with responding to the instruments that followed only. The responses to the questionnaires in Phase I (i.e., those on PVQ-RR) were unaffected by the influence of the priming from both cohorts (i.e., the control and the (later) primed). Moreover, note that the students were not made aware of the primes on the screens, nor were they made aware of which priming cohort they were assigned to. This was done to allow for the feasibility of the priming influence to occur, as making the primed aware of the priming intent inhibits the influence of the priming (Bargh & Chartrand, 2000). Additionally, had any of the students questioned the presence of the pictures on the screens/documents, the intention was to respond with “for aesthetic purposes”, but there were no questions regarding the presence of the pictures.

The designs were collected and qualitatively analysed to be declared as Communal Designs or not Communal Designs, according to their inclusivity of the criteria specified in **Table 4** – see *The Proposed Concept of Communal Designs* section above for more information on the declaration of Communal Designs.

The questionnaires used in this intervention variation included the PVQ-RR (Schwartz’s personal values system; (Schwartz, et al., 2012)), SSA (Self- and Social-Awareness Assessment; (Joslyn & Hynes, 2016)), IRI (empathy; (Davis M. , 1983)), ACV (agency and communion personal value system; (Trapnell & Paulhus, 2012)), and The Marlowe-Crowne Scale – Reynolds’s Form C (Social Desirability; (Reynolds 1982)). These multiple questionnaires used in this intervention variatrion were set in accordance to the different and more thorough reasearch objective of this study, as oppposed to the single objective held in intervention variation 1 (where only the SSA was used then).

*4.4.2.2 Form of Priming*

Only half of the cohort were primed during the human-centred designing assignment, the other half acted as the control group. Note that none of the students were primed during the Personal Value (PVQ-RR) data collection – i.e., Phase I of the study; see **Figure 8**. The primed and the control (non-primed) cohorts were split quasi-randomly, in attempt to maintain an equal home to international, and male to female student ratios, in both cohorts – i.e. for both the primed and non-primed group to have a relatively similar number of female and international students during Phase II of the study; see **Figure 8**.

Directly after the students’ provision of a solution and design for the people of Shatila (i.e., Parts A and B of the assignment), all students were requested to provide responses to other questionnaires – namely, the SSA, IRI, ACV, and the Marlowe-Crowne Scale – Reynolds’s Form C (on Social Desirability). Those who were primed answered these sets of questionnaires whilst continuously being primed.

The assignment was set to take place on Canvas for a duration of two weeks, and students had the liberty to log in and out of the assignment, provided they upload the document including their designs, solutions and questionnaire responses before the deadline was due. The primed cohort were primed with pictures scattered around the text in the word document, in a way to prevent the pictures from taking a focal point of attention; this was to avoid students from cognising the primes, which would then threaten the feasibility of the priming influence to occur, and was in line with Maljkovic &

Nakayama (1996) study showing that “position priming is largely object- or landmark-centred”. The primes were scattered on the page (screen) around the task questions and questionnaires. One, or a combination of primes occupied a range of 2.17% to 5.44% of the visible screen area, at a time. The primes were only added to the word document encompassing the assignment brief, the task questions and the questionnaires that followed. Primes were therefore not added to the maps, quality-of-life reports, not the Matrix of Human Needs and Satisfiers.

Similar to the intervention variation 1, had any of the students questioned the presence of the pictures, the intention was to respond with “for aesthetic purposes”, but there were no questions regarding the presence of the pictures. The students primed were also not briefed or informed of the priming, for the feasibility of such experiments, as for priming experiment to work, primes have to remain undetected (Bargh & Chartrand, 2000).

*4.4.2.3 Participants*

This case study involved first year and third year civil engineering students at Swansea University, Wales.

108 first year civil engineering students were involved in this study (9.3% of them were female, 0.9% were non-binary, and 13.0% were international students).

31 third year civil engineering students were also involved in this study (29.0% of them were female, and 38.7% were international students).

*4.4.2.4 Procedure*

Prior to the human-centred designing task, all students were requested to fill PVQ-RR (Schwartz, et al., 2012) questionnaires to collect data on their Personal Values – this was Phase I of the study; see **Figure 8.** A month later, the human-centred designing assignments was set – this was Phase II of the study (see **Figure 8**). The assignment was set for two weeks, in which students had to individually work on the comparative analyses and solution design for the people of Shatila (i.e., Parts A and B of the assignment), and respond the questionnaires that followed – i.e., the SSA (Self- and Social-Awareness; (Joslyn & Hynes, 2016)), IRI (empathy; (Davis M. , 1983)), ACV (agency and communion personal value system; (Trapnell & Paulhus, 2012)), and The Marlowe-Crowne Scale – Reynolds’s Form C (Social Desirability; (Reynolds 1982)). Note that the priming only commenced in Phase II of the study (i.e., whilst working on the human-centred designing assignment and answering the subsequent questionnaires); see **Figure 8**. Further note that it was the same cohort of students that underwent all phases of the intervention, at different times (separated according to year group) – i.e., not different students undergoing the different phases of the procedure shown in **Figure 8**.

Moreover, although it was intended for both the first- and third-year students to undergo an identical experiment (for both Phase I and II), Phase II of the workshop was halted for the third-year students, due to COVID-19 implications on their module.

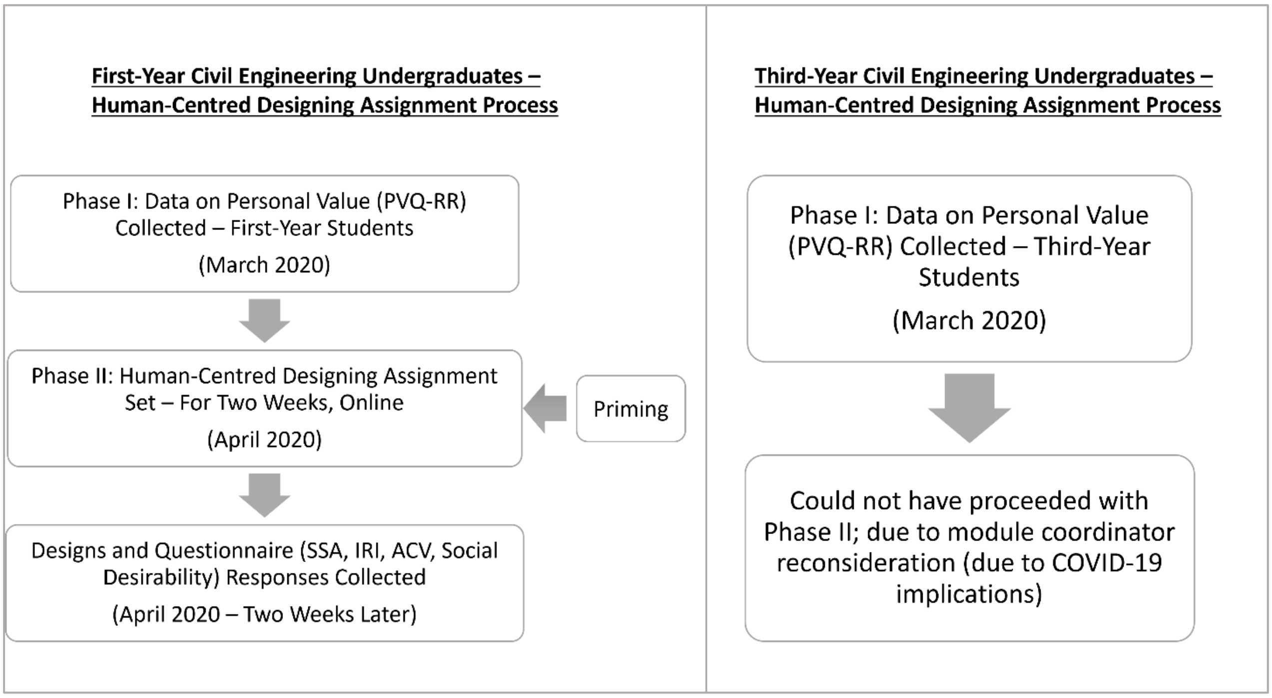


*Figure 8 - Intervention Variation 2 Procedure Layout*

*4.4.2.5* Instruments Used

1. <u>Personal Value Systems – PVQ-RR</u>

The ‘Refined’ Revised Personal Value Questionnaire (PVQ-RR) is the latest and most updated (to this date) questionnaire by Schwartz et al. (2012), designed to detect responders’ dominant personal value systems – which are argued and known to be influencers and drivers of decision-making and behaviour.

The PVQ-RR consists of 57 items that measure the ‘tradeoff’ between 19 values, which are present in every individual, but in different priority. These values have been mentioned earlier (see Literature Review and (Schwartz, et al., 2012; Schwartz S. , 2012).

Each item on the questionnaire describes a person with particular interests, importance(s), and values, and responders are requested to rate how much the person described is like them – note that the PVQ-RR proposes identical item questions, but with different gender-matched pronouns, for males and females separately. Responses range from 1 (*Not like me at all*) to 6 (*Very much like me*), for each item.

Examples of the items include: “It is important to him to plan his activities independently” and “It is to her to be very successful”.

2. Self-awareness and Social-awareness Assessment– SSA Instrument

This instrument has already been described in detail, in section 4.4.1.5.

3. The Interpersonal Reactivity Index (IRI)

The IRI scale, designed by Davis (1983) measures four different facets of empathy – namely, *Empathic Concern* (‘other-oriented’ empathy), *Personal Distress* (‘self-oriented’ empathy), *Perspective Taking*, and *Fantasy*. Definitions for each of these subscales are directly quoted from (Davis M. , 1983):

- Perspective Taking – the tendency to spontaneously adopt the psychological point of view of others;
- Fantasy – taps respondents' tendencies to transpose themselves imaginatively into the feelings and actions of fictitious characters in books, movies, and plays;
- Empathic Concern – assesses "other-oriented" feelings of sympathy and concern for unfortunate others;
- Personal Distress – measures "self-oriented" feelings of personal anxiety and unease in tense interpersonal settings;

The IRI scale consists of 28 items, that eventually map onto the four subscales of empathy mentioned above. Each item response ranges from *Does not describe me well* (0) to *Describes me very well* (4). An example of these items is “I try to look at everybody's side of a disagreement before I make a decision” (a *Perspective Taking* item). The IRI scale consists of reversely coded items as well; an example of such items is “Sometimes I don't feel very sorry for other people when they are having problems” (an *Empathic Concern* item, and is reversely scored).

4. The Agency Communion Value (ACV) Scale

The *Agency Communion Value (ACV) Scale* (Trapnell & Paulhus, 2012) measures for and identifies which of the two dominant personal value schemas is found more leading in the characteristics of the responder – detailed explanations on the values Agency and Communion have been addressed in the Literature Review (Section 2.6.1.3). The longer, 12-item version questionnaire was used in this study. Responders were asked to first familiarize themselves with the provided 12 principles, and notice which of the 12 principles are most important to them, and then for each of the 12 given principles, rate how important or ‘guiding’ it is to them, from 1 (not important) to 9 (highly important). Examples of the principles are: "FORGIVENESS (pardoning others’ faults, being merciful)” and “RECOGNITION (becoming notable, famous, or admired)”.

5. <u>The *Marlowe-Crowne Scale – Reynolds's Form C; for measuring Social Desirability*</u>

The *Marlowe-Crowne Scale – Reynolds's Form C* (Reynolds, 1982) is a short version *The Marlowe – Crowne Social Desirability Scale* (Crowne & Marlowe, 1960). These scales measure how socially desirable (or complying to a more socially preferable) responses provided by a responder are. Social Desirability indicates "the need of Ss [subjects] to obtain approval by responding in a culturally appropriate and acceptable manner" (Crowne & Marlowe 1960, p. 353), in other words, taps into how *true* (and intrinsic as opposed to extrinsic) the motivation for the responses of the responder(s) are. High social desirability scores are therefore interpreted as an indication of a less intrinsic and more extrinsic (or 'imposed upon') driving motivation for the responses/designs provided by the engineering students, in this study; it could be considered a measure of 'truthfulness' also.

This scale consists of 13 items, and for each item, a responder has to select whether it *truly* or *falsely* applies to them. The higher the cumulative score, the higher the social desirability is considered the responses are. Examples of such items include "I'm always willing to admit it when I make a mistake" and "I have never deliberately said something that hurt someone's feelings".

It is important to note that in this study, those who are to be interpreted as ranking 'high' on the Social Desirability score, are those with higher than the average Social Desirability scores of their year group cohort as a whole; and similarly, those ranked 'low' on the Social Desirability, will be interpreted as those holding a response score lower than the year group cohort's average Social Desirability score.

Note that in this intervention variation, only the first-year students managed to continue with Phase II and respond to the aforementioned instruments (as the third-year students could not have proceeded with Phase II of the assignment), therefore, the high/low scores to be analysed and discussed later will be measured against the first-year's average score of that scale or characteristic in question.

### 4.4.3 Intervention Variation 3 (May 2021) – Exploring the prevalence of Perfectionism in civil engineering undergraduates, and perfectionism's associations with human-centred designing and Communal Design production.

#### *4.4.3.1 Brief Overview of Variation*

Similar to Intervention variation 2, the present intervention variation also had to take place online due to COVID-19 restrictions on face-to-face lecturing; the designs and questionnaire responses were also submitted individually in this intervention variation (unlike the designs submitted in intervention variation 1).

Unlike Intervention Variation 2, this variation's assignment was set as a 'canvas quiz' on Canvas, as opposed to the word document (encompassing the question and questionnaires) to be uploaded upon completion. In the present variation, the information brief pack and task questions were in the forms of questions of a 'quiz' on Canvas. The quiz was time restricted, and students were prevented from resuming backwards to questions they have already answered and moved on from. This workshop 'quiz' lasted for 5 continuous hours with simultaneous online supervision taking place on Zoom, throughout the whole duration of the workshop; comparative to what was held in the intervention variation 1.

The lecture presentation and discussions were held once on Zoom; this was done before the quiz went live on Canvas, and before students could commence their work on their assignments, or go through the information pack. The information pack contained all the information brief, the maps, the quality-of-life reports and the Matrix of Human Needs and Satisfiers). Unlike variation 2, in the present variation, the assignment task questions were set as Canvas quiz questions, with a restriction to retrieve previous questions once students moved forwards in the quiz. The quiz was restricted to 5 hours. Additionally, questionnaires were prepared in an MS Form; where a link to this form was provided as a quiz question for students to follow and respond to, before they could proceed and submit the quiz. The quiz encompassing the solutions, designs and questionnaire responses was to be submitted individually by the students before the time was due (i.e., within the 5-hour window, of that day). Note that there were two quizzes set up on Canvas – one for the control group (where the information pack, assignment tasks quiz questions and questionnaires had no priming pictures), and the other for the primed cohort (where the information pack, assignment task quiz questions and questionnaires contained priming pictures); each student could only access one form of the quizzes and information packs, according to their priorly allocated priming cohort set up.

The class discussion (regarding topics of social impact, social-awareness and social responsibility) took place during an hour-long Zoom lecture, at the beginning of the 5-hour workshop (before the Canvas assignment went live); this was comparable to what was done in intervention variation 1. In the present variation, students did not have the liberty to log in and out of the quiz, as by doing so, the quiz would have been automatically submitted; however, to compensate for if mistakes were to occur, a word documents, similar to that used in variation 2, containing the assignment brief, information pack, assignment questions and questionnaires (with and without the priming pictures – according to the students' allocation) were to be distributed to the students as a backup plan, but such documents were found later not needed.

Using Canvas and MS Form in this intervention (as opposed to the responses being collected as an MS Word document like in variation 2, or as hardcopies like in variation 1), the designs and questionnaire responses, were automatically digitalised and stored as MS Excel files. Instrument data, however, had to be sorted according to the codes provided in the questionnaires' technical manuals, and were also analysed according to the technical manuals. The solutions and designs were also automatically stored in an MS excel spreadsheet upon the students' submission of their quizzes.

Similar to intervention variation 2, only half of the students were primed, whilst the other half acted as the control group. Both the primed and control (non-primed) cohorts were given identical information packs, lecture presentation and discussions, except that the primed cohort had the priming pictures (identical to those used in intervention variation 1 and 2) scattered around the task questions, questionnaire items, and in the information brief, in their Canvas quiz. The non-primed cohort did not have any of the priming pictures in their information pack or quiz. Both the primed and non-primed students engaged in the same Zoom lecture presentation and discussion prior to their commencement of work on the assignment, took part in the same discussions, and received identical information regarding the assignment at all times.

The primed and the control (non-primed) cohorts were split quasi-randomly, in attempt to maintain an equal home to international, and male to female student ratios, in both cohorts – i.e., for both the primed and non-primed group to have a relatively similar number of female and international students. This was done prior to setting-up the assignment on Canvas, as students were to be assigned to access only one of the two information quizzes and information packs (according to the priming cohort allocations) on Canvas, after it goes live.

The primes were only added to the word document encompassing the assignment brief, the task questions and the questionnaires that followed; they were scattered on the page (screen) around the task questions and questionnaires, and were therefore not added to the maps, quality-of-life reports, not the Matrix of Human Needs and Satisfiers. One, or a combination of priming pictures were observed on the screen at a time. Comparable to the primes in intervention variation 2, the primes of the present variation were restricted to occupy a range of 2.17% to 5.44% of the visible screen area, at a time. To my knowledge, the percentage of primes to screen size in supraliminal priming interventions is not typically necessarily addressed, however this study addresses the specific percentages tested, arguing that such sizes were convincingly adequate enough to influence, yet small enough to not take a focal point of attention and cognition, in the present study. As for the positioning of the primes around the main object (i.e., the text and questions), it was in line with a popular study by Maljkovic & Nakayama (1996) showing that “position priming is largely object- or landmark-centred”.

Note that in this intervention variation, the priming influence was effectively affective during phase II of the workshop only (see **Figure 9**), i.e., during the students’ work on the human-centred design and solutions, along with responding to the instruments that followed only. The responses to the questionnaires in Phase I (i.e., those on APS-R) were unaffected by the influence of the priming from both cohorts (i.e., the control and the (later) primed). This intervention variation was set online, and therefore the students’ physical placement could not have been controlled. All student participants in this intervention variation (of both year groups) were given the same workshop/quiz online, but those who were set to be in the primed group had their assignments/quizzes inclusive of the priming pictures (taking place in Phase II – see **Figure 9**). Moreover, note that the students were not made aware of the primes on the screens, nor were they made aware of which priming cohort they were assigned to. This was done to allow for the feasibility of the priming influence to occur, as making the primed aware of the priming intent inhibits the influence of the priming (Bargh & Chartrand, 2000). Additionally, had any of the students questioned the presence of the pictures on the screens/documents, the intention was to respond with “for aesthetic purposes”, but there were no questions regarding the presence of the pictures.

The designs were collected and qualitatively analysed to be declared as Communal Designs or not Communal Designs, according to their inclusivity of the criteria specified in **Table 4** – see *The Proposed Concept of Communal Designs* section above for more information on the declaration of Communal Designs. Note that, similar to intervention variation 2 (and unlike intervention variation 1), in the present intervention variation, the designs collected from students were the products of individual work, as opposed to group work (which was the case in intervention variation 1).

The questionnaires used in this intervention variation included the APS-R (Almost Perfect Scale – Revised; (Slaney, Rice, Mobley, Trippi, & Ashby, 2001)), SSA (Self- and Social-Awareness Assessment; (Joslyn & Hynes, 2016)), IRI (empathy; (Davis M. , 1983)), The Prosocianlness Scale for Adults (Caprara, Steca, Zelli, & Capanna, 2005), Prosocial Behavioral Intentions Scale (Baumsteiger & Siegel, 2019), MPS-SF (multidimensional perfectionism scale – short form; (Hewitt, Habke, Lee-Baggley, Sherry, & Flett, 2008)), and The Marlowe-Crowne Scale – Reynolds’s Form C (Social Desirability; (Reynolds 1982)). These multiple questionnaires used in this intervention variatrion were set in accordance to the different reasearch objectives of this study variation.

*4.4.3.2 Form of Priming*

Only half of the cohort were primed during the human-centred designing assignment, the other half acted as the control group – in both year groups. Note that none of the students were primed during the Perfectionism (APS-R) data collection – i.e., Phase I of the study; see **Figure 9**. The primed and the control (non-primed) cohorts were split quasi-randomly, in attempt to maintain an equal home to international, and male to female student ratios, in both cohorts – i.e. for both the primed and non-primed group to have a relatively similar number of female and international students during Phase II of the study; see **Figure 9**.

Directly after the students' provision of a solution and design for the people of Shatila (i.e., Parts A and B of the assignment), all students were requested to provide responses to other questionnaires – namely, the SSA, IRI, Prosocianlness Scale for Adults, Prosocial Behavioral Intentions Scale, MPS-SF, and the Marlowe-Crowne Scale – Reynolds's Form C (on Social Desirability). Those who were primed answered these sets of questionnaires whilst continuously being primed.

The assignment was set to take place as a Canvas quiz for a duration of five continuous hours, to be submitted by the students within the 5-hour window of that day. Students did not have the liberty to log in and out of the quiz, as was seen in intervention variation 2. Moreover, in the present intervention variation, students were also restricted to retrieve previous answers to questions already solved and moved on from. The primed cohort were primed with pictures scattered around the text in the quiz on screen, in a way to prevent the pictures from taking a focal point of attention; this was to avoid students from cognising the primes, which would then threaten the feasibility of the priming influence to occur, and was in line with Maljkovic & Nakayama (1996) study showing that "position priming is largely object- or landmark-centred". The primes were scattered on the screen around the task questions and questionnaires. One, or a combination of priming pictures were observed on the screen at a time. Comparable to the primes in intervention variation2, the primes of the present variation were restricted to occupy a range of 2.17% to 5.44% of the visible screen area, at a time. The primes were only added to the information pack, the task questions and the questionnaires that followed. Primes were therefore not added to the maps, quality-of-life reports, not the Matrix of Human Needs and Satisfiers.

Similar to the intervention variation 1 and 2, had any of the students questioned the presence of the pictures, the intention was to respond with "for aesthetic purposes", but there were no questions regarding the presence of the pictures. The students primed were also not briefed or informed of the priming, for the feasibility of such experiments, as for priming experiment to work, primes have to remain undetected (Bargh & Chartrand, 2000).

#### *4.4.3.3 Participants*

This case study involved first year and third year civil engineering students at Swansea University, Wales.

90 first-year civil engineering students were involved in this study (11.1% of them were female, and 13.3% were international students).

94 third-year civil engineering students were also involved in this study (17.0% of them were female, 2.1% non-binary, and 28.7% were international students).

In total, this case study involved 184 civil engineering undergraduate students (14.1% of them were female, 1.1% non-binary, and 21.2% international students).

#### *4.4.3.4 Procedure*

In this intervention variation, both first- and third-year civil engineering students underwent the same intervention process, inclusive of all of its phases – both Phases I and II of the Human-Centred Designing assignment; therefore, both the description of procedure, and the illustration presented in **Figure 9**, address the delivery of the Human-Centred Designing workshops of both year groups similarly. Note that it was the same first- and third-year students that underwent all phases of the intervention, at different times (separated according to year group) – i.e., not different first- or third-year students undergoing the different phases of the procedure shown in **Figure 9**.

Prior to the human-centred designing task, all students were requested to fill in a APS-R (Slaney, Rice, Mobley, Trippi, & Ashby, 2001) questionnaires to collect data on their perfectionism status (to determine whether perfectionist or not) – this was Phase I of the study; see **Figure 9**. A few months later, the human-centred designing assignments was set – this was Phase II of the study (see **Figure 9**). The assignment was set as a Canvas quiz, ran live for five continuous hours, with simultaneous online supervision taking place on Zoom. The quiz composed of the identical assignment in which students had to work on the comparative analyses and solution design for the people of Shatila (i.e., Parts A and B of the assignment), and respond the questionnaires that followed – i.e., the SSA (Self- and Social-Awareness; (Joslyn & Hynes, 2016)), IRI (empathy; (Davis M. , 1983)), the Prosocianlness Scale for Adults (Caprara, Steca, Zelli, & Capanna, 2005), Prosocial Behavioral Intentions Scale (Baumsteiger & Siegel, 2019), MPS-SF (Multidimensional Perfectionism Scale – Short Form; (Hewitt, Habke, Lee-Baggley, Sherry, & Flett, 2008)), and The Marlowe-Crowne Scale – Reynolds's Form C (Social Desirability; (Reynolds 1982)). Note that the priming only commenced in Phase II of the study (i.e., whilst working on the human-centred designing assignment and answering the subsequent questionnaires); see **Figure 9**.

Unlike intervention variation 2, in the present variation both first- and third-year group proceeded with both Phases I and II of the intervention and followed identical procedures; see **Figure 9**.

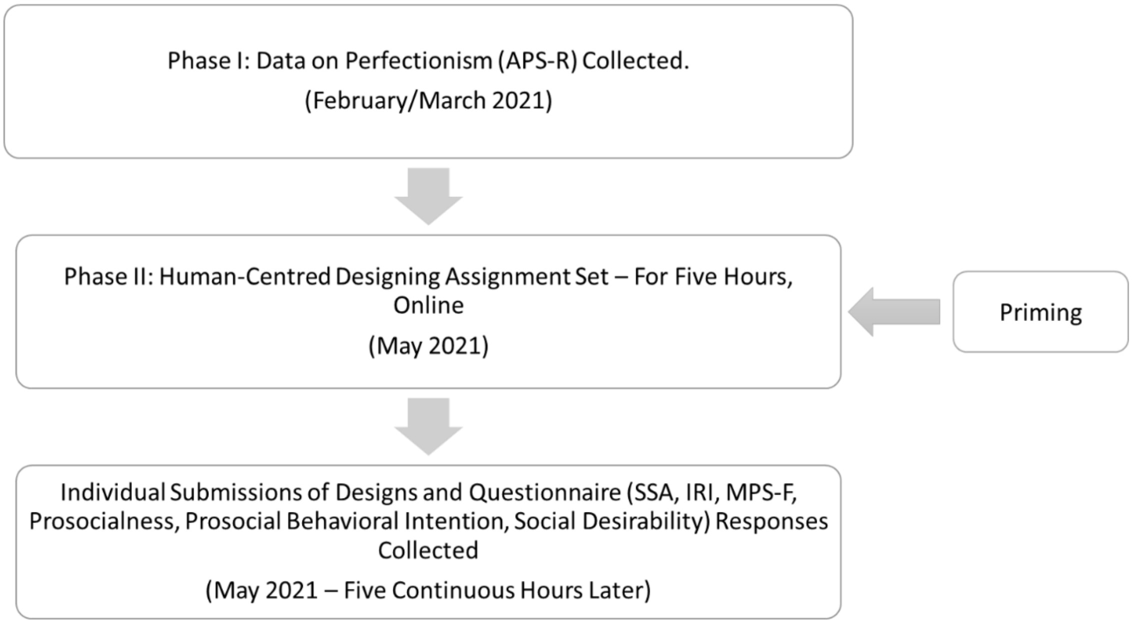


*Figure 9 - Intervention Variation 3 Procedure Layout*

*4.4.3.5 Instruments Used*

1. <u>Almost Perfect Scale – Revised (ASP-R)</u>

The Revised Almost Perfect Scale (ASP-R), designed by Slaney et al. (2001), measures the *Standard* and the *Discrepancy* subscales of perfectionism of the responders, based on which they are classified as *adaptive* perfectionists, *maladaptive* perfectionists, or non-perfectionists. The ASP-R also measures *Order* Scales of perfectionism, but these are disregarded, as they do not contribute to the said classification of the responders, and thus, to the synopsis or hypotheses to be tested in this study.

The ASP-R consists of 23 items, all of which responders are requested to respond with their degree of agreement with each item. The scale of agreement ranges from 1 (*Strongly Disagree)* to 4 (*Neutral)* to 7 (*Strongly Agree*).

Responders were advised not to spend too much time on the individual statements whilst responding, and were reassured that there were no ‘right’ or ‘wrong’ answers. Examples of the items include: “I have high standards for my performance at work or at school”, and “My performance rarely measures up to my own expectations”.

Cut-off scores used to differentiate perfectionists from non-perfectionists, and maladaptive perfectionists from adaptive ones were those adopted from Gilman, Adams, & Nounopoulos’s (2010) study – as this paper also studied students, had an adequately high number of participants (N=984) for cut-off score analyses, and was a relevantly recent analysis of cut-off scores in this context (to my knowledge).

2. <u>Self-awareness and Social-awareness Assessment– SSA Instrument</u>

This instrument has already been described in detail, in section 4.4.1.5.

3. <u>The Interpersonal Reactivity Index (IRI)</u>

The IRI scale, designed by Davis (1983) measures four different facets of empathy – namely, *Empathic Concern* ('other-oriented' empathy), *Personal Distress* ('self-oriented' empathy), *Perspective Taking*, and *Fantasy*. Definitions for each of these subscales are directly quoted from (Davis M. , 1983):

- Perspective Taking – the tendency to spontaneously adopt the psychological point of view of others;
- Fantasy – taps respondents' tendencies to transpose themselves imaginatively into the feelings and actions of fictitious characters in books, movies, and plays;
- Empathic Concern – assesses "other-oriented" feelings of sympathy and concern for unfortunate others;
- Personal Distress – measures "self-oriented" feelings of personal anxiety and unease in tense interpersonal settings;

The IRI scale consists of 28 items, that eventually map onto the four subscales of empathy mentioned above. Each item response ranges from *Does not describe me well* (0) to *Describes me very well* (4). An example of these items is "I try to look at everybody's side of a disagreement before I make a decision" (a *Perspective Taking* item). The IRI scale consists of reversely coded items as well; an example of such items is "Sometimes I don't feel very sorry for other people when they are having problems" (an *Empathic Concern* item, and is reversely scored). In the present study variation, 16 out of the 28 items were used as shorter form of the IRI scale; this Brief Interpersonal Reactivity Index was established and confirmed by Ingoglia et al (2016).

4. <u>The Prosocialness Scale for Adults</u>

The Prosocianlness Scale for Adults, designed by Caprara et al. (2005), was found to effectively measure four central facets of prosocialness – namely "behaviors of 1. helping, 2. sharing, 3. taking care of, and 4. feeling empathic with others" (p.88).

The instrument consists of 16 items, each of which the responders were requested to 'immediately' and 'spontaneously' answer to. Responses ranged from 1 (*never/almost never true*) to 5 (*almost always/always true)* for each item.

Examples of the items include: "I try to help others", "I try to console those who are sad" and "I immediately sense my friends' discomfort even when it is not directly communicated to me".

5. <u>The Prosocial Behavioral Intentions Scale</u>

Prosocial Behavioral Intentions Scale, design by Baumsteiger & Siege  (2019), measures the intentions for prosocial, based on the argument that intentions are the 'direct antecedent' of behaviour.

The scale consists of four items, headed with the instructions: "Imagine that you encounter the following opportunities to help others. Please indicate how willing you would be to perform each behavior from 1 (Definitely would not do this) to 7 (Definitely would do this)".

Examples of the items include: "Comfort someone I know after they experience a hardship" and "Assist a stranger with a small task (e.g., help carry groceries, watch their things while they use the restroom".

6. <u>Multidimensional Perfectionism Scale – Short Form (MPS-SF)</u>

The MPS-SF, designed by Hewitt et al. (2008), is a shortened version of the MPS designed by Hewitt and Flett (;et al.) (1991; 1991).

The MPS-SF consists of 15 items that measure three dimensions of perfectionism – *Self-Oriented*, *Other-Oriented*, and *Socially Prescribed* perfectionism. Responders are requested to "read each item and decide whether [they] agree or disagree and to what extent". Responses ranged from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*).

Examples of the items include: "I demand nothing less than perfection for myself", "People expect nothing less than perfection from me", and "If I ask someone to do something, I expect it to be done flawlessly".

Note that in this study, the three subscales were addressed and analysed both individually, and as a sum (– namely, 'the Total MPS Score').

7. <u>The *Marlowe-Crowne Scale – Reynolds's Form C; for measuring Social Desirability*</u>

The *Marlowe-Crowne Scale – Reynolds's Form C* (Reynolds, 1982) is a short version *The Marlowe – Crowne Social Desirability Scale*  (Crowne & Marlowe, 1960). These scales measure how socially desirable (or complying to a more socially preferable) responses provided by a responder are. Social Desirability indicates "the need of Ss [subjects] to obtain approval by responding in a culturally appropriate and acceptable manner" (Crowne & Marlowe 1960, p. 353), in other words, taps into how *true* (and intrinsic as opposed to extrinsic) the motivation for the responses of the responder(s) are. High social desirability scores are therefore interpreted as an indication of a less intrinsic and more extrinsic (or 'imposed upon') driving motivation for the responses/designs provided by the engineering students, in this study; it could be considered a measure of 'truthfulness' also.

This scale consists of 13 items, and for each item, a responder has to select whether it *truly* or *falsely* applies to them. The higher the cumulative score, the higher the social desirability is considered the responses are. Examples of such items include "I'm always willing to admit it when I make a mistake" and "I have never deliberately said something that hurt someone's feelings".

It is important to note that in this study, those who are to be interpreted as ranking 'high' on the Social Desirability score, are those with higher than the average Social Desirability scores of their year group cohort as a whole; and similarly, those ranked 'low' on the Social Desirability, will be interpreted as those holding a response score lower than the year group cohort's average Social Desirability score.

Note that, as in this intervention variation, the high/low scores to be analysed and discussed later will be measured against the average score of both of the civil engineering undergraduate cohorts combined (i.e., both year groups combined – reason to be discussed in results) of that scale or characteristic in question.

## Chapter 5: Results

All results were computed using SPSS and/or MS Excel.

The results will be displayed in order of intervention variation number and research questions proposed earlier.

Instruments' technical manuals have been used for computing scale results for the proposed characteristics.

Recapping: the designs were collected and qualitatively analysed to be declared as Communal Designs or not Communal Designs, according to their inclusivity of the criteria specified in **Table 4** – see *The Proposed Concept of Communal Designs* section in the Methodology for more information on the declaration of Communal Designs.

Statistical analyses that result in p-values<.05 are considered statistically significant, whilst p-values<.1 can be argued to be tending-to-be significant (Andrade, 2019; Thiese, Ronna, & Ott, 2016; Benjamin, Berger, Johannesson, & al., 2018); particularly when addressed in smaller studies of psychological nature. Studies (Andrade, 2019; Thiese, Ronna, & Ott, 2016; Benjamin, Berger, Johannesson, & al., 2018) argued that findings should not be disregarded if p-values were found above .05, but below 0.1. This is because p-values are said to be heavily dependent on the sample size from which data was gathered; therefore, such studies (including the present ones) argue that findings related to .05<p-value<0.1 should not be disregarded particularly in small sample studies, particularly when such findings hold possible significance in contribution to the research community when/if studies/interventions in question are repeated, or sample sizes have been largened with time and repetition. See (Andrade, 2019; Thiese, Ronna, & Ott, 2016; Benjamin, Berger, Johannesson, & al., 2018) for more information.

### 5.1 Intervention Variation 1 Results

#### 5.1.1 Recap on Hypotheses and Intervention Variant Specific Research Questions

Intervention Variant 1 Proposed Hypotheses:

V1-H1. Based on the literature promising a positive induction of other-oriented empathy in responders via the use of priming, it is hypothesised that primed civil engineering undergraduates are to show higher scores of empathy-correlated characteristics (i.e. consciousness) compared to those non-primed.

V1-H2. By extension to Variation1-Hypothesis1 (V1-H1), it is hypothesised that the primed groups are therefore more likely than the non-primed groups to produce more Communal

Designs (which, in this research, are considered more metaphysically informed forms of human-centred designs).

Intervention Variant 1 Proposed Research Questions:

V1-RQ1. What effect does engaging with the Human-Centred Designing Task have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) of the Primed (P3) and Non-Primed (P1) groups? (Before vs After engagement with HCD).

V1-RQ2. What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) before engaging with the Human-Centred Designing Task?

V1-RQ3. What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) after engaging with the Human-Centred Designing Task?

V1-RQ4. How does Communal Design production associate with the priming?

### 5.1.2 Sample Logistics

This case study involved third year civil engineering students at Swansea University, Wales.

127 third year civil engineering students were involved in this study (16.5% of them were female, and 43.3% were international students).

A total of 78 individual SSA Responses were collected before the Human-Centred Designing Engagement; 30 from the non-primed/control (P1), 24 from middle (P2), 24 from primed (P3) cohort.

A total of 77 individual SSA Responses were collected after Human-Centred Designing Engagement; 34 from the non-primed/control (P1), 26 from middle (P2), 17 from primed (P3) cohort.

A total of 18 group designs were collected at the end of the workshop – note, that these are the designs collected in total, of which some were declared Communal Designs later; 7 from the non-primed (P1), 6 from the middle (P2), 5 from the primed (P3) cohort.

After disregarding the responses of the Middle (P2) group from the dataset, a total of 54 SSA Instrument responses were collected from the students before, and a total of 51 responses was collected after, the engagement with the human-centred designing (HCD) task/workshop.

Due to the ordinal nature of the data collected using the SSA Instruments, significant differences across the groups were obtained by running a Nonparametric Mann Whitney Tests on SPSS. P-values obtained from Mann Whitney tests on SPSS are all with a confidence interval ($\alpha$) of 95%, by default.

Examples of Communal Designs Produced in Intervention Variation 1 are displayed in **Table 98**, found in Appendix B. **Table 98** displays extracts of the conceptual designs produced by the student groups – i.e., examples of what permitted these designs' classifications as Communal Designs (as opposed to *Not* Communal Designs).

### 5.1.3 Quantitative

Mean values, Standard Deviations, as well as Mean Ranks have been provided for each researched cohort.

Emboldened p-values indicate significance in difference; with (*) indicating $p < .05$ and (**) indicating $p < .01$.

*V1-RQ1. What effect does engaging with the Human-Centred Designing Task have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) of the Primed (P3) and Non-Primed (P1) groups? (Before vs After engagement with HCD).*

**Table** 5 displays the SSA Instrument results for the Primed (P3) group only – before and after their engagement with the human-centred designing task. The displayed p-values indicate that there exists no significant differences across the before versus after results of the Primed (P3) group, and thus engagement with the human-centred designing task showed no significant effect on the Self- and Social-Awareness Indicators of the Primed (P3) group students.

**Table** 6 displays the SSA Instrument results for the non-primed/control (P1) group only – before and after their engagement with the human-centred designing task. The displayed p-values indicate that there exists no significant differences across the before versus after results of the non-primed (P1) group, and thus engagement with the human-centred designing task showed no significant effect on the Self- and Social- Awareness Indicators of the non-primed (P1) group students.

*Table 5 - SSA Instrument Results of the Primed (P3) group only – before versus after engagement with the Human-Centred Designing Task.*

| | | Statements (Indicators) | Primed Group (P3) (*Before Task*) (N =24) | | | Primed Group (P3) (*After Task*) (N =17) | | | Mann Whitney-Significance in before/after results – P3 group only. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean Rank | Mean | SD | Mean Rank | p-value |
| Self - Awareness Indicators | | Private Self Consciousness | 14.10 | 3.538 | 16.80 | 13.96 | 3.497 | 17.31 | .899 |
| | | Public Self Consciousness | 10.85 | 4.246 | 19.95 | 9.47 | 3.091 | 15.40 | .202 |
| | | Social Anxiety | 7.65 | 3.511 | 17.54 | 8.15 | 3.051 | 20.19 | .474 |
| Social-Awareness Indicators | Public Welfare Beliefs | Professional and Ethical Responsibilities | 3.75 | 1.539 | 22.23 | 3.35 | 1.498 | 19.26 | .414 |
| | | Understanding the Consequences of Technology | 3.57 | 1.409 | 21.83 | 3.18 | 1.468 | 18.71 | .416 |
| | | Understanding how People use Machines | 3.50 | 1.383 | 21.69 | 3.29 | 1.448 | 20.03 | .652 |
| | Social Consciousness | Improving Society | 3.08 | 1.018 | 21.40 | 3.00 | 1.061 | 20.44 | .787 |
| | | Promoting Racial Understanding | 2.75 | 0.944 | 20.92 | 2.82 | 0.883 | 21.12 | .954 |
| | | Helping Others in Need | 3.29 | 0.751 | 22.25 | 3.00 | 1.000 | 19.24 | .387 |
| | | Ethical and/or Social Issues | 2.83 | 1.007 | 19.83 | 3.00 | 1.173 | 22.65 | .434 |
| | | Policy Implications of Engineering | 2.83 | 0.868 | 22.19 | 2.65 | 0.862 | 19.32 | .397 |
| | | Broad Education in Humanities and Social Sciences | 2.71 | 0.955 | 19.94 | 2.88 | 1.111 | 22.50 | .480 |
| | | Averaged 'Social Consciousness' | 2.917 | 0.765 | 21.27 | 2.892 | 0.775 | 20.62 | .863 |

*Table 6 - SSA Instrument Results of the Non-Primed (P1) group only – before versus after engagement with the Human-Centred Designing Task.*

| | | Statements (Indicators) | Non-Primed Group (P1) (*Before Task*) (N = 30) | | | Non-Primed Group (P1) (*After Task*) (N = 34) | | | Mann Whitney-Significance in before/after – P1 group only. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean Rank | Mean | SD | Mean Rank | p-value |
| Self - Awareness Indicators | | Private Self Consciousness | 13.14 | 4.688 | 27.13 | 14.32 | 4.534 | 32.60 | .220 |
| | | Public Self Consciousness | 11.59 | 3.053 | 32.98 | 10.69 | 3.831 | 29.20 | .403 |
| | | Social Anxiety | 8.52 | 4.540 | 31.33 | 7.80 | 5.020 | 28.72 | .558 |
| Social-Awareness Indicators | Public Welfare Beliefs | Professional and Ethical Responsibilities | 4.77 | 0.430 | 35.15 | 4.53 | 0.788 | 30.16 | .184 |
| | | Understanding the Consequences of Technology | 4.30 | 0.651 | 31.20 | 4.32 | 0.878 | 33.65 | .563 |
| | | Understanding how People use Machines | 4.37 | 0.556 | 33.50 | 4.18 | 0.936 | 31.62 | .653 |
| | Social Consciousness | Improving Society | 3.53 | 0.629 | 31.53 | 3.59 | 0.657 | 33.35 | .646 |
| | | Promoting Racial Understanding | 3.53 | 0.681 | 31.82 | 3.56 | 0.746 | 33.10 | .742 |
| | | Helping Others in Need | 3.63 | 0.556 | 32.85 | 3.50 | 0.862 | 32.19 | .864 |
| | | Ethical and/or Social Issues | 3.43 | 0.774 | 33.23 | 3.35 | 0.849 | 31.85 | .740 |
| | | Policy Implications of Engineering | 3.37 | 0.615 | 32.15 | 3.35 | 0.734 | 32.81 | .875 |
| | | Broad Education in Humanities and Social Sciences | 3.23 | 0.817 | 30.08 | 3.44 | 0.705 | 34.63 | .277 |
| | | Averaged 'Social Consciousness' | 3.456 | 0.420 | 30.63 | 3.466 | 0.621 | 34.15 | .446 |

*V1-RQ2. What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) before engaging with the Human-Centred Designing Task?*

**Table 7** displays the SSA Instrument results for the Primed (P3) and Non-Primed (P1) groups, before engaging with the human-centred designing task. The displayed p-values in **Table 7** indicate that there exists no significant differences across the Primed (P3) and Non-Primed (P1) groups' Self-Awareness Indicators, signifying that the priming showed no apparent effect on the Self-Awareness Indicators of the civil engineering undergraduates, before their engagement with the human-centred designing task.

However, the p-values displayed in **Table 7**, show that the difference between the two groups' majority of Social-Awareness Indicators and Social Consciousness scale (which is the average score of the social awareness indicators) are significant. This indicates that the priming seems to show influence on (all but three) Social-Awareness Indicators, and Social Consciousness of the students, before their engagement with the human-centred designing task. Observing the mean values of the flagged-significant Social-Awareness Indictors, the priming appeared to decrease, rather than increase, these Indicators and Social Consciousness.

*Table 7 - SSA Instrument Results before engagement with the Human-Centred Designing Task only – Primed (P3) group versus the Non-Primed (P1) group results.*

| | | Statements (Indicators) | Primed Group (P3) (*Before Task*) (N =24) | | | Non-Primed Group (P1) (*Before Task*) (N = 30) | | | Mann Whitney-Significance in P1/P3 groups – *before* HCD Task only. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean Rank | Mean | SD | Mean Rank | p-value |
| Self - Awareness Indicators | | Private Self Consciousness | 14.10 | 3.538 | 26.08 | 13.14 | 4.688 | 23.38 | .508 |
| | | Public Self Consciousness | 10.85 | 4.246 | 23.93 | 11.59 | 3.053 | 25.74 | .660 |
| | | Social Anxiety | 7.65 | 3.511 | 25.15 | 8.52 | 4.540 | 27.57 | .566 |
| Social-Awareness Indicators | Public Welfare Beliefs | Professional and Ethical Responsibilities | 3.75 | 1.539 | 21.85 | 4.77 | 0.430 | 32.02 | **.006**** |
| | | Understanding the Consequences of Technology | 3.57 | 1.409 | 23.09 | 4.30 | 0.651 | 30.00 | .084 |
| | | Understanding how People use Machines | 3.50 | 1.383 | 22.15 | 4.37 | 0.556 | 31.78 | **.015*** |
| | Social Consciousness | Improving Society | 3.08 | 1.018 | 23.96 | 3.53 | 0.629 | 30.33 | .102 |
| | | Promoting Racial Understanding | 2.75 | 0.944 | 20.13 | 3.53 | 0.681 | 33.40 | **.001**** |
| | | Helping Others in Need | 3.29 | 0.751 | 23.60 | 3.63 | 0.556 | 30.62 | .064 |
| | | Ethical and/or Social Issues | 2.83 | 1.007 | 22.13 | 3.43 | 0.774 | 31.80 | **.015*** |
| | | Policy Implications of Engineering | 2.83 | 0.868 | 22.44 | 3.37 | 0.615 | 31.55 | **.018*** |
| | | Broad Education in Humanities and Social Sciences | 2.71 | 0.955 | 22.63 | 3.23 | 0.817 | 31.40 | **.029*** |
| | | Averaged 'Social Consciousness' | 2.917 | 0.765 | 20.23 | 3.456 | 0.420 | 33.32 | **.002**** |

*Emboldened p-values indicate significance; (*) indicate $p < .05$ and (**) indicate $p < .01$*

*V1-RQ3. What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) after engaging with the Human-Centred Designing Task?*

**Table 8** displays the SSA Instrument results for the Primed(P3) and Non-Primed (P1) groups, after their engagement with the human-centred designing task.

Similar to **Table 7**, the displayed p-values in **Table 8** indicate that there exists no significant differences across the Primed (P3) and Non-Primed (P1) groups' Self-Awareness Indicators, signifying that the priming showed no apparent effect on the Self-Awareness Indicators of the students, after their engagement with the human-centred designing task, as well.

*Table 8 - SSA Instrument Results after engagement with the Human-Centred Designing Task only – Primed (P3) group versus the Non-Primed (P1) group results.*

| | | Statements (Indicators) | Primed Group (P3) (*After Task* Only) (N =17) | | | Non-Primed Group (P1) (*After Task* Only) (N =34) | | | Mann Whitney-Significance in P1/P3 groups – after HCD Task only. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean Rank | Mean | SD | Mean Rank | p-value |
| Self - Awareness Indicators | | Private Self Consciousness | 13.69 | 3.497 | 20.00 | 14.32 | 4.534 | 23.55 | .401 |
| | | Public Self Consciousness | 9.47 | 3.091 | 20.23 | 10.69 | 3.831 | 25.77 | .194 |
| | | Social Anxiety | 8.15 | 3.051 | 22.92 | 7.80 | 5.020 | 21.60 | .764 |
| Social Awareness Indicators | Public Welfare Beliefs | Professional and Ethical Responsibilities | 3.35 | 1.498 | 18.59 | 4.53 | 0.788 | 29.71 | **.006**** |
| | | Understanding the Consequences of Technology | 3.18 | 1.468 | 18.18 | 4.32 | 0.878 | 29.91 | **.005**** |
| | | Understanding how People use Machines | 3.29 | 1.448 | 19.91 | 4.18 | 0.936 | 29.04 | **.029*** |
| | Social Consciousness | Improving Society | 3.00 | 1.061 | 20.26 | 3.59 | 0.657 | 28.87 | **.028*** |
| | | Promoting Racial Understanding | 2.82 | 0.883 | 17.79 | 3.56 | 0.746 | 30.10 | **.002**** |
| | | Helping Others in Need | 3.00 | 1.000 | 20.50 | 3.50 | 0.862 | 28.75 | **.036*** |
| | | Ethical and/or Social Issues | 3.00 | 1.173 | 23.65 | 3.35 | 0.849 | 27.18 | .382 |
| | | Policy Implications of Engineering | 2.65 | 0.862 | 18.15 | 3.35 | 0.734 | 29.93 | **.004**** |
| | | Broad Education in Humanities and Social Sciences | 2.88 | 1.111 | 21.26 | 3.44 | 0.705 | 28.37 | .078 |
| | | Averaged 'Social Consciousness' | 2.892 | 0.775 | 17.59 | 3.466 | 0.621 | 30.21 | **.004**** |

*Emboldened p-values indicate significance; (*) indicate p < .05 and (**) indicate p < .01*

Moreover, the p-values displayed in **Table 8**, show that the difference between the two groups' majority of Social-Awareness Indicators (and their resultant average, i.e., Social Consciousness), are significant. This indicates that the priming seems to show influence on (all but two) Social-Awareness Indicators, and Social Consciousness of the civil engineering undergraduates, after their engagement with the human-centred designing task. Observing the mean values of the flagged-significant Social-Awareness Indictors of **Table 8**, the priming appears to also decrease, rather than increase, Social Awareness Indicators and Social Consciousness.

Observing **Table 7** and **Table 8**, it is interesting to note that the difference between the Primed (P3) and the Non-Primed (P1) groups, for the Social-Awareness Indicators: *Understanding Consequences of Technology*, *Improving Society*, and *Helping Others in Need*, only *became* significant after the engagement with the Human-Centred Designing Task. On the other hand, the difference between the Primed (P3) and the Non-Primed (P1) groups for the Social-Awareness Indicators: *Ethical and/or Social Issues* and *Broad Education in Humanities and Social Science*, changed to *no longer significant*, after the engagement with the human-centred designing task.

V1-RQ4. *How does Communal Design production associate with the priming?*
*Table 9 - Communal Design contribution from Year 3 student groups, with regard to their association with the Priming.*

| **Primed Groups (P3)** | | **Middle Groups (P2)** | | **Non-Primed/ Control Group (P1)** | |
|---|---|---|---|---|---|
| **Group Number** | **Produced Communal Design?** | **Group Number** | **Produced Communal Design?** | **Group Number** | **Produced Communal Design?** |
| Group 1 | *N/A (Did Not Submit Any Design)* | Group 3 | Produced *Communal Design* | Group 14 | Produced *Communal Design* |
| Group 2 | Produced *Communal Design* | Group 4 | Produced *Communal Design* | Group 15 | Not Produced *Communal Design* |
| Group 5 | Not Produced *Communal Design* | Group 7 | Produced *Communal Design* | Group 16 | Produced *Communal Design* |
| Group 6 | Not Produced *Communal Design* | Group 11 | Not Produced *Communal Design* | Group 17 | Not Produced *Communal Design* |
| Group 8 | Not Produced *Communal Design* | Group 13 | Not Produced *Communal Design* | Group 18 | Produced *Communal Design* |
| Group 9 | *N/A (Did Not Submit Any Design)* | Group 22 | Not Produced *Communal Design* | Group 19 | Not Produced *Communal Design* |
| Group 10 | Not Produced *Communal Design* | | | Group 20/21 | Produced *Communal Design* |
| Group 12 | *N/A (Did Not Submit Any Design)* | | | | |

**Table 9** displays the distribution of designs collected from each student group (that consisting of 5 or 6 students – present by the module coordinator). Three of the student group did not submit a design (as they found it to be non-beneficial, unnecessary, or “ridiculous”), and eighteen student groups did

submit designs, which were later thematically analysed according to the classification criteria displayed in **Table 4** and discussed in the methodology section. Reminder: the designs and SSA responses from the middle group (i.e., P2) have been disregarded to enhance the quality of this study's findings.

Regarding the designs and responses of the primed (P3) and the non-primed/control groups only, the association of the priming with Communal Design Production, was observed. A chi-squared test of independence was computed to capture the significance of the association of the priming to the production of Communal Designs of the third-year students; see **Table 10** for more information.

*Table 10 - Association of Priming and Communal Design Production – Intervention Variation 1.*

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| No. Primed Groups (P3) | 1 | 4 | 5 |
| No. of Non-Primed Groups (P1) | 4 | 3 | 7 |
| Column Totals | 5 | 7 | Grand Total = 12 |

A chi-square test of independence was performed to examine the relation between the priming (i.e., the categories of Primed Groups versus the Non-Primed Groups) and their production of Communal Designs. The relation between these variables was found not significant, $X^2$ (1, $N$ = 12) = 1.656, p = .198; see **Table 10** for more information. Arguing that the counts in **Table 10** might have proposed promisingly significant associations (with those primed being likely to **not** produce Communal Designs), had the sample size been bigger.

### 5.1.4 Summary

To recap, this intervention variation was to test the feasibility of priming civil engineering students into human-centred designing; this was done by exposing a cohort of students to empathy-inducing primes (i.e., pictures of the people students are designing for), during their work on a human-centred designing workshop. Data on students' self and social consciousness was captured before and after their engagement with the human-centred designing assignment, and the influence of the priming on such consciousness characteristics was also observed. Findings revealed that students' consciousness levels were not influenced by their work/engagement with the designing assignment; however, they were found significantly influenced by the priming. Opposite to what was anticipated, the priming showed to significantly decrease, rather than increase social consciousness (and thus by extension, empathy) scores of students. Resuming back to the literature of make sense of the present findings, it was found that reduced empathy levels were negatively correlated with self-protecting and anxiety-avoidant personal motives. This led to believe that motives of self-protection and anxiety-avoidance of the students, could possibly be the reason why they could not have positively associated with priming that was meant to promote empathy, subconsciously. Contextualising the present findings with others in the field, on the resistance and declination of students' social consideration beliefs over time in engineering educational programmes, the present findings show that such a resistance is possibly 'deeper' (rooted in the subconscious), than what we initially thought. These findings will be discussed in further detail, in the Discussions chapter.

## 5.2 Intervention Variation 2 Results

### 5.2.1 Recap on Hypotheses and Intervention Variant Specific Research Questions

Intervention Variant 2 Proposed Hypotheses:

V2-H1. With existing literature indicating that members of the STEM community (and therefore, engineers and engineering students) are more likely to hold Agentic Values, as opposed to Communal ones, it is hypothesised that civil engineering undergraduates are most likely to hold Self Enhancement and/or Openness to Change Higher Order Values as opposed to Self-Transcendence and/or Conservation values.

V2-H2. Based on the literature associating positively the Self-Transcending and Openness to Change Values to prosocial, altruistic, empathic traits, with Self Transcendence being the most aligned to Communal Value traits and outcomes, it is hypothesised that those with Higher Order Values rooted in the communal Self Transcendence (as opposed to the agentic Openness to Change) are the most likely to engage (empathically and consciously) with the proposed Human-Centred Designing assignment (i), and subsequently, produce more Communal Designs (ii).

V2-H3. By extension to Variation2-Hypothesis2 (V2-H2), it is therefore hypothesised that those with Higher Order Values rooted in the communal Self Transcendence to be most likely to positively engage with (or respond to) the priming (compared to those with values rooted in the agentic Openness to Change).

Intervention Variant 2 Proposed Research Questions:

V2-RQ1. What is the most common proclaimed Higher Order Value amongst civil engineering students?

V2-RQ2. How do the Higher Order Values associate with Communal Design Production?

V2-RQ3. How do the Higher Order Values associate with other characteristics (like communal/agentic values (thus intentions), empathy, and consciousness) that are known to be positively associated with human-centred designing engagement and Communal Design production?

V2-RQ4. How does Communal Design production and Higher Order Value associate with Social Desirability scores – thus, with intrinsic and/or extrinsic motives of the students for the design?

V2-RQ5. What is the effect of the Priming on the engagement with the Human-Centred Designing assignment (i.e., empathy, consciousness) and Communal Design production, in light of Higher Order Values?

V2-RQ6. Reiterating on V2-RQ2 and V2-RQ3 for self-cross-check – Intervention Variation 2.

V2-RQ7. What are the differences in characteristics of those who produced Communal Designs as opposed to those who did not produce Communal Designs? – Intervention Variation 2.

V2-RQ8. How (if) does the intention-behaviour gap manifests in light of the Civil Engineering Undergraduates' Personal Values?

V2-RQ9. Finally, can an equation be developed to predict students' likelihood of Communal Design production given students' personal values and other characteristics' scores?

### 5.2.2 Sample Logistics

This case study involved first year and third year civil engineering students at Swansea University, Wales.

108 first year civil engineering students were involved in this study (9.3% of them were female, 0.9% were non-binary, and 13.0% were international students).

31 third year civil engineering students were also involved in this study (29.0% of them were female, and 38.7% were international students).

A total of 61 individual PVQ-RR questionnaires were submitted by first-year civil engineering undergraduates, and a total of 31 individual PVQ-RR questionnaires were submitted by third-year civil engineering undergraduates – this was Phase I of the study (see **Figure 8**).

Reminder that only the first-year student proceeded to participate in Phase II of the study (see **Figure 8**);

A total of 87 individual designs were collected at the end of Phase II of the study (see **Figure 8**) – note that, these are the designs collected in total, of which some were declared Communal Designs later. Moreover, 86 individual questionnaire(s) responses (i.e., SSA, IRI, ACV, and Social Desirability) were collected from first-year students at the end of Phase II of the study too (see **Figure 8**).

42 out of the 87 first-year students (who both delivered a design and end-of-task questionnaire responses) were primed; whilst 45 out of the 87 contributed as the control (non-primed) group, in this study.

Examples of Communal Designs Produced in Intervention Variation 2 are displayed in **Table 110**, found in Appendix B.

**Table 110** displays extracts of the conceptual designs produced by the civil engineering undergraduates – i.e., examples of what permitted these designs' classifications as Communal Designs (as opposed to *Not* Communal Designs).

5.2.3 Quantitative

Due to the categorical and continuous nature of the data to be analysed in this study variation, Pearson chi square tests have been analysed to observe the associations between categories. Also, two-tailed heteroscedastic t-tests to compare the means between two groups, and Pearson correlative tests have been computed to observe the correlations between characteristics. All tests were computed using MS Excel and/or IBM SPSS. Significance obtained are all within a confidence interval of 95%, by default.

*V2-RQ1. What is the most common proclaimed Higher Order Value amongst civil engineering students?*

*Table 11 - Breakdown of first-year civil engineering* undergraduates' Higher Order Value categories

| Highest Ranking Higher Order Value Category | Number of Year 1 Students (N) | Percentage of Year 1 Students (%) |
|---|---|---|
| Conservation | 3 | 4.92 |
| Self Enhancement | 2 | 3.28 |
| Openness to Change | 17 | 27.87 |
| Self Transcendence | 39 | 63.93 |
| Total | 61 | 100 |

The breakdown of the first – year students' categories of the four Higher Order Values are displayed **Table 11.** The majority of first year students seem to have their dominant (highest) Higher Order Value to be *Self Transcendence*.

*Table 12 - Breakdown of third-year civil engineering* undergraduates' Higher Order Value categories

| Highest Ranking Higher Order Value Category | Number of Year 3 Students (N) | Percentage of Year 3 Students (%) |
|---|---|---|
| Conservation | 5 | 16.13 |
| Self Enhancement | 1 | 3.22 |
| Openness to Change | 8 | 25.81 |
| Self-Transcendence | 17 | 54.84 |
| Total | 31 | 100 |

Similar to the first-years, the majority of third-year civil engineering undergraduates categorise as having ranked the Higher Order Value of *Self Transcendence* the highest. This can be viewed in **Table 12.**

*Table 13 – Comparative breakdown of civil engineering* undergraduates' Higher Order Value categories

| Highest Ranking Higher Order Value Category | Number of Year 1 Civil Engineering Students (%) | Number of Year 3 Civil Engineering Students (%) | Row Totals |
|---|---|---|---|
| Conservation | 3 (4.92 %) | 5 (16.13 %) | 8 (8.70 %) |
| Self Enhancement | 2 (3.28 %) | 1 (3.23 %) | 3 (3.26 %) |
| Openness to Change | 17 (27.87 %) | 8 (25.81 %) | 25 (27.17 %) |
| Self Transcendence | 39 (63.93 %) | 17 (54.84 %) | 56 (60.87 %) |
| Total (Column Totals) | 61 (100%) | 31 (100%) | Grand Total = 92 (100%) |

Comparing the Higher Order Value categories across the two year groups, a Pearson chi-square test of independence was performed to examine the associations between civil engineering undergraduates' dominant (highest ranked) Higher Order Value categories, and their relevant year of study. The relation between these variables was found not significant, $X^2$ (3, $N$ = 92) = 3.283, $p$ =.350. A chi-square test of independence showed that there was no significant association between the Higher Order Value categories of the students and the different year groups; i.e., the majority of civil engineering undergraduates have the Higher Order Value rooted in *Self Transcendence* to be the most dominant, with the second most dominant Higher Order Value being *Openness to Change*, regardless of the year of study. See **Table 13** for more information**.**

Note that, as it is now established that the majority of civil engineering students claim to have dominant Higher Order Values rooted in *Self Transcendence,* followed by the second largest majority being those with dominant Higher Order Value rooted in *Openness to Change (*See **Table 11, Table 12, Table 13**); this, coupled with the notion implied by Bayram (2016) on values of *Openness to Change* and *Self Transcendence* are more likely to relate to prosocial and thus communal behaviour, this project shall only consider these two Higher Order Value categories in the following analyses to observe their associations with human-centred designing engagement and *Communal Design* production.

Moreover, to further observe how (and if) basic, subgroup personal values (as opposed to Higher Order Values) of civil engineering undergraduates differ across the year groups, or change with progression in the civil engineering programme, a series of two-tailed heteroscedastic t-test was computed on MS Excel, to observe how first-year values (basic or Higher Order) compares with those of third-years. Results of this test (i.e., mean values and p-values) are displayed in **Table 14** ; emboldened p-values indicate significance or a tendency to be significant.

*Table 14 – A series of two-tailed heteroscedastic t-test on Higher Order Values subsets across the two year groups of civil engineering undergraduates*

| | p-value | 1st Year | 3rd Year |
|---|---|---|---|
| Self Direction Thought | .901 | 0.526 | 0.549 |
| Self Direction Action | .313 | 0.441 | 0.635 |
| Stimulation | .712 | 0.343 | 0.264 |
| Hedonism | .104 | 0.791 | 0.441 |
| Achievement | .899 | 0.329 | 0.355 |
| Power Dominance | .674 | -1.166 | -1.053 |
| Power Resources | .799 | -0.709 | -0.774 |
| Face | .926 | -0.283 | -0.257 |
| Security Personal | .532 | 0.250 | 0.409 |
| Security Societal | **.071** | -0.045 | 0.366 |
| Tradition | **.022** | -1.015 | -0.311 |
| Conformity Rules | .105 | -0.308 | 0.097 |
| Conformity Interpersonal | .912 | -0.234 | -0.204 |
| Humility | .317 | 0.173 | -0.021 |
| Universalism Nature | .169 | 0.015 | 0.355 |
| Universalism Concern | .877 | 0.665 | 0.635 |
| Universalism Tolerance | .664 | 0.731 | 0.651 |
| Benevolence Care | .729 | 0.728 | 0.796 |
| Benevolence Dependability | .301 | 0.542 | 0.753 |
| Self Transcendence | .508 | 2.680 | 3.191 |
| Self Enhancement | .893 | -1.546 | -1.471 |
| Openness to Change | .740 | 2.100 | 1.889 |
| Conservation *(minus Humility and Face)* | **.059** | -1.353 | 0.358 |
| Humility and Face | .664 | -0.110 | -0.278 |
| Conservation | .196 | -1.463 | 0.079 |

Emboldened p-values indicate significance or a tendency to be significant.

**Table 14** displays that the third-year civil engineering undergraduates have a tending-to-be significantly higher value for *Security Societal* (p=.071), *Conservation (minus the Humility and Face)* (p=.059), and a significantly higher value for *Tradition* (p=.022). Note that the mean values displayed in **Table 14** are centred around zero (due to following the technical manual of the scale) – i.e., the larger and higher the mean value above zero, the higher the ranking of this personal value within that cohort.

As the basic value of Tradition flagged to be significantly higher in the third-year undergraduates when compared to the first-years, two-tailed Pearson correlations were computed to understand what the basic personal value of *Tradition* signifies, or how it resonates with other personal values, within each year group. See **Table 15** for results. Embolden figures resemble significance (* indicates p≤.005 (2-tails, Pearson); ** indicates p≤.001 (2-tails, Pearson)).

*Table 15 - Size of the correlation between the value of Tradition and other values within each year group*

| Pearson Corelation of *Tradition Basic Value score* with: | Year 1 | Year 3 |
|---|---|---|
| Self Direction Thought | .123 | .216 |
| Self Direction Action | **.332**** | .272 |
| Stimulation | **.312*** | **.479**** |
| Hedonism | -.008 | .119 |
| Achievement | .156 | **.396*** |
| Power Dominance | **.336**** | .166 |
| Power Resources | .266* | .096 |
| Face | -.025 | .295 |
| Security Personal | .151 | .232 |
| Security Societal | **.269*** | **.739**** |
| Tradition | 1 | 1 |
| Conformity Rules | .054 | .095 |
| Conformity Interpersonal | -.026 | .221 |
| Humility | -.015 | **.382*** |
| Universalism Nature | .186 | .145 |
| Universalism Concern | -.098 | **.385*** |
| Universalism Tolerance | .118 | .336 |
| Benevolence Care | **.287*** | **.431*** |
| Benevolence Dependability | .176 | **.494**** |
| *Self Transcendence (Higher Order)* | .202 | **.455*** |
| *Self Enhancement (Higher Order)* | **.334**** | .278 |
| *Openness to Change (Higher Order)* | **.268*** | .334 |
| *Conservation (minus Humility and Face) (Higher Order)* | **.481**** | **.658**** |
| Humility and Face | -.028 | **.382*** |
| *Conservation (Higher Order)* | **.388**** | **.610**** |

Embolden figures resemble significance (* indicates p≤.005 (2-tails, Pearson); ** indicates p≤.001 (2-tails, Pearson)).

It was surprising to observe that, within in the third-year group, *Tradition* correlated significantly with *Communal related Values* (see ***Table 15***) whilst in the first year group, *Tradition* correlated significantly with more *Agentic related Values* (see ***Table 15***). An example of this includes third-year students having a significant correlation between *Tradition* and *Self Transcendence*, whilst first-year students instead have a significant correlation between *Tradition* and *Self Enhancement* as well as *Tradition* and *Openness to Change*. Schwartz et al. (2012) categorised *Self Enhancement* and *Openness to Change* Higher Order Values as ‘personal focused’, and *Self Transcendence* and *Conservation* as ‘social focused’ (see **Figure 3**). Further, Trapnell & Paulhus (2012) indicated that the value of *Tradition* “corresponds to a very broad communal dimension”. This led me to question whether engineers, or at least ‘future engineers’, consider themselves to ‘become’ more communal as their value for *Tradition* increases over time? Empirical tests to study this, however, are outside the scope of this PhD.

Third-year students also showed a higher correlation of *Tradition* to *Conservation* (r=.610**) compared to that of first year students (r=.388**) (see ***Table 15***). This further visually emphasises the growth of the value and nature of *Conservation* over time in civil engineering educational programmes, which in turn, simultaneously underrates *Openness to Change*, as these two Higher Order Values are opposing in nature, and are mutually exclusive (see **Figure 3** and (Schwartz, et al., 2012)**)**. This decrease in the value and nature of Openness to Change was also seen in results displayed in ***Table 15***, where only first-year students showed correlation between *Tradition* and the Higher Order Value *Openness to Change* (r=.268*) – third-year students showed no such correlation.

*V2-RQ2. How do the Higher Order Values associate with Communal Design Production?*
As mentioned earlier, the following analyses (responding to the research questions V2-RQ2 to V2-RQ8) will only consider the Higher Order Values of *Openness to Change* and *Self Transcendence*, and their associations with human-centred designing engagement and Communal Design Production.

*Table 16 - Association of Communal Design Production and Higher Order Value Categories (Openness to Change, Self Transcendence).*

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| Openness to Change | 11 | 4 | 15 |
| Self-Transcendence | 10 | 26 | 36 |
| Column Totals | 21 | 30 | Grand Total = 51 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Value categories, and the production of Communal Designs, in a first-year civil engineering undergraduate cohort. The relation between these variables was found significant, $X^2$ (1, $N$ = 51) = 9.072, p = .003. Those with dominant Higher Order Value rooted in *Openness to Change* were significantly more likely than those with dominant Higher Order Values rooted in *Self Transcendence* to produce Communal Designs. See **Table 16** for more information.

*V2-RQ3. How do the Higher Order Values associate with other characteristics (like communal/agentic values (thus intentions), empathy, and consciousness) that are known to be positively associated with human-centred designing engagement and Communal Design production?*
*Table 17 – Association of Communal Design Production, Empathy, and Higher Order Value Categories*

| | Openness to Change | Self Transcendence | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy* Scores | 5 | 5 | 10 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy* Scores | 6 | 5 | 11 |
| Column Totals | 11 | 10 | Grand Total = 21 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Values and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy* Scores. The relation between these variables was found not significant, $X^2$ (1, N = 21) = 0.043, p = .835. See **Table** 17 for more information.

The Pearson chi-square tests regarding **Table 99**, **Table 100**, and **Table 101** (viewed in Appendix B) explore and display the association between the Higher Order Values and Communal Designs in light of the four subcategories of empathy, individually. It was found that such an association was tending-to-be significant (p=.05) with only one subcategory of empathy, which was Empathy: Perspective Taking, see **Table 18**; whereas similar associations with the other subcategories of Empathy were found not significant (see **Table 99**, **Table 100**, and **Table 101** in Appendix B for more information).

*Table 18 - Association of Communal Design Production, Empathy: Perspective Taking, and Higher Order Value Categories*

| | Openness to Change | Self Transcendence | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Perspective Taking* Scores | 3 | 7 | 10 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Perspective Taking* Scores | 8 | 3 | 11 |
| Column Totals | 11 | 10 | Grand Total = 21 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Values and the production of Communal Designs whilst having higher- or lower-than-average *Empathy: Perspective Taking* scores. The relation between these variables was found tending-to-be significant, $X^2$ (1, N = 21) = 3.834, p = .050. Those with dominant Higher Order Values rooted in *Self Transcendence* were found tending-to-be significantly more likely than those with dominant Higher Order Value rooted in *Openness to Change,* to produce Communal Designs with higher-than-average Empathy: Perspective Taking scores. See **Table 18** for more information.

A postcondition to empathy is consciousness, as argued by Thompson (2001) – “Empathy is the precondition (the condition of possibility) of the science of consciousness”; therefore, empathy as well as self- and social-consciousness, are analysed in the context of human-centred designing and Communal Design production, along with their association with Higher Order Values, in this study.

*Table 19 - Association of Communal Design Production, Self Consciousness, and Higher Order Value Categories*

| | Openness to Change | Self Transcendence | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Self Consciousness* Scores | 8 | 6 | 14 |
| No. of Communal Designs Produced – whilst having lower-than-average *Self Consciousness* Scores | 3 | 4 | 7 |
| Column Totals | 11 | 10 | Grand Total = 21 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Values and the production of Communal Designs whilst having higher-than-average or lower-than-average *Self Consciousness* scores. The relation between these variables was found not significant, $X^2$ (1, N = 21) = 0.382, p = .537. See **Table 19** for more information.

*Table 20 - Association of Communal Design Production, Social Consciousness, and Higher Order Value Categories*

| | Openness to Change | Self Transcendence | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Social Consciousness* Scores | 4 | 4 | 8 |
| No. of Communal Designs Produced – whilst having lower-than-average *Social Consciousness* Scores | 7 | 6 | 13 |
| Column Totals | 11 | 10 | Grand Total = 21 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Values and the production of Communal Designs whilst having higher-than-average or lower-than-average *Social Consciousness* scores. The relation between these variables was found not significant, $X^2$ (1, N = 21) = 0.029, p = .864. See **Table 20** for more information.

*V2-RQ4. How does Communal Design production and Higher Order Value associate with Social Desirability scores – thus, with intrinsic and/or extrinsic motives of the students for the design?*

*Table 21 - Association of Communal Design Production, Social Desirability, and Higher Order Value Categories*

| | Openness to Change | Self Transcendence | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average '*Social Desirability'* Scores | 2 | 5 | 7 |
| No. of Communal Designs Produced – whilst having lower-than-average '*Social Desirability*' Scores | 9 | 5 | 14 |
| Column Totals | 11 | 10 | Grand Total = 21 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Values and the production of Communal Designs whilst having higher-than-average or lower-than-average *Social Desirability* scores. The relation between these variables was found not significant, $X^2$ (1, N = 21) = 2.386, p = .122; see **Table 21** for more information.

However, results displayed in **Table 22** show that those with dominant Higher Order Value rooted in *Self Transcendence* were tending-to-be more likely than those with dominant Higher Order Values rooted in *Openness to Change*, to have higher-than-average *Social Desirability* scores in general.

*Table 22 - Associations of Higher Order Values and Social Desirability in Civil Engineering Undergraduates.*

| | Higher-than-average Social Desirability | Lower-than-average Social Desirability | Row Totals |
|---|---|---|---|
| Openness to Change | 5 | 10 | 15 |
| Self-Transcendence | 21 | 13 | 34 |
| Column Totals | 26 | 23 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Value categories and Social Desirability scores. The relation between these variables was found tending-to-be significant, $X^2$ (1, N = 49) = 3.378, p = .066. Those with dominant Higher Order Value rooted in *Self Transcendence* were tending-to-be more likely than those with dominant Higher Order Values rooted in *Openness to Change,* to have higher-than-average *Social Desirability* scores in general. See **Table 22** for more information.

*V2-RQ5. What is the effect of the Priming on the engagement with the Human-Centred Designing assignment (i.e., empathy, consciousness) and Communal Design production, in light of Higher Order Values?*

To observe the association between priming and the production of Communal Designs, whilst temporarily disregarding the association with the personal values, a Pearson chi-square test was computed. Results are displayed in **Table 23**.

*Table 23 - Association of Priming and Communal Design Production – Intervention Variation 2*

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| Primed Cohort | 17 | 25 | 42 |
| Non-Primed (Control) Cohort | 17 | 28 | 45 |
| Column Totals | 34 | 53 | Grand Total = 87 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs, regardless of the students' personal values for the time being. The relation between these variables was found not significant, $X^2$ (1, N = 87) = 0.066, p = .797. The priming influence seems to be independent to, or ineffective on, the production of Communal Design. See **Table 23** for more information.

To observe the effect of priming on Communal Design production, and in light of the students' personal values, a chi squared test was computed to observe if indeed such an association or influence is profound. **Table 24** displays the results obtained.

*Table 24 - Association of Communal Design Production, Priming, and Higher Order Value Categories*

| | Openness to Change | Self Transcendence | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst being *Primed* (Primed Cohort) | 5 | 6 | 11 |
| No. of Communal Designs Produced – whilst *not being Primed* (Control Cohort) | 6 | 4 | 10 |
| Column Totals | 11 | 10 | Grand Total = 21 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Values and the production of Communal Designs whilst being Primed (Primed cohort) or Non-Primed (control cohort). The relation between these variables was found not significant, $X^2$ (1, N = 21) = 0.444, p = .505. See **Table 24** for more information.

To further explore the effect of the priming, a series of two-tailed heteroscedastic t-test was computed to observe the differences in questionnaire responses collected in Phase II (See **Figure 8**), between the primed and the non-primed (control) cohorts. Results (mean values and p-values) are displayed in are displayed in **Table 25**; emboldened p-values indicate significance and/or a tendency-to-be significant. In **Table 25,** the results displayed indicate that those who were primed seemed to have tending-to-be significantly higher Social Consciousness scores, compared to those who were not primed (i.e., the control group).

*Table 25 – A series of two-tailed heteroscedastic t-test on Primed Vs Non-Primed (Control) Cohort Questionnaire Responses – Intervention Variation 2*

| | p-value | Primed | Non-Primed |
|---|---|---|---|
| Self Consciousness | 0.921 | 33.476 | 33.682 |
| Social Consciousness | **0.092** | 3.448 | 3.263 |
| Agentic Value | 0.499 | 5.266 | 5.072 |
| Communal Values | 0.668 | 7.272 | 7.362 |
| Empathy: Fantasy | 0.658 | 13.310 | 12.791 |
| Empathy: Empathic Concern | 0.421 | 17.524 | 18.186 |
| Empathy: Perspective Taking | 0.436 | 16.488 | 17.227 |
| Empathy: Personal Distress | 0.593 | 10.381 | 9.886 |
| Empathy (Sum) | 0.974 | 57.310 | 57.386 |
| Social Desirability | 0.827 | 6.625 | 6.750 |

Emboldened p-values indicate significance and/or a tendency-to-be significant

Pearson chi-square tests were also computed to observe more closely the associations between the priming, Communal Design production, empathy, consciousness, and social desirability scores of the civil engineering undergraduates, during their work on the human-centred designing initiative. Results obtained are displayed in **Table 102** to **Table 109**, in Appendix B, highlighting if indeed such associations are profound.

Results displayed in **Table 102** to **Table 109** indicate that the priming had no significant association with (i.e., or influence on) any of the aforementioned characteristics (i.e., empathy, consciousness, and social desirability) of the students, during Communal Design production or work on the human-centred designing initiative; see **Table 102** to **Table 109** for more information in Appendix B.

*V2-RQ6. Reiterating on V2-RQ2 and V2-RQ3 for self-cross-check – Intervention Variation 2.*
*<u>Recap on Research Questions V2-RQ2 and V2-RQ3:</u>*

> V2-RQ2. How do the Higher Order Values associate with Communal Design Production?
>
> V2-RQ3. How do the Higher Order Values associate with other characteristics (like communal/agentic values (thus intentions), empathy, and consciousness) that are known to be positively associated with human-centred designing engagement and Communal Design production?

This reiteration is to research the association of Communal Design production and human-centred designing engagement, with personal values using the Agency Communion Value (ACV) Scale (Trapnell & Paulhus, 2012) as opposed to the PVQ-RR (Schwartz, et al., 2012; Schwartz S. , 2016) used previously, for self-cross-check.

Using the data obtained on the civil engineering undergraduates' dominant value system (either Agentic or Communal) using the ACV scale, I draw results that either support (or oppose), in concept, my previous findings. In this section, I shall observe the AC (Agency/Communion) Values with regard to the human-centred designing engagement, Communal Design production, and the priming.

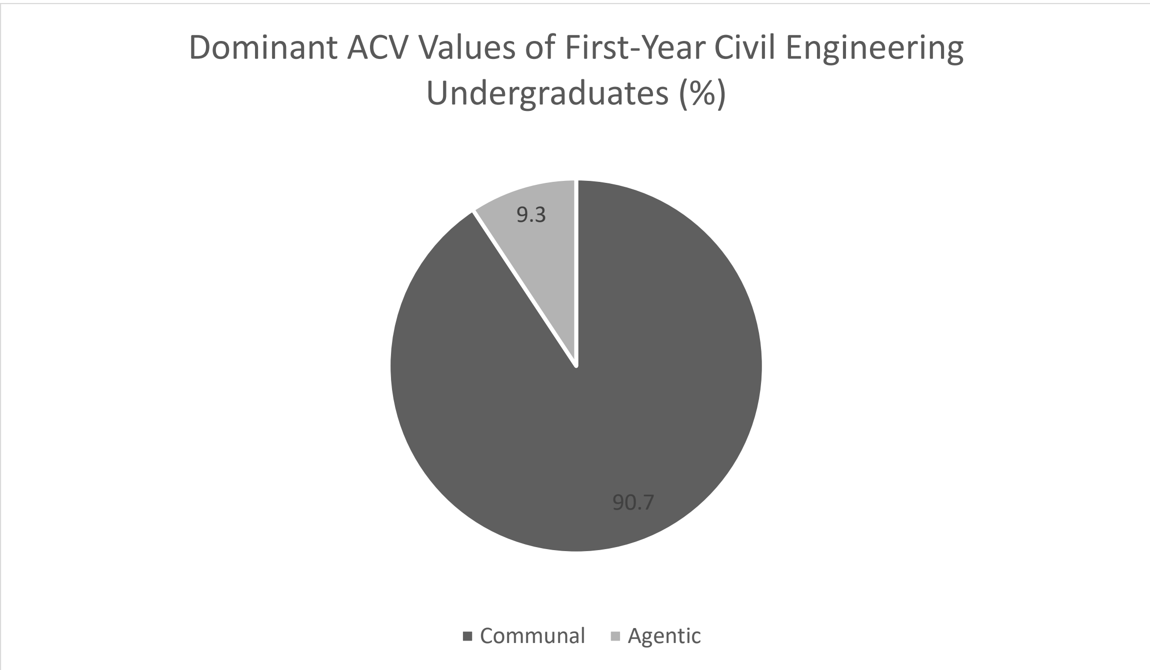


*Figure 10 - Dominant personal value systems in civil engineering undergraduates.*

Using the ACV scale, it was found that 78/86 (90.7%) of the civil engineering undergraduates have dominant communal (as opposed to agentic) values, and 8/86 (9.3%) of them have dominant agentic (as opposed to communal) values – see **Figure 10**. These findings resonate with the results found previously on the majority of civil engineering undergraduates having dominant Higher Order Values rooted in the communal Self Transcendence, whilst the second highest majority of civil engineering undergraduates having dominant Higher Order Values rooted in the agentic Openness to Change – see **Table 11, Table 12, Table 13.** To confirm this resonance and support to initial findings, a Fisher exact (as opposed to Pearson chi-squared, for one category count is 0) test was computed to check the association between the two dominant Higher Order Values categories, and the dominating Agency/Communion Values found in civil engineering undergraduates. See **Table 26** for more information**.**

*Table 26 - Association of the dominant Higher Order Values and dominant AC (Agency/Communion) Values found in first-year Civil Engineering Undergraduates.*

| | Dominant Communal Values | Dominant Agentic Values | Row Totals |
|---|---|---|---|
| Dominant Openness to Change | 13 | 2 | 15 |
| Dominant Self Transcendence | 35 | 0 | 35 |
| Column Totals | 48 | 2 | Grand Total = 50 |

The relation between these variables was found tending-to-be significant as the Fisher exact test p-value is 0.086; see **Table 26** for more information. This indicates that those with dominant Higher Order Values rooted in Self Transcendence were tending to be those who have dominant Communal values (as opposed to dominant agentic ones). This indicates that indeed, the majority of civil engineering undergraduates have (or at least, claim to have) communal values (as opposed to agentic ones) rooted in Self Transcendence. I state 'claim to have' here, as it was observed that those who provided questionnaire responses that reflect their dominant values to be rooted in Communion and/or the Higher Order Value of Self Transcendence, simultaneously provided responses that reflect their tending-to-be higher than average Social Desirability (see **Table 28** and **Table 22**, respectively, for more information); the social desirability nature of the responses prohibits scepticism in the *truthfulness* of the responders' proclaimed dominantly communal personal values.

On the association of the AC (Agency/Communion) Values to the production of Communal Designs, a Pearson chi-squared test of independence was computed, revealing that the relation between these variables was not significant, $X^2$ (1, N = 86) = 0.404, p = .525; see **Table 27** for more information.

*Table 27 - Association of Communal Designs production, and the AC Values of civil engineering undergraduates.*

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| Dominant Communal Value | 30 | 48 | 78 |
| Dominant Agentic Value | 4 | 4 | 8 |
| Column Totals | 34 | 52 | Grand Total = 86 |

Further, a Pearson chi-square test of independence was performed to examine the relation between AC (Agency/Communion) Value categories and Social Desirability scores in the civil engineering undergraduates. The relation between these variables was found tending-to-be significant, $X^2$ (1, N = 84) = 3.162, p = .075. Those with dominant communal values were tending-to-be more likely than those with dominant agentic values to have higher-than-average Social Desirability scores; see **Table 28** for more information. These findings align with previous findings (displayed in **Table 22**) on those with dominant Higher Order Value rooted in the communal *Self Transcendence* having tending-to-be significantly (p=.066) higher Social Desirability scores too.

*Table 28 - Association of ACV (Communal Values, Agentic Values) and Social Desirability in civil engineering undergraduates.*

| | Dominant Communal Values | Dominant Agentic Values | Row Totals |
|---|---|---|---|
| High Social Desirability | 44 | 2 | 46 |
| Low Social Desirability | 32 | 6 | 38 |
| Column Totals | 76 | 8 | Grand Total = 84 |

For understanding the association of the AC Values, the production of Communal Designs, and the priming, a Pearson chi-square test was computed. A Pearson chi-square test of independence was performed to examine the relationship between the dominant AC (Agency/Communion) values of the civil engineering undergraduates, and their production of Communal Designs whilst being primed (i.e., primed cohort) or non-primed (i.e., control cohort). The relation between these variables was found not significant, $X^2$ (1, $N$ = 34) = 0, p = 1; see **Table 29** for more information**.**

*Table 29 - Association of Communal Design Production, Priming, and AC Value Categories*

| | Dominant Communal Value | Agentic Values (highest) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst being *Primed* (Primed Cohort) | 15 | 2 | 17 |
| No. of Communal Designs Produced – whilst *not being Primed* (Control Cohort) | 15 | 2 | 17 |
| Column Totals | 30 | 4 | Grand Total = 34 |

As a final set of results for this research question, and to further recognise the difference in characteristics of those who have dominant communal values as opposed to those with dominant agentic values, a series two-tailed heteroscedastic t-test was computed. **Table 30** displays the results (mean values and p-values) found for each set of characteristics; emboldened p-values indicate significant or a tendency-to-be significant.

Results displayed in **Table 30** show that those with dominant communal values had significantly less value for Power Resource (p=.026), Tradition (p=.001), Self Enhancement (p=.009), and a tending-to-be a significantly less value for Power Dominance (p=.059), compared to those with dominant agentic values. The also showed a significantly higher value for Universalism Concern (p=.031) compared to those with dominant agentic values in engineering education.

*Table 30 - A series of two-tailed heteroscedastic t-test comparing dominantly communal and dominantly agentic personal values in civil engineering undergraduates.*

| | Agentic | Communal | p-value |
|---|---|---|---|
| Self Direction Thought (Phase I) | 0.557 | 0.516 | 0.917 |
| Self Direction Action (Phase I) | 0.724 | 0.434 | 0.580 |
| Stimulation (Phase I) | 0.390 | 0.304 | 0.860 |
| Hedonism (Phase I) | 0.390 | 0.872 | 0.462 |
| Achievement (Phase I) | 0.974 | 0.350 | 0.115 |
| Power Dominance (Phase I) | 0.057 | -1.317 | **0.059** |
| Power Resources (Phase I) | 0.890 | -0.824 | **0.026** |
| Face (Phase I) | -0.193 | -0.268 | 0.909 |
| Security Personal (Phase I) | 0.640 | 0.258 | 0.438 |
| Security Societal (Phase I) | 0.390 | -0.049 | 0.306 |
| Tradition (Phase I) | -0.193 | -1.092 | **0.001** |
| Conformity Rules (Phase I) | -0.860 | -0.324 | 0.507 |
| Conformity Interpersonal (Phase I) | -0.026 | -0.255 | 0.834 |
| Humility (Phase I) | -0.610 | 0.238 | 0.199 |
| Universalism Nature (Phase I) | -0.693 | 0.068 | 0.446 |
| Universalism Concern (Phase I) | -0.693 | 0.774 | **0.031** |
| Universalism Tolerance (Phase I) | 0.557 | 0.774 | 0.391 |
| Benevolence Care (Phase I) | 0.807 | 0.797 | 0.954 |
| Benevolence Dependability (Phase I) | 0.724 | 0.582 | 0.483 |
| Self Transcendence (Phase I) | 0.702 | 2.996 | 0.232 |
| Self Enhancement (Phase I) | 1.921 | -1.791 | **0.009** |
| Openness To Change (Phase I) | 2.061 | 2.127 | 0.964 |
| Conservation (Minus Humility and Face) (Phase I) | -0.048 | -1.462 | 0.493 |
| Humility And Face (Phase I) | -0.803 | -0.030 | 0.533 |
| Conservation (Phase I) | -0.851 | -1.491 | 0.831 |
| Self Consciousness (Phase II) | 31.625 | 33.782 | 0.304 |
| Social Consciousness (Phase II) | 3.021 | 3.388 | 0.221 |
| Empathy: Fantasy (Phase II) | 13.250 | 13.026 | 0.862 |
| Empathy: Empathic Concern (Phase II) | 15.875 | 18.065 | 0.275 |
| Empathy: Perspective Taking (Phase II) | 15.000 | 17.065 | 0.381 |
| Empathy: Personal Distress (Phase II) | 10.125 | 10.128 | 0.998 |
| Empathy (Sum) (Phase II) | 54.250 | 57.667 | 0.481 |
| Social Desirability (Phase II) | 5.625 | 6.803 | 0.221 |

*V2-RQ7. What are the differences in characteristics of those who produced Communal Designs as opposed to those who did not produce Communal Designs? – Intervention Variation 2.*

To differentiate the characteristics of those who produced Communal Designs, as opposed to those who did not eventually produced them, a series of two-tailed heteroscedastic t-test was computed. This was to observe if (and how) such differences are prevalent and presented. Results (mean values and p-values) are displayed in **Table 31**; emboldened p-value indicate significance or a tendency-to-be significant.

*Table 31 - A series of two-tailed heteroscedastic t-test across characteristics of those who produced Communal Designs (CD), versus those who did not produce Communal Design (N_CD) – Intervention Variation 2.*

| | N_CD | CD | p-value |
|---|---|---|---|
| Self Direction Thought (Phase I) | 0.333 | 0.738 | **0.078** |
| Self Direction Action (Phase I) | 0.297 | 0.613 | 0.175 |
| Stimulation (Phase I) | 0.203 | 0.432 | 0.340 |
| Hedonism (Phase I) | 0.765 | 0.876 | 0.631 |
| Achievement (Phase I) | 0.218 | 0.543 | 0.131 |
| Power Dominance (Phase I) | -1.349 | -1.026 | 0.256 |
| Power Resources (Phase I) | -1.021 | -0.276 | **0.031** |
| Face (Phase I) | -0.479 | -0.012 | **0.095** |
| Security Personal (Phase I) | 0.067 | 0.529 | **0.047** |
| Security Societal (Phase I) | -0.370 | 0.432 | **0.006** |
| Tradition (Phase I) | -0.917 | -1.124 | 0.515 |
| Conformity Rules (Phase I) | -0.172 | -0.596 | 0.103 |
| Conformity Interpersonal (Phase I) | -0.354 | -0.096 | 0.428 |
| Humility (Phase I) | 0.401 | -0.137 | **0.018** |
| Universalism Nature (Phase I) | 0.047 | -0.068 | 0.704 |
| Universalism Concern (Phase I) | 0.817 | 0.432 | **0.054** |
| Universalism Tolerance (Phase I) | 0.786 | 0.682 | 0.514 |
| Benevolence Care (Phase I) | 0.771 | 0.807 | 0.834 |
| Benevolence Dependability (Phase I) | 0.521 | 0.654 | 0.479 |
| Self Transcendence (Phase I) | 2.941 | 2.507 | 0.529 |
| Self Enhancement (Phase I) | -2.152 | -0.760 | **0.033** |
| Openness To Change (Phase I) | 1.598 | 2.659 | 0.115 |
| Conservation (Minus Humility and Face) | -1.746 | -0.854 | 0.321 |
| Humility And Face (Phase I) | -0.079 | -0.150 | 0.850 |
| Conservation (Phase I) | -1.825 | -1.004 | 0.455 |
| Self Consciousness (Phase II) | 31.404 | 37.061 | **0.008** |
| Social Consciousness (Phase II) | 3.383 | 3.313 | 0.569 |
| Agentic Value Score (Phase II) | 5.083 | 5.263 | 0.550 |
| Communal Value Score (Phase II) | 7.219 | 7.438 | 0.301 |
| Empathy: Fantasy (Phase II) | 12.824 | 13.485 | 0.581 |
| Empathy: Empathic Concern (Phase II) | 17.365 | 18.656 | 0.106 |
| Empathy: Perspective Taking (Phase II) | 17.019 | 16.719 | 0.764 |
| Empathy: Personal Distress (Phase II) | 9.788 | 10.758 | 0.306 |
| Sum Empathy (Phase II) | 56.750 | 58.545 | 0.461 |
| Social Desirability Score (Phase II) | 6.940 | 6.364 | 0.317 |

Emboldened p-value indicate significance or a tendency-to-be significant.

**Table 31** displays results indicating those who produced Communal Designs had a tending-to-be significantly higher value score for Self Direction Thought (p=.078) and Face (p=.095), but a tending-to-be significantly lower value score for Universalism Concern (p=.054).

Moreover, **Table 31** displays that those who produced Communal Designs were found to have a significantly higher value score for Power Resource (p=.031), Security Personal (p=.047), Security Societal (p=.006), Self Enhancement (p=.033), Self Consciousness (p=.008), and interestingly, significantly lower value score Humility (p=.018).

To further observe the difference in characteristics of those who produced Communal Designs whilst having dominant Higher Order Value rooted in *Self Transcendence (CD_ST)*, as opposed to those who produced Communal Designs whilst having dominant Higher Order Value rooted in *Openness to Change (CD_OC)*, a series of two-tailed heteroscedastic t-test was computed. This was to observe if (and how) such differences are prevalent and presented. Results (mean values and p-values) are displayed in **Table 32**; emboldened p-values indicate significance or a tendency-to-be significant.

*Table 32 - A series of two-tailed heteroscedastic t-test computed across those who produced Communal Design whilst holding dominant values of Self Transcendence (CD_ST) versus those who produced Communal Designs whilst holding dominant values of Openness to Change (CD_OC).*

| | CD_ST | CD_OC | p-values |
|---|---|---|---|
| Self Direction Thought (Phase I) | 0.374 | 1.110 | **0.042** |
| Self Direction Action (Phase I) | 0.140 | 1.171 | **0.006** |
| Stimulation (Phase I) | -0.026 | 0.959 | **0.006** |
| Hedonism (Phase I) | 0.607 | 1.352 | **0.037** |
| Achievement (Phase I) | 0.474 | 0.534 | 0.857 |
| Power Dominance (Phase I) | -1.393 | -0.799 | 0.234 |
| Power Resources (Phase I) | -0.793 | -0.102 | 0.220 |
| Face (Phase I) | -0.160 | 0.110 | 0.535 |
| Security Personal (Phase I) | 0.374 | 0.534 | 0.571 |
| Security Societal (Phase I) | 0.274 | 0.474 | 0.606 |
| Tradition (Phase I) | -1.360 | -1.223 | 0.783 |
| Conformity Rules (Phase I) | -0.493 | -0.738 | 0.372 |
| Conformity Interpersonal (Phase I) | -0.293 | -0.011 | 0.560 |
| Humility (Phase I) | -0.026 | -0.102 | 0.822 |
| Universalism Nature (Phase I) | 0.174 | -0.163 | 0.454 |
| Universalism Concern (Phase I) | 0.774 | 0.292 | **0.076** |
| Universalism Tolerance (Phase I) | 0.707 | 0.656 | 0.820 |
| Benevolence Care (Phase I) | 1.007 | 0.534 | 0.110 |
| Benevolence Dependability (Phase I) | 0.707 | 0.595 | 0.696 |
| Self Transcendence (Phase I) | 3.368 | 1.914 | **0.081** |
| Self Enhancement (Phase I) | -1.712 | -0.367 | 0.210 |
| Openness To Change (Phase I) | 1.095 | 4.592 | **0.000** |
| Conservation (Minus Humility and Face) (Phase I) | -1.498 | -0.965 | 0.530 |
| Humility And Face (Phase I) | -0.186 | 0.008 | 0.742 |
| Conservation (Phase I) | -1.684 | -0.957 | 0.512 |
| Self Consciousness (Phase II) | 36.900 | 38.545 | 0.723 |
| Social Consciousness (Phase II) | 3.183 | 3.409 | 0.345 |
| Agentic Value Score (Phase II) | 5.083 | 5.258 | 0.764 |
| Communal Value Score (Phase II) | 7.750 | 7.130 | **0.070** |
| Empathy: Fantasy (Phase II) | 11.100 | 13.182 | 0.353 |
| Empathy: Empathic Concern (Phase II) | 18.400 | 18.000 | 0.766 |
| Empathy: Perspective Table (Phase II) | 16.778 | 14.455 | 0.253 |
| Empathy: Personal Distress (Phase II) | 10.400 | 10.545 | 0.933 |
| Sum Empathy (Phase II) | 55.000 | 56.182 | 0.809 |
| Social Desirability Score (Phase II) | 6.900 | 5.364 | 0.169 |

When those who produced Communal Designs whilst holding dominant values rooted in *Self Transcendence* (CD_ST) were compared to those who produced Communal Designs whilst holding dominant values rooted in *Openness to Change (*CD_OC), significant (and a tending-to-be significant) differences emerged. CD_OC showed to have had higher value for Self Direction Thought (p=.042) and Action (p=.006), Stimulation (p=.006) – this was expected, as these appear as subset values to the Higher Order Value of Openness to Change (**Figure 3**). On the other hand, CD_ST showed to have higher value for Universalism Concern (p=.076); this was also expected, as Universalism Concern is a subset to the Higher Order Value of Self Transcendence (**Figure 3**). It was also expected to see a significance in difference for values of *Openness to Change* (p=.000) and *Self Transcendence* (p=.081), however, it was evidently interesting to observe that the latter (difference in value for *Self Transcendence*) between CD_ST and CD_OC was not significant, but tending-to-be significant. See **Table 32** for more information.

Moreover, it was also observed that CD_ST held tending-to-be significantly higher value for Communal Value (p=.070) compared to CD_OC; this is interesting, as those who held dominant values rooted in the communal Self Transcendence, were also found significantly less likely to produce Communal Designs (see **Table 16**).

Furthermore, it was interesting to observe that CD_OC showed a significantly higher value for Hedonism (p=.037), when compared to CD_ST. Hedonism represents the pleasure of achievement (Schwartz, et al., 2012), is an agentic value (Trapnell & Paulhus, 2012), and holds personal (as opposed to social) focus (see **Figure 3**). It was therefore interesting to observe that those who were more likely to produce Communal Designs (i.e., those with dominant Openness to Change Values – see **Table 16**) were also simultaneously those who produced Communal Designs with personal-focussed intent and agentic motivation (as opposed to social and communal motivation) behind it. See **Table 32** for more information.

*V2-RQ8. How (if) does the intention-behaviour gap manifests in light of the Civil Engineering Undergraduates' Personal Values?*

For observing and analysing how the intentions and motivations for producing Communal Designs are manifested, correlative Pearson tests have been computed. The 'communal intention' is observed in relation to other characteristics of the undergraduates (like empathy, and consciousness– which are known to be positively associated human-centred designing and engagement). A series of two-tailed Pearson corelations were computed to examine how the civil engineering undergraduates' communal intentions associate with the rest of their characteristics. In this section, this is done via addressing the communal value of the undergraduates, and what it correlated to in each of the independent factors (i.e., the different priming and Higher Order Value categories). These correlations will act as facilitators to grasp an understanding of what the students' communal intention translates to in each of the categories, and additionally, under the effect of the priming.

Results of these Pearson correlations are displayed in **Table 33** to **Table 35**. Embolden figures in the tables resemble significance; (*) indicates p≤.005 (2-tails, Pearson), and (**) indicates p≤.001 (2-tails, Pearson).

*Table 33* **-** *Addressing the 'Intention' to Produce the Communal Designs across Higher Order Value Categories.*

| Pearson Corelation of *Communal Value score* with: | Self Transcendence Category | Openness to Change Category |
|---|---|---|
| Self Direction Thought | **.339*** | .310 |
| Self Direction Action | .149 | .141 |
| Stimulation | .012 | -.176 |
| Hedonism | -.090 | .165 |
| Achievement | .027 | -.228 |
| Power Dominance | -.028 | -.402 |
| Power Resources Face | .313 | -.444 |
| Face | .144 | .163 |
| Security Personal | .173 | -.050 |
| Security Societal | .143 | .102 |
| Tradition | .076 | -.280 |
| Conformity Rules | .182 | .220 |
| Conformity Interpersonal | .264 | .002 |
| Humility | .130 | -.050 |
| Universalism Nature | -.034 | -.047 |
| Universalism Concern | **.373*** | **.529*** |
| Universalism Tolerance | .031 | .377 |
| Benevolence Care | .194 | -.109 |
| Benevolence Dependability | .120 | -.039 |
| Higher Order Value: Self Transcendence | .188 | .265 |
| Higher Order Value: Self Enhancement | .164 | -.481 |
| Higher Order Value: Openness to Change | .164 | .117 |
| Higher Order Value: Conservation (minus Humility and Face) | .256 | -.037 |
| Humility and Face | .202 | .082 |
| Higher Order Value: Conservation (including Humility and Face) | .273 | .014 |
| Self Consciousness | .331 | **.636*** |
| Social Consciousness | .025 | .151 |
| Agentic Value Score | **.401*** | -.182 |
| Communal Value Score | 1 | 1 |
| Empathy: Fantasy | .199 | -.159 |
| Empathy: Empathic Concern | .279 | .256 |
| Empathy: Perspective Taking | -.090 | .352 |
| Empathy: Personal Distress | .187 | .019 |
| Empathy (Sum) | .298 | .226 |
| Social Desirability | -.216 | .175 |

Embolden figures resemble significance (* indicates p≤.005 (2-tails, Pearson); ** indicates p≤.001 (2-tails, Pearson)).

**Table 33** shows that the communal value (i.e., the communal intention) of those with dominant Higher Order Value of Self Transcendence correlated positively with the value of Self Direction – Thought (r=.339*) whilst this association was not seen in those with dominant Higher Order Value of

Openness to Change did not. This is interesting, as Self Direction – Thought is a basic value that subsidises the Higher Order Value of Openness to Change (see **Figure 3**); moreover, this is interesting as the Higher Order Value of Openness to Change and its sub-values are known to be more agentic in nature, as opposed to communal (Schwartz, et al., 2012; Schwartz S. , 2012; Trapnell & Paulhus, 2012).

On the other hand, the communal intention of those with dominant Higher Order Values rooted in Openness to Change correlated positively with Self Consciousness (r=.636*), whilst this correlation was not seen in those with dominant Higher Order Values rooted Self Transcendence category, although such a characteristic is known (and hypothesised) to be mostly associated with the communal Higher Order Value of Self Transcendence. Moreover, the communal intentions of those with dominant Higher Order Values rooted in Self Transcendence corelated with Universalism Concern (r=.373*), to a lesser extent than those with dominant values rooted in Openness to Change, whom showed higher positive correlation with Universalism Concern (r=.529*). This was similarly interesting, as the value of Universalism Concern is a subsidiary value to the communal Higher Order Value of Self Transcendence (see **Figure 3**), and is thus obviously mostly associated (in theory) with the Higher Order Value of Self Transcendence.

Additionally, those with dominant Higher Order Values rooted in the (communal) Self Transcendence showed a positive correlation between their communal intention and the Agentic Value score (r=.401*), whereas a similar correlation was not found in those with dominant values rooted in the (agentic) Openness to Change. This is interesting, as this reassures on the presence of an apparent dissonance in civil engineering undergraduates' motivation and intent for Communal Design production, and their ability to act upon that intention, and/or the production of Communal Designs – especially those who claim to have dominant communal values rooted in Self Transcendence, which were found to be the majority of civil engineering undergraduates (see **Table 13**). This therefore calls for further researching the truthfulness of those who claim to have dominant communal values rooted in Self Transcendence, their intentions' alignment to produce socially considerate Communal Designs, and/or their ability to act upon that communal intent – i.e., questioning: 'are they practicing what they preach?' ( - see paper (Al Kakoun, Boy, & Xavier, 2021)).

*Table 34 - Addressing the 'Intention' to produce Communal Designs across those who produced Communal Designs vs. those who did not – Intervention Variation 2.*

| Pearson Corelation of *Communal Value score* with: | Produced Communal Design | Not Produced Communal Design |
|---|---|---|
| Self Direction Thought | .152 | **.376*** |
| Self Direction Action | .020 | .305 |
| Stimulation | -.122 | .135 |
| Hedonism | -.043 | .082 |
| Achievement | -.327 | .153 |
| Power Dominance | -.224 | -.178 |
| Power Resources Face | -.162 | .119 |
| Face | -.057 | .200 |
| Security Personal | -.301 | .269 |
| Security Societal | .276 | .139 |
| Tradition | .051 | .127 |
| Conformity Rules | .161 | .203 |
| Conformity Interpersonal | -.066 | .300 |
| Humility | .205 | .088 |
| Universalism Nature | .112 | .143 |
| Universalism Concern | .402 | **.404*** |
| Universalism Tolerance | .345 | .223 |
| Benevolence Care | .120 | **.372*** |
| Benevolence Dependability | .045 | .247 |
| Higher Order Value: Self Transcendence | .316 | .351 |
| Higher Order Value: Self Enhancement | -.293 | .043 |
| Higher Order Value: Openness to Change | -.001 | .316 |
| Higher Order Value: Conservation (minus Humility and Face) | .052 | .284 |
| Humility and Face | .074 | .213 |
| Higher Order Value: Conservation (including Humility and Face) | .071 | .299 |
| Self Consciousness | .220 | .235 |
| Social Consciousness | .153 | **.338*** |
| Agentic Value Score | .118 | .060 |
| Communal Value Score | 1 | 1 |
| Empathy: Fantasy | -.172 | .144 |
| Empathy: Empathic Concern | **.411*** | **.480**** |
| Empathy: Perspective Taking | .230 | .107 |
| Empathy: Personal Distress | .196 | .010 |
| Empathy (Sum) | .109 | .346* |
| Social Desirability | .073 | .245 |

Embolden figures resemble significance (* indicates $p \leq .005$ (2-tails, Pearson); ** indicates $p \leq .001$ (2-tails, Pearson)).

When addressing how the communal intention translates in the categories of those who produced Communal Designs as opposed to those who did not, it was found that those who did not produce Communal Designs showed positive correlations between their communal intention and Self

Direction Thought (r=.376* - a subset value to the higher order value of Openness to Change), Universalism Concern (r=.404*) and Benevolence Care (r=.372* - both are two subset values to the higher order value of Self Transcendence), social consciousness (r=.338*) and Empathy (Sum) (r=.346*); whilst similar correlations were not see in the other category (i.e., those who produced Communal Designs). See **Table 34** for more information. These correlations are interesting, as they clearly indicate that communal intentions (i.e., high universalism and benevolence values and motives) were not translated into producing Communal Designs in an undergraduate cohort of civil engineers. This then clearly showcases an apparent intention-behaviour gap in engineering undergraduates perhaps intending to, but then failing to produce Communal Design. Reasons to the existence of such an apparent dissonance, or intention-behaviour gap, may include the inadequate training to act upon communal intentions in engineering practice and engineering, as previously reviewed in the literature. These therefore highlight a necessity for further research into understanding the prevalence of such an apparent intention-behaviour gap, particularly in contexts of social consideration education in engineering, to understand where such a dissonance originates from, and how it develops in engineering education or paradigm, particularly when social consideration in now in demand in design. This 'call' will be further addressed in later chapters of this thesis. Additionally, it was found that those who did not produce Communal Designs showed higher positive correlations between their communal intention and Empathy: Empathic Concern (r=.480**), compared to those who did not produce Communal Design; whom showed positive correlations with Empathy: Empathic Concern (r=.411*) but to a lesser extent (see **Table 34**). This further emphasises the prevalence of an apparent cognitive dissonance or intention-behaviour gap in civil engineering undergraduates perhaps intending to, but then failing to act upon their intentions and produce Communal Designs. Moreover, it is important to recap here that those with dominant Higher Order Values rooted in the communal Self Transcendence (i.e., those who are known to be more empathic generally – see Literature Review), were found to be more likely **not** to produce Communal Designs as well (see **Table 16**), which further adds to the emphasis of a dissonance.

To continue identifying the presence of an intention-behaviour gap, it is important to note that Self Direction Thought and Universalism were flagged as positively correlated to the communal intention in both **Table 33** and **Table 34,** under the categories of 'Self Transcendence' and 'Not Produced Communal Designs', respectively. Drawing from this, and tethering it to the previous findings on those with dominant Self Transcendence values being more likely to **not** produce Communal Designs (see **Table 16**) as opposed to produce them albeit their more communal and empathic nature (when compared to those with dominant values rooted in the agentic Openness to Change), therefore establishes an identification of the very likely present cognitive dissonance or intention-behaviour gap in engineering undergraduates, who may intend to, but then fail to produce socially considerate Communal Designs, due to reasons which call for future research.

*Table 35 - Addressing the 'Intention' to Produce the Communal Designs across the Priming Cohorts – Intervention Variation 2.*

| Pearson Corelation of *Communal Value score* with: | Primed Cohort | Non-Primed Cohort |
|---|---|---|
| Self Direction Thought | .361 | .246 |
| Self Direction Action | .083 | .254 |
| Stimulation | -.027 | .086 |
| Hedonism | -.172 | .194 |
| Achievement | -.166 | .088 |
| Power Dominance | -.386 | -.060 |
| Power Resources Face | -.172 | .145 |
| Face | .199 | .052 |
| Security Personal | .020 | .144 |
| Security Societal | -.092 | **.372*** |
| Tradition | .026 | .157 |
| Conformity Rules | .103 | .250 |
| Conformity Interpersonal | .138 | .134 |
| Humility | .294 | .015 |
| Universalism Nature | .233 | .038 |
| Universalism Concern | .398 | .349 |
| Universalism Tolerance | **.635**** | .068 |
| Benevolence Care | .365 | .221 |
| Benevolence Dependability | .023 | .274 |
| Higher Order Value: Self Transcendence | **.421*** | .272 |
| Higher Order Value: Self Enhancement | -.308 | .076 |
| Higher Order Value: Openness to Change | .079 | .256 |
| Higher Order Value: Conservation (minus Humility and Face) | .064 | .315 |
| Humility and Face | .322 | .050 |
| Higher Order Value: Conservation (including Humility and Face) | .150 | .282 |
| Self Consciousness | .244 | .270 |
| Social Consciousness | **.338*** | .225 |
| Agentic Value Score | -.018 | .203 |
| Communal Value Score | 1 | 1 |
| Empathy: Fantasy | .227 | -.214 |
| Empathy: Empathic Concern | **.510**** | **.415**** |
| Empathy: Perspective Taking | .128 | .156 |
| Empathy: Personal Distress | .159 | .002 |
| Empathy (Sum) | **.364*** | .133 |
| Social Desirability | .205 | .117 |

Embolden figures resemble significance (* indicates p≤.005 (2-tails, Pearson); ** indicates p≤.001 (2-tails, Pearson)).

Results displayed in **Table 35** address the communal intention in light of the priming.

The control (non-primed) cohort showed a unique positive correlations between their communal intentions and Security Social (r=.372* - a subset of the higher order value of Conservation); whilst this was not seen in the primed cohort.

Meanwhile, the communal intention of the primed cohort correlated positively with Universalism Tolerance (r=.635** - a subset of the communal higher order value of Self Transcendence), the Higher Order Value of Self Transcendence (r=.421*), social consciousness (r=.338*), and Empathy (Sum) (r=.364*); whereas similar correlations were not found in the non-primed cohort. See **Table 35** for more information. As communal values of Self Transcendence, empathy and consciousness are known to positively associate with human-centred designing engagement and social consideration (see Literature Review), the present findings of **Table 35**, therefore, are indicators of a subtle positive influence of the priming, on characterising empathy (and its extensions, i.e., consciousness), acting in accordance to what was intended in the Methodology (unlike what was seen in intervention variation 1– reasonings to this was not further empirically studied in the present project, and therefore calls for further research; however, this finding hints towards that the method of priming may have had an impact on the priming's influence on the students). These findings showing the subtle or 'hidden' (and *strong*, r=.635** with Universalism Tolerance) positive impact of priming (as opposed the 'bold' negative seen in intervention variation 1) on students' characteristics known to be positively associated with human-centred designing therefore calls for further understanding of the mechanism of priming and its interaction with students of engineering in particular, unpacking its possible dissonance in influence on students as *people* (i.e., human beings, with a unconscious go-to emotional drivers to decision making and engagement) as opposed to *engineers* (i.e., human-beings with conscious go-to logical, technical drivers to decision-making and engagement) – see Daniel Kahneman's "Thinking, Fast and Slow" (2011) on what he calls 'System 1 and System 2 thinking' (respectively). Moreover, this also calls for further understanding how this associates with the 'engineering identity formation' (as reviewed in the Literature Review), and how the values of the students as people may intertwine (or clash) with the values they cultivate from the more agentic, technocentric engineering paradigm with time.

*V2-RQ9. Finally, can an equation be developed to predict students' likelihood of Communal Design production given students' personal values and other characteristics' scores?*

To produce a mathematical equation predictive of the students' likelihood of producing Communal Designs, based on their responses to questionnaires on personal values, empathy, consciousness (etc.), two analyses have to be calculated, a Factor Analysis and then a Binary Logistic Regression; both using SPSS. It was found that a sample size (N) greater than 25 is adequate enough to compute a regression analysis (Jenkins & Quintana-Ascencio, 2020).

V2-RQ9 (i): Factor Analysis

A factor reduction analysis has been computed to test for the suitability of the data collected, and to thereafter perform a logistical regression model that predicts students' production of Communal Design based upon their provided characteristics scores (i.e., scores of personal values, empathy, consciousness etc.) and their exposure to the priming. The suitability of sampling is tested via a Kaiser Meyer Olkin (KMO) test (Kaiser, 1974; Kaiser & Rice, 1974), whereas the strength of the relationship among variables is assessed through Bartlett's test of sphericity (Bartlett, 1954), which assesses the validity and adequacy of the responses collected to solve the research question proposed in this section (i.e., V2-RQ9). Both the factor reduction and the binary logistics tests have been computed using IBM SPSS.

The sampling is thought to be acceptable if the value of Kaiser Meyer Olkin is larger than 0.5 (see (Kaiser, 1974; Kaiser & Rice, 1974)). Whereas if significance (i.e., p-value<.05) was yielded from the Bartlett test, the data collected would then be accepted and be considered fit for further analyses (Field, 2018; Pallant, 2020) and is thus suitable for responding to the proposed research question. Accepted data on variables (i.e., characteristics) would then be fed into a binary logistic model to predict students' likelihood of producing of Communal Designs. The test was computed using SPSS.

**Table *36*** displays all the variables entered into the factor analysis test for intervention variation 2 – displaying the count number, the means and standard variations for each of the characteristics of civil engineering students.

*Table 36 - Variation 2 Factor Analysis Descriptive Statistics*

| Descriptive Statistics | | | |
|---|---|---|---|
| | Mean | Std. Deviation | Analysis N |
| Self Direction Thought | .54740 | .838490 | 52 |
| Self Direction Action | .46727 | .864427 | 52 |
| Stimulation | .33266 | .893809 | 52 |
| Hedonism | .84548 | .802105 | 52 |
| Achievement | .39676 | .774359 | 52 |
| Power Dominance | -1.23785 | 1.003325 | 52 |
| Power Resources | -.70901 | 1.271122 | 52 |
| Face | -.29875 | 1.046849 | 52 |
| Security Personal | .27497 | .910504 | 52 |
| Security Societal | -.00067 | 1.138256 | 52 |
| Tradition | -1.01029 | 1.182322 | 52 |
| Conformity Rules | -.34042 | 1.006327 | 52 |
| Conformity Interpersonal | -.22824 | 1.193362 | 52 |
| Humility | .19804 | .877512 | 52 |
| Universalism Nature | -.01991 | 1.079600 | 52 |
| Universalism Concern | .67881 | .705268 | 52 |
| Universalism Tolerance | .74291 | .615835 | 52 |
| Benevolence Care | .80381 | .626651 | 52 |
| Benevolence Dependability | .61791 | .691553 | 52 |
| Self Consciousness | 35.19 | 9.792 | 52 |
| Social Consciousness | 3.30128 | .556246 | 52 |
| Agentic Value | 5.08974 | 1.379298 | 52 |
| Communal Value | 7.40256 | .829201 | 52 |
| Empathy: Fantasy | 12.63 | 4.822 | 52 |
| Empathy: Empathic Concern | 17.96 | 3.248 | 52 |
| Empathy: Perspective Taking | 16.81 | 4.159 | 52 |
| Empathy: Personal Distress | 10.48 | 3.998 | 52 |
| Social Desirability | 6.77 | 2.422 | 52 |

*Table 37 - Variation 2 Factor Analysis FMO and Bartlett's Test*

| **KMO and Bartlett's Test** | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .513 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 782.585 |
| | df | 378 |
| | Sig. | <.001 |

**Table 37** shows that the KMO measure of the characteristics addressed in **Table *36*** for intervention variation 2 is .513 (i.e., KMO>0.5), indicating sampling acceptance (Kaiser, 1974; Kaiser & Rice, 1974) and adequacy. **Table 37** also shows that the Bartlett's Test of Sphericity indicates significance (p<.001), therefore indicating that the measures (or characteristics) specified in **Table *36*** are fit for further analyses (Bartlett, 1954) – i.e., input into a binary logistic model to predict Communal Design production.

As the following variables (i.e., characteristics) displayed in **Table *36*** were found fit for further analyses, they were input into a binary logistics regression model to predict the likelihood of production of Communal Designs using them.

V2-RQ9 (ii) Binary Logistics

Logistic regressions "estimate for the likelihood that an event occurs, given a set of conditions" (Sweet & Grace-Martin, 2003). When the output (or predicted event) is dichotomous in nature, then binary logistics regressions are computed. Logistic regressions do not claim to predict the behaviour of an individual, but it can, however, predict behaviour based on several given conditions to that individual (or inputs to a model) together (see (Sweet & Grace-Martin, 2003)).

Binary logistic regressions produce logistic coefficients ($\beta$) and exponentiated logistic coefficients (Exp($\beta$)) of the analysis. Logistic coefficients are observed to determine the direction of relationship (i.e., positive or negative) with the output, whereas the exponentiated logistic coefficients directly resembles the magnitude of change in the odds value, from which one can determine the probability of the output happening based on the corresponding characteristic. The following formula is used to calculate said probability: *Probability*= $\frac{Odds}{1+Odds}$ (see (Sreejesh, Mohapatra, & Anusree, 2014; Sweet & Grace-Martin, 2003) for more information). The outcome (y) on whether a Communal Design is to be produced (1) or not (0) is therefore calculated using the following formula: $y = \frac{Exp(\beta_0+\beta X_1+\beta X_2+etc.)}{1+Exp(\beta_0+\beta X_1+\beta X_2+etc.)}$ . Using the outputs of a logistic regression, one can determine a predictive equation for the production of Communal Designs using the variables (scores of characteristics) entered into the model. The present regression has been computed on SPSS.

**Table 38** to **Table 40** show descriptives of the number of counts (N) and the coding used for the present regression analysis. For this regression, the output 'Not Produced Communal Designs' is coded as 0; whilst 'Produced Communal Designs' is coded 1. Similarly, the independent variable (input) of those primed is coded as 1, whereas the non-primed is coded 0. "The Classification table indicates how many correct and incorrect predictions would be made for a wide range of probability cut-off points used for the model" (Sreejesh, Mohapatra, & Anusree, 2014). In the present case, 55.8% of the outputs are correctly predicted without the input of variables, i.e., in block 0 (the null) classification table (see **Table 41**). Data in block 0 will be compared against the block 1 classification table after the input of variables (characteristics) hypothesised to contribute to the output (production of Communal Designs), to see how the input of the variables makes a difference on the predictability of the model. This will be addressed in the next few paragraphs.

*Table 38 - Variation 2 Regression Cases (N)*

| **Case Processing Summary** | | | |
|---|---|---|---|
| Unweighted Cases[a] | | N | Percent |
| Selected Cases | Included in Analysis | 52 | 48.1 |
| | Missing Cases | 56 | 51.9 |
| | Total | 108 | 100.0 |
| Unselected Cases | | 0 | .0 |
| Total | | 108 | 100.0 |
| a. If weight is in effect, see classification table for the total number of cases. | | | |

*Table 39 - Variation 2 Coding of Dependent Variable: Produced Communal Designs (Y) vs. Not Produced Communal Designs (N)*

| **Dependent Variable Encoding** | |
|---|---|
| Original Value | Internal Value |
| N | 0 |
| Y | 1 |

*Table 40 - Variation 2 Coding of Independent Variable: Primed (Y) vs. Non-Primed (N)*

| Categorical Variables Codings | | | |
|---|---|---|---|
| | | Frequency | Parameter coding |
| | | | (1) |
| Primed? | N | 31 | .000 |
| | Y | 21 | 1.000 |

*Table 41 - Variation 2 Block 0 (i.e., before entering variables) Classification Table; Variation 2 Null Table*

| Classification Table[a,b] | | | | | |
|---|---|---|---|---|---|
| | Observed | | Predicted | | |
| | | | Produced Communal Design? | | Percentage Correct |
| | | | N | Y | |
| Step 0 | Produced Communal Design? | N | 29 | 0 | 100.0 |
| | | Y | 23 | 0 | .0 |
| | Overall Percentage | | | | 55.8 |
| a. Constant is included in the model. | | | | | |
| b. The cut value is .500 | | | | | |

**Table 42** shows how each variable (characteristic) independently influence the output (production of Communal Design); it shows that Security Societal (p=.022), Universalism Concern (p=.007) are the only characteristics that can contribute to the output independently (i.e., before considering their influence within a model, in combination with other variables). Characteristics contributing independently will be compared to those contributing all together (as a model). This will be addressed in the next few paragraphs, when discussing the *Omnibus Test of Model Coefficients*.

*Table 42 - Variation 2 Block 0 Variables Not in the Equation (i.e., weight of parameters in null model)*

| Variables not in the Equation | | | | | |
|---|---|---|---|---|---|
| | | | Score | df | Sig. |
| Step 0 | Variables | Self Direction Thought | 2.095 | 1 | .148 |
| | | Self Direction Action | 1.289 | 1 | .256 |
| | | Stimulation | .363 | 1 | .547 |
| | | Hedonism | .006 | 1 | .939 |
| | | Achievement | 1.017 | 1 | .313 |
| | | Power Dominance | .894 | 1 | .344 |
| | | Power Resources | 3.310 | 1 | .069 |
| | | Face | 1.648 | 1 | .199 |
| | | Security Personal | 2.630 | 1 | .105 |
| | | Security Societal | 5.242 | 1 | .022 |
| | | Tradition | .134 | 1 | .714 |
| | | Conformity Rules | 2.469 | 1 | .116 |
| | | Conformity Interpersonal | .441 | 1 | .507 |
| | | Humility | 7.158 | 1 | .007 |
| | | Universalism Nature | .365 | 1 | .546 |
| | | Universalism Concern | 7.212 | 1 | .007 |
| | | Universalism Tolerance | .724 | 1 | .395 |
| | | Benevolence Care | .174 | 1 | .677 |
| | | Benevolence Dependability | .000 | 1 | .995 |
| | | Primed?(1) | 2.381 | 1 | .123 |
| | | Self Consciousness | 2.845 | 1 | .092 |
| | | Social Consciousness | .798 | 1 | .372 |
| | | Agentic Value | .950 | 1 | .330 |
| | | Communal Value | .004 | 1 | .953 |
| | | Empathy: Fantasy | .044 | 1 | .833 |
| | | Empathy: Empathic Concern | .357 | 1 | .550 |
| | | Empathy: Perspective Taking | 1.420 | 1 | .233 |
| | | Empathy: Personal Distress | 1.785 | 1 | .182 |
| | | Social Desirability | 2.183 | 1 | .140 |
| | Overall Statistics | | 29.806 | 29 | .424 |

The Omnibus test is interpreted to show that, when all variables are considered together (as a model) to predict the output, the model is determined significant or not (i.e., fit to predict or not) by addressing its significance (i.e., p<.05). **Table 43** shows that the model is significant (p<.001), inferring that when all variables (i.e., characteristics) are considered together in a model, they significantly contribute to (or are influential on) the output.

*Table 43 - Variation 2 Omnibus Test of Model Coefficients*

| **Omnibus Tests of Model Coefficients** | | | | |
|---|---|---|---|---|
| | | Chi-square | df | Sig. |
| Step 1 | Step | 71.393 | 29 | <.001 |
| | Block | 71.393 | 29 | <.001 |
| | Model | 71.393 | 29 | <.001 |

To assess the model's fit and predictive ability, the Nagelkerke $R^2$ value and the Hosmer and Lemeshow test are observed (Sreejesh, Mohapatra, & Anusree, 2014). The closer the value for Nagelkerke $R^2$ is to 1, the better the fit of the model, and it is observed in **Table 44** that the value of Nagelkerke $R^2$ is 1.000, indicating a very high fitness of the model. As for assessing the predictive ability of the model, observing **Table 45**, it is seen that the p-value of the Hosmer and Lemeshow test equals to 1 (i.e., p>.05), suggesting a that the present model has a good predictive value (Sreejesh, Mohapatra, & Anusree, 2014); this can also be seen in the last row presented in **Table 46**, where the predicted Communal Values (10.000) is close to (or in this case, exactly equal to) those actual/observed Communal Designs collected – i.e., for every 10 observed/counted Communal Designs counts, the present model have correctly predicted 10 of them. These observations therefore indicate that the model composed of the variables listed in **Table 48** is a fit and reliable tool for predicting whether students will produce Communal Designs or not, based on data to be collected on their characteristics (listed in **Table 48**).

Moreover, after the input of variables, it is seen that 100% of the outputs are correctly predicted with the input of variables; i.e., in block 1 classification table (see **Table 47**); this means that with the input of the variables, the model became a better predictor of outputs when compared to the block 0 classification table (before input the variables), i.e., **Table 41** (which showed that only 55.8% of the outputs are correctly predicted without the input of variables into the model).

*Table 44 - Variation 2 Model Fitness*

| **Model Summary** | | | |
|---|---|---|---|
| Step | -2 Log likelihood | Cox & Snell R Square | Nagelkerke R Square |
| 1 | .000[a] | .747 | 1.000 |
| a. Estimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found. | | | |

*Table 45 - Variation 2 Model Predictive Ability*

| **Hosmer and Lemeshow Test** | | | |
|---|---|---|---|
| Step | Chi-square | df | Sig. |
| 1 | .000 | 8 | 1.000 |

*Table 46 - Variable 2 Contingency Table for Hosmer and Lemeshow Test*

| **Contingency Table for Hosmer and Lemeshow Test** | | | | | | |
|---|---|---|---|---|---|---|
| | | Produced Communal Design? = N | | Produced Communal Design? = Y | | Total |
| | | Observed | Expected | Observed | Expected | |
| Step 1 | 1 | 5 | 5.000 | 0 | .000 | 5 |
| | 2 | 5 | 5.000 | 0 | .000 | 5 |
| | 3 | 5 | 5.000 | 0 | .000 | 5 |
| | 4 | 5 | 5.000 | 0 | .000 | 5 |
| | 5 | 5 | 5.000 | 0 | .000 | 5 |
| | 6 | 4 | 4.000 | 1 | 1.000 | 5 |
| | 7 | 0 | .000 | 5 | 5.000 | 5 |
| | 8 | 0 | .000 | 5 | 5.000 | 5 |
| | 9 | 0 | .000 | 2 | 2.000 | 2 |
| | 10 | 0 | .000 | 10 | 10.000 | 10 |

*Table 47 - Variation 2 Block 1 (i.e., after entering variables) Classification Table*

| Classification Table[a] | | | | | |
|---|---|---|---|---|---|
| | Observed | | Predicted | | |
| | | | Produced Communal Design? | | Percentage Correct |
| | | | N | Y | |
| Step 1 | Produced Communal Design? | N | 29 | 0 | 100.0 |
| | | Y | 0 | 23 | 100.0 |
| | Overall Percentage | | | | 100.0 |
| a. The cut value is .500 | | | | | |

**Table 48** shows the logistic coefficients (B) and exponentiated logistic coefficients (Exp(B)) of the analysis. Logistic coefficients are observed to determine the magnitude and direction (i.e., positive or negative) of relationship  or influence of the characteristic on  the output, whereas the exponentiated logistic coefficients directly resembles the magnitude of change in the odds value; from which one can determine the probability of the output happening based on a single variable (see (Sreejesh, Mohapatra, & Anusree, 2014; Sweet & Grace-Martin, 2003)). The coefficients (i.e., personal value and other characteristics' scores) can be used to develop an equation predictive of the likelihood of producing Communal Designs (y=1), or not produce Communal Designs (y=0); see **Equation 2** on the following few pages.

*Table 48 – Variation 2 Block 1 Variables in the Equation (i.e., weight of parameters in the model after entering variables)*

| Variables in the Equation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | B | S.E. | Wald | df | Sig. | Exp(B) | 95% C.I.for EXP(B) | |
| | | | | | | | | Lower | Upper |
| Step 1[a] | Self Direction Thought | 90.758 | 43846.935 | .000 | 1 | .998 | 2.606E+39 | .000 | . |
| | Self Direction Action | -151.092 | 74197.169 | .000 | 1 | .998 | .000 | .000 | . |
| | Stimulation | 3.436 | 18496.359 | .000 | 1 | 1.000 | 31.053 | .000 | . |
| | Hedonism | -10.967 | 20738.602 | .000 | 1 | 1.000 | .000 | .000 | . |
| | Achievement | 18.576 | 129967.286 | .000 | 1 | 1.000 | 116769956.810 | .000 | . |
| | Power Dominance | -32.364 | 111171.009 | .000 | 1 | 1.000 | .000 | .000 | . |
| | Power Resources | 107.135 | 42048.473 | .000 | 1 | .998 | 3.373E+46 | .000 | . |
| | Face | -69.392 | 146327.371 | .000 | 1 | 1.000 | .000 | .000 | . |
| | Security Personal | -20.284 | 82170.337 | .000 | 1 | 1.000 | .000 | .000 | . |
| | Security Societal | 50.730 | 69009.450 | .000 | 1 | .999 | 1075518798746986800000.000 | .000 | . |
| | Tradition | -21.184 | 64976.733 | .000 | 1 | 1.000 | .000 | .000 | . |
| | Conformity Rules | -100.736 | 21618.062 | .000 | 1 | .996 | .000 | .000 | . |
| | Conformity Interpersonal | 17.616 | 9137.637 | .000 | 1 | .998 | 44703869.973 | .000 | . |
| | Humility | -32.256 | 108000.463 | .000 | 1 | 1.000 | .000 | .000 | . |
| | Universalism Nature | -26.733 | 16260.801 | .000 | 1 | .999 | .000 | .000 | . |
| | Universalism Concern | -94.626 | 61220.726 | .000 | 1 | .999 | .000 | .000 | . |
| | Universalism Tolerance | 45.449 | 50705.474 | .000 | 1 | .999 | 547479610262243100000.000 | .000 | . |
| | Benevolence Care | 42.649 | 66058.175 | .000 | 1 | .999 | 332802581851038620000.000 | .000 | . |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Benevolence Dependability | 85.670 | 115371.245 | .000 | 1 | .999 | 1.607E+37 | .000 | . |
| | Primed?(1) | -47.011 | 20393.826 | .000 | 1 | .998 | .000 | .000 | . |
| | Self Consciousness | .996 | 5255.148 | .000 | 1 | 1.000 | 2.708 | .000 | . |
| | Social Consciousness | 59.909 | 46741.026 | .000 | 1 | .999 | 10431008597001347000000000.000 | .000 | . |
| | Agentic Value | -35.282 | 36857.419 | .000 | 1 | .999 | .000 | .000 | . |
| | Communal Value | 47.339 | 38069.023 | .000 | 1 | .999 | 362429194647667150000.000 | .000 | . |
| | Empathy: Fantasy | 3.771 | 4727.414 | .000 | 1 | .999 | 43.427 | .000 | . |
| | Empathy: Empathic Concern | 1.528 | 16384.551 | .000 | 1 | 1.000 | 4.607 | .000 | . |
| | Empathy: Perspective Taking | -12.520 | 4487.226 | .000 | 1 | .998 | .000 | .000 | . |
| | Empathy: Personal Distress | 1.433 | 9865.121 | .000 | 1 | 1.000 | 4.191 | .000 | . |
| | Social Desirability | 8.802 | 10723.532 | .000 | 1 | .999 | 6650.174 | .000 | . |
| | Constant | -384.207 | 377067.480 | .000 | 1 | .999 | .000 | | |

a. Variable(s) entered on step 1: Self Direction Thought, Self Direction Action, Stimulation, Hedonism, Achievement, Power Dominance, Power Resources, Face, Security Personal, Security Societal, Tradition, Conformity Rules, Conformity Interpersonal, Humility, Universalism Nature, Universalism Concern, Universalism Tolerance, Benevolence Care, Benevolence Dependability, Primed?, Self Consciousness, Social Consciousness, Agentic Value, Communal Value, Empathy: Fantasy, Empathy: Empathic Concern, Empathy: Perspective Taking, Empathy: Personal Distress, Social Desirability.

Observing **Table 48,** one could therefore determine a predictive equation for the production of Communal Design. With the logistic regression equation being

*Equation 1 - Logistic Regression Equation (see (Sreejesh, Mohapatra, & Anusree, 2014; Sweet & Grace-Martin, 2003))*

$$y = \frac{Exp(\beta_0+\beta X_1+\beta X_2+etc.)}{1+Exp(\beta_0+\beta X_1+\beta X_2+etc.)},$$

the present findings determine the equation for the likelihood production of Communal Designs (i.e., y (output)= between 0 (i.e., not produce Communal Design) and 1 (i.e., produce Communal Design)) as:

*Equation 2 - Intervention Variation 2 Equation Predictive of Communal Design Production*

$$y_{(intervention\ variation\ 2)} = \frac{\begin{array}{c} Exp(-384.207+90.758X_1\mp 151.092X_2+3.436X_3-10.967X_4+18.576X_5-32.364X_6+107.135X_7-69.392X_8-20.284X_9+50.730X_{10}-21.184X_{11}-100.736X_{12}+17.616X_{13} \\ -32.256X_{14}-26.733X_{15}-94.626X_{16}+45.449X_{17}+42.649X_{18}+85.670X_{19}-47.011X_{20}+0.996X_{21}+59.909X_{22}-35.282X_{23}+47.339X_{24}+3.771X_{25}+1.528X_{26}-12.520X_{27}+1.433X_{28}+8.802X_{29}) \end{array}}{\begin{array}{c} 1+Exp(-384.207+90.758X_1\mp 151.092X_2+3.436X_3-10.967X_4+18.576X_5-32.364X_6+107.135X_7-69.392X_8-20.284X_9+50.730X_{10}-21.184X_{11}-100.736X_{12}+17.616X_{13} \\ -32.256X_{14}-26.733X_{15}-94.626X_{16}+45.449X_{17}+42.649X_{18}+85.670X_{19}-47.011X_{20}+0.996X_{21}+59.909X_{22}-35.282X_{23}+47.339X_{24}+3.771X_{25}+1.528X_{26}-12.520X_{27}+1.433X_{28}+8.802X_{29}) \end{array}}$$

Where the $\beta_0$ is the constant; and the $\beta_x's$ are the values displayed in the 'B' column in **Table 48**, in the same order, running from the top of the column (i.e., $\beta_1$) till the bottom of the column (i.e., $\beta_{29}$); see **Table 48**. In **Equation 2**, $X_1$= Self Direction Thought score, $X_3$= Self Direction Action score, $X_3$= Stimulation score, $X_4$= Hedonism score, $X_5$= Achievement score, $X_6$= Power Dominance score, $X_7$= Power Resources score, $X_8$= Face score, $X_9$= Security Personal score, $X_{10}$= Security Social score, $X_{11}$= Tradition score, $X_{12}$=Conformity Rules scores, $X_{13}$= Conformity Interpersonal score, $X_{14}$= Humility score, $X_{15}$=Universalism Nature score, $X_{16}$= Universalism Concern score, $X_{17}$= Universalism Tolerance score, $X_{18}$= Benevolence Care score, $X_{19}$= Benevolence Dependability score, $X_{20}$ = Priming factor score, $X_{21}$= Self Consciousness score, $X_{22}$= Social Consciousness score, $X_{23}$= Agentic Value score, $X_{24}$= Communal Value score, $X_{25}$= Empathy: Fantasy score, $X_{26}$= Empathy: Empathic Concern score, $X_{27}$= Empathy: Perspective Taking score, $X_{28}$= Empathy: Personal Distress score, and $X_{29}$= Social Desirability score. This equation was primarily developed to show how, and to what extent, do each of the individual characteristics (like personal values, empathy, and consciousness, etc.) contribute to the likelihood of producing Communal Designs. Based on the data displayed in **Table 48**, and the coefficients of the factors displayed in **Equation 2**, it seems that the students' Self Direction score, followed by the Power Resources score, then followed by the Conformity Rules score, were the most influential factors, or mindset characteristics (addressed in intervention variation 2), contributing to the production of Communal Designs (or not producing Communal Designs – as some were 'negative' coefficients (B)). It was interesting to observe that Self Direction Action and Conformity Rules contributed negatively, whilst Power Resources contributed positively to the likelihood of producing Communal Designs. With the highest (positive) odds being associated with Power Resources, these findings then highlight an apparent strong agentic motive (as opposed to a communal one) behind Communal Design production in civil engineering education – further elaborating on the presence of an apparent aforementioned cognitive dissonance. Moreover, as much as empathy has been glorified in the context of producing human-centric designs in the literature review, the present findings show that personal values, and other characteristics, hold greater (larger) coefficients contributing to higher likelihood of producing Communal Designs, compared to the different facets of empathy (see **Table 48**). Additionally, in the present model, it was also seen that the priming factor had a negative contribution to the likelihood of producing Communal Designs (see **Table 48**); i.e. indicating a negative influence of priming in intervention variation 2 on the production of Communal Designs. Finally however, none of the characteristics displayed in **Table 48** had a significant p-value, indicating that the characteristics do not have a significant effect on the probability of Communal Design production; indicating that the data values entered into the model are equally suggestive of improving or decreasing the probability of Communal Design production (see (Field, 2018) for more information). However, the Nagelkerke $R^2$ value indicated that 100% of the variance in the production of Communal Design probability can be explained by variances in the predictive characteristics entered into the model (see **Table 44**), indicating a high fitness of the model, as a whole.

### 5.2.4 Summary

This intervention variation was to observe how personal values of civil engineering students influence or associate with their engagement with human-centred designing, and the type of designs they produce. This was carried forward from the findings of intervention variation 1 for further research, and to serve by unpacking the 'subjectivity' of sustainable decision making in civil engineering (see **Figure 2 - 'PhD Track of Thought' Flowchart**, for more information). There is discourse STEM disciplines (and by extension, civil engineering) have personal values being rooted in *Agency*, as opposed to *Communion* – which translates to them being rooted in Higher Order Values of *Self Enhancement* and *Openness to Change*, as opposed to *Self Transcendence* and *Conservation* (see **Figure 5**). Unlike others, the present findings show that the majority (60.87%) of civil engineering students have personal values rooted in the communal Higher Order Value of Self Transcendence, followed by almost a third (27.17%) of them hold personal values rooted in the agentic Higher Order Value of Openness to Change. To make it more interesting, it was found that although those with personal values rooted in the communal Self Transcendence showed higher engagement (i.e., higher scores of characteristics known to be positively associated with human-centred designing) during the human-centred designing assignments compared to those with values rooted in Openness to Change; however, it was those with personal values rooted in the agentic Openness to Changes that were significantly more likely to produce Communal Designs (which is a human-centred design with extra emphasis on metaphysical needs as well as physical needs of the end-user). This proposed a series of scepticism, for example in the 'truthfulness' of students' self-report on their personal values, and/or in the prevalence of a viable cognitive dissonance, or an intention behaviour gap, in students perhaps intending to produce Communal Designs (i.e., by showing higher engagement with the design), but then later failed to eventually produce them. The latter was discussed to be possibly due to inadequate non-technical training, which would enable students to build upon these engagements and communal intentions. The influence of priming on such engagements and Communal Design production was also observed, where the priming showed a 'subtle' positive influence on cultivating the communal intention in the students. These findings will be discussed in further detail, in the Discussions chapter.

### 5.3 Intervention Variation 3 Results

Recap, classification of perfectionism categories using the ASP-R instrument in intervention variation 3, was based on cut-off points proposed by Gilman, Adams, & Nounopoulos (2010).

#### 5.3.1 Recap on Hypotheses and Intervention Variant Specific Research Questions

<u>Intervention Variant 3 Proposed Hypotheses:</u>

V3-H1. Based on the notions addresses in the literature review, linking the positivistic manner of problem solving to that of perfectionism, it is therefore hypothesised that civil engineering undergraduates are more likely to be Perfectionists, as opposed to Non-Perfectionists.

V3-H2. Due to the existing literature on positivism rejecting metaphysical input (i.e., empathy-informed ones) to problem solving methodologies, and perfectionists being less likely to be display creative attributes in nature, it is therefore hypothesised that Perfectionists are less likely than Non-Perfectionists to 'fully' engage with Design Thinking approaches and thus with the human-centred designing assignment (i), and subsequently, are less likely to produce Communal Designs (ii). Note that V3-H2 does not assume that such perfectionistic individuals cannot consciously apply a creative design approach needed for the design thinking and human-centred designing, it implies that due to the reviewed research found on perfectionism being likely to hinder creativity in people, it was hypothesised that perfectionists are therefore naturally less likely than non-perfectionists to display creative attributes (needed for 'proper' engagement with design thinking), and are therefore less likely to 'properly' engage with design-thinking driven human-centred designing workshop/assignment, in their natural state or without any prior intervention to prompt creativity in said students.

V3-H3. By extension to Variation3-Hypothesis2 (V3-H2), it is therefore hypothesised that Perfectionists to be less likely than Non-Perfectionists to positively engage with (or respond to) the priming; where the priming is intended to channel students' mindset towards one more aligned with a human-centred designing, promoting empathy (i.e., a notion likely to be rejected by those adopting positivistic approaches, which are presently hypothesised to be perfectionists (see V3-H1)) during their design.

<u>Intervention Variant 3 Proposed Research Questions:</u>

V3-RQ1. How common is perfectionism amongst civil engineering students?

V3-RQ2. How does perfectionism associate with Communal Design Production?

V3-RQ3. How does perfectionism associate with other characteristics (like prosocial behaviour and intention, empathy, and consciousness) that are known to be positively associated with human-centred designing engagement and Communal Design production?

V3-RQ4. How does Communal Design production and perfectionism associate with Social Desirability scores – thus, with intrinsic and/or extrinsic motives of the students for the design?

V3-RQ5. What is the effect of the Priming on the engagement with the Human-Centred Designing assignment (i.e., empathy, consciousness, and prosocial behaviour) and Communal Design production, in light of perfectionism?

V3-RQ6. Reiterating on V3-RQ2 and V3-RQ3 for self-cross-check – Intervention Variation 3.

V3-RQ7. What are the differences in characteristics of those who produced Communal Designs as opposed to those who did not produce Communal Designs? – Intervention Variation 3.

V3-RQ8 How (if) does the intention-behaviour gap manifests in light of the Civil Engineering Undergraduates' Perfectionism?

V3-RQ9. Finally, can an equation be developed to predict students' likelihood of Communal Design production given students' perfectionism and other characteristics' scores?

### 5.3.2 Sample Logistics

This case study involved first-year and third-year civil engineering students at Swansea University, Wales.

90 first-year civil engineering students were involved in this study (11.1% of them were female, and 13.3% were international students).

94 third-year civil engineering students were also involved in this study (17.0% of them were female, 2.1% non-binary, and 28.7% were international students).

In total, this case study involved 184 civil engineering undergraduate students (14.1% of them were female, 1.1% non-binary, and 21.2% international students).

A total of 78 individual APS-R questionnaires were submitted by first-year civil engineering undergraduates, and a total of 67 individual APS-R questionnaires were submitted by third-year civil engineering undergraduates – this was Phase I of the study (see **Figure 9**).

Moreover, a total of 90 individual designs were collected from first-year students at the end of Phase II of the study (see **Figure 9**) – note that, these are the designs collected in total, of which some were declared Communal Designs later. In addition, 89 individual questionnaire(s) responses (i.e., SSA, IRI, Prosocialness Scale for Adults, Prosocial Behavioral Intention Scale, MPS-SF, and Social Desirability) were collected from first-year students at the end of Phase II of the study too (see **Figure 9**).

Similarly, a total of 94 individual designs were collected from third-year students at the end of Phase II of the study (see **Figure 9**) – note that, these are the designs collected in total, of which some were declared Communal Designs later. Moreover, 90 individual questionnaire(s) responses (i.e., SSA, IRI, Prosocialness Scale for Adults, Prosocial Behavioral Intention Scale, MPS-SF, and Social Desirability) were collected from third-year students at the end of Phase II of the study too (see **Figure 9**).

48 out of the 90 first-year students (who both delivered a design and end-of-task questionnaire responses) were primed; whilst 42 out of the 90 contributed as the control (non-primed) group, in this study. Likewise, 52 out of the 94 third-year students (who both delivered a design and end-of-task questionnaire responses) were primed; whilst 42 out of the 94 contributed as the control (non-primed) group, in this study.

Examples of Communal Designs Produced in Intervention Variation 3 displayed in **Table 129**, found in Appendix B. **Table 129** displays extracts of the conceptual designs produced by the civil engineering undergraduates – i.e., examples of what permitted these designs' classifications as Communal Designs (as opposed to *Not* Communal Designs).

### 5.3.3 Quantitative

Due to the categorical and continuous nature of the data to be analysed in this study variation, Pearson chi square tests have been analysed to observe the associations between categories. Also, two-tailed heteroscedastic t-tests to compare the means between two groups, and Pearson correlative tests have been computed to observe the correlations between characteristics. All tests were computed using MS Excel and/or IBM SPSS. Significance obtained are all within a confidence interval of 95%, by default.

*V3-RQ1. How common is perfectionism amongst civil engineering students?*
*Table 49 - Breakdown of first-year civil engineering undergraduates' Perfectionism categories*

| ASP-R Perfectionism Category | Number of Year 1 Students (N) | Percentage of Year 1 Students (%) |
|---|---|---|
| Non-Perfectionists | 19 | 24.36 |
| Adaptive Perfectionists | 20 | 25.64 |
| Maladaptive Perfectionists | 39 | 50.00 |
| Total | 78 | 100 |

**Table 49** shows that 75.64% of first year civil engineering undergraduates indeed categorise as perfectionists – with 72% of the first-year perfectionists being maladaptive perfectionists (as opposed to adaptive perfectionists).

*Table 50 - Breakdown of third-year civil engineering undergraduates' Perfectionism categories*

| Perfectionism Category | Number of Year 3 Students (N) | Percentage of Year 3 Students (%) |
|---|---|---|
| Non-Perfectionists | 18 | 26.87 |
| Adaptive Perfectionists | 14 | 20.89 |
| Maladaptive Perfectionists | 35 | 52.24 |
| Total | 67 | 100 |

**Table 50** shows that 73.13% of third year civil engineering students indeed categorise as perfectionists – with 71.43% of the third-year perfectionists being maladaptive perfectionists (as opposed to adaptive perfectionists).

*Table 51 – Comparative breakdown of civil engineering undergraduates' Perfectionism categories*

| Perfectionism Category | Number of Year 1 Civil Engineering Students (%) | Number of Year 3 Civil Engineering Students (%) | Row Totals |
|---|---|---|---|
| Non-Perfectionists | 19 (24.36%) | 18 (26.87%) | 37 (25.52%) |
| Adaptive Perfectionists | 20 (25.64%) | 14 (20.89%) | 34 (23.45%) |
| Maladaptive Perfectionists | 39 (50.00%) | 35 (52.24%) | 74 (51.03%) |
| Total (Column Totals) | 78 (100%) | 67 (100%) | Grand Total = 145 (100%) |

To observe and comparing perfectionism categories of either year group, a Pearson chi-square test of independence was performed to examine the relation between perfectionism categories of students and the year group they belong to. The relation between these variables was found not significant, as the test showed that there was no significant association between the different year groups and the breakdown of the perfectionism categories, $X^2$ *(2, N = 145) = 0.470, p = .790;* see **Table 51** for more information. This suggests that the majority of civil engineering students categorise as perfectionists (with the majority of the perfectionists being maladaptive), regardless of their year group, and/or their progression in the civil engineering curriculum.

To further explore how APS-R Perfectionism subsets (i.e., the Standard, Discrepancy, and Order scales of perfectionism) may differ across the two year groups, or change with the progression in the engineering programme, a series of two-tailed heteroscedastic t-test was computed to observe such differences, if existing. The results (mean values and p-values) are displayed in **Table 52**; emboldened p-values indicate significance or a tendency-to-be significant.

*Table 52 – A series of two-tailed heteroscedastic t-test on APS-R Perfectionism subsets across the two year groups of civil engineering undergraduates*

| | Standard Scale (ASP-R) | Order Scale (ASP-R) | Discrepancy Scale (ASP-R) |
|---|---|---|---|
| p-value | 0.408 | 0.948 | 0.451 |
| First-Year Civil Engineering Undergraduates | 39.974 | 20.564 | 49.769 |
| Third-Year Civil Engineering Undergraduates | 39.209 | 20.522 | 51.433 |

Emboldened p-values indicate significance or a tendency-to-be significant.

It appears that the two year groups do not have any significant (or tending-to-be significant) differences in APS-R perfectionistic subsets. See **Table 52** for more information.

In summary, it was found that the majority of civil engineering undergraduates appear to hold perfectionistic traits according to their responses to the APS-R Scale (Slaney, Rice, Mobley, Trippi, & Ashby, 2001) and the cut-off points adopted from Gilman, Adams, & Nounopoulos (2010). This was found in both year groups (first- and third-year student groups) studied – see **Table 49** to **Table 51**. **Table 51** shows that 74.48% of civil engineering students classify as perfectionists – with 68.52% of the perfectionists being maladaptive, and 31.48% adaptive.

Note that for further efficiency and simplicity of analyses, maladaptive and adaptive perfectionists subcategories will be combined into a single 'Perfectionist' Category – this will be addressed in comparison to the 'Non-Perfectionist' category. The responses of the two year groups will also be combined, as there appears no significant differences in APS-R responses and perfectionism classification in either year group, nor a significant association between year group and the perfectionism categorical distribution (see ***Table 51*** and ***Table 52***).

The above was done to simplify the research and observations to be made on the associations between the students' perfectionistic traits and their engagement with human-centred, public-welfare considerate initiatives, and subsequent production of Communal Designs – i.e., this is to observe how the trait generally interferes with such engagements and design strategies, as analysing how each subgroup of perfectionism (i.e., maladaptive as opposed to adaptive), and year group (first-year as opposed to third-year) individually associate with human-centred designing and Communal Design production, call for further resources which are outside the scope of this PhD project.

*V3-RQ2. How does perfectionism associate with Communal Design Production?*

*Table 53* - Association of Communal Design Production and Perfectionism Categories (Perfectionists, Non-Perfectionists).

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| Perfectionists | 31 | 77 | 108 |
| Non-Perfectionists | 20 | 17 | 37 |
| Column Totals | 51 | 94 | Grand Total = 145 |

A Pearson chi-square test of independence was performed to examine the relation between perfectionism and the production of Communal Designs. The relation between these variables was found significant, $X^2$ (1, $N$ = 145) = 7.767, $p$ = .005. Perfectionists were significantly more likely than Non-Perfectionists to **not** produce Communal Designs. See ***Table 53*** for more information.

*V3-RQ3. How does perfectionism associate with other characteristics (like prosocial behaviour and intention, empathy, and consciousness) that are known to be positively associated with human-centred designing engagement and Communal Design production?*

*Table 54 – Association of Communal Design Production, Empathy, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy* Scores | 8 | 20 | 28 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy* Scores | 11 | 10 | 21 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relation between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy* scores. The relation between these variables was found tending-to-be significant, $X^2$ (1, $N$ = 49) = 2.866, p = .090. Perfectionists were obscurely tending-to-be more likely than Non-Perfectionists to produce Communal Design whilst having higher-than-average *Empathy* scores. See ***Table 54*** for more information.

*Table 55 - Association of Communal Design Production, Empathy: Empathic Concern, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Empathic Concern* Scores | 4 | 18 | 22 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Empathic Concern* Scores | 15 | 12 | 27 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relation between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Empathic Concern* scores. The relation between these variables was found significant, $X^2$ (1, N = 49) = 7.133, p = .008. Perfectionists were more likely than Non-Perfectionists to produce Communal Design whilst having higher-than-average *Empathy: Empathic Concern* scores. See **Table 55** for more information.

*Table 56 - Association of Communal Design Production, Empathy: Fantasy, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Fantasy* Scores | 5 | 20 | 25 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Fantasy* Scores | 14 | 10 | 24 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relation between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Fantasy* scores. The relation between these variables was found significant, $X^2$ (1, N = 49) = 7.580, p = .006. Perfectionists were more likely than Non-Perfectionists to produce Communal Design whilst having higher-than-average *Empathy: Fantasy* scores. See **Table 56** for more information.

*Table 57 - Association of Communal Design Production, Empathy: Perspective Taking, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Perspective Taking* Scores | 12 | 19 | 31 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Perspective Taking* Scores | 7 | 11 | 18 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relation between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Perspective Taking* scores. The relation between these variables was found not significant, $X^2$ (1, N = 49) = 0.000, p = .990. See **Table 57** for more information.

*Table 58 - Association of Communal Design Production, Empathy: Personal Distress, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Personal Distress* Scores | 10 | 15 | 25 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Personal Distress* Scores | 9 | 15 | 24 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relation between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Personal Distress* scores. The relation between these variables was found not significant, $X^2$ (1, N = 49) = 0.032, p = .858. See **Table 58** for more information.

*Table 59 - Association of Communal Design Production, Self Consciousness, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Self Consciousness* Scores | 5 | 17 | 22 |
| No. of Communal Designs Produced – whilst having lower-than-average *Self Consciousness* Scores | 14 | 13 | 27 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relation between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Self Consciousness* Scores. The relation between these variables was found significant, $X^2$ (1, N = 49) = 4.331, p = .037. Perfectionists were more likely than Non-Perfectionists to produce Communal Design whilst having higher-than-average *Self Consciousness* scores. See **Table 59** for more information.

*Table 60 - Association of Communal Design Production, Social Consciousness, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Social Consciousness* Scores | 6 | 20 | 26 |
| No. of Communal Designs Produced – whilst having lower-than-average *Social Consciousness* Scores | 13 | 10 | 23 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relation between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Social Consciousness* scores. The relation between these variables was found significant, $X^2$ (1, N = 49) = 5.750, p = .016. Perfectionists were more likely than Non-Perfectionists to produce Communal Design whilst having higher-than-average *Social Consciousness* scores. See **Table 60** for more information.

*Table 61 - Association of Communal Design Production, Prosocialness, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Prosocialness* Scores | 4 | 17 | 21 |
| No. of Communal Designs Produced – whilst having lower-than-average *Prosocialness* Scores | 15 | 13 | 28 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relationship between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Prosocialness* scores. The relation between these variables was found significant, $X^2$ (1, N = 49) = 6.025, p = .014. Perfectionists were more likely than Non-Perfectionists to produce Communal Design whilst having higher-than-average *Prosocialness* scores. See **Table 61** for more information.

*Table 62 - Association of Communal Design Production, Prosocial Behavioral Intention, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Prosocial Behavioral Intention* Scores | 9 | 21 | 30 |
| No. of Communal Designs Produced – whilst having lower-than-average *Prosocial Behavioral Intention* Scores | 10 | 9 | 19 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relation between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Prosocial Behavioral Intention* scores. The relation between these variables was found not significant, $X^2$ (1, N = 49) = 2.510, p = .113. See **Table 62** for more information.

*V3-RQ4. How does Communal Design production and perfectionism associate with Social Desirability scores – thus, with intrinsic and/or extrinsic motives of the students for the design?*

*Table 63 - Association of Communal Design Production, Social Desirability, and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Social Desirability* Scores | 8 | 19 | 27 |
| No. of Communal Designs Produced – whilst having lower-than-average *Social Desirability* Scores | 11 | 11 | 22 |
| Column Totals | 19 | 30 | Grand Total = 49 |

A Pearson chi-square test of independence was performed to examine the relationship between Perfectionism and the production of Communal Designs whilst having higher-than-average or lower-than-average *Social Desirability* scores. The relation between these variables was found not significant, $X^2$ (1, N = 49) = 2.119, p = .145; see ***Table 63*** for more information.

However, **Table 64** shows that those categorised as Perfectionists were tending-to-be more likely to have higher-than-average *Social Desirability* scores in general, compared to those categorised as Non-Perfectionists.

*Table 64 - Association of Perfectionism and Social Desirability in civil engineering undergraduates.*

| | Higher-than-average Social Desirability | Lower-than-average Social Desirability | Row Totals |
|---|---|---|---|
| Non-Perfectionists | 16 | 20 | 36 |
| Perfectionists | 66 | 40 | 106 |
| Column Totals | 82 | 60 | Grand Total = 142 |

A Pearson chi-square test of independence was performed to examine the relationship between Perfectionism and *Social Desirability* scores of civil engineering undergraduates. The relation between these variables was found tending-to-be significant, $X^2$ (1, N = 142) = 3.497, p = .061. Perfectionists were tending-to-be more likely than Non-Perfectionists to have higher-than-average *Social Desirability* in general. See **Table 64** for more information.

*V3-RQ5. What is the effect of the Priming on the engagement with the Human-Centred Designing assignment (i.e., empathy, consciousness, and prosocial behaviour) and Communal Design production, in light of perfectionism?*

To observe the association between priming and the production of Communal Designs, whilst temporarily disregarding the association with the perfectionism, a Pearson chi-square test was computed. Results are displayed in ***Table 65***.

*Table 65 - Association of Priming and Communal Design Production – Intervention Variation 3*

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| Primed Cohort | 31 | 69 | 100 |
| Non-Primed Cohort | 36 | 48 | 84 |
| Column Totals | 67 | 117 | Grand Total = 184 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs, regardless of the students' perfectionism for the time being. The relation between these variables was found tending-to-be significant, $X^2$ (1, N = 184) = 2.772, p = .096. Those who were primed were obscurely tending-to-be more likely to **not** produce Communal Designs, than to produce them. See **Table 65** for more information.

To observe the effect of priming on *Communal Design* production in light of the students' perfectionism, a Pearson chi-squared test was computed to observe if indeed an influence was profound. ***Table 66*** displays the results obtained.

*Table 66 - Association of Communal Design Production, Priming and Perfectionism Categories*

| | Non-Perfectionists | Perfectionists | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst being *Primed* (Primed Cohort) | 15 | 11 | 26 |
| No. of Communal Designs Produced – whilst *not being Primed* (Control Cohort) | 5 | 20 | 25 |
| Column Totals | 20 | 31 | Grand Total = 51 |

A Pearson chi-square test of independence was performed to examine the relationship between Perfectionism and the production of Communal Designs whilst being Primed (primed cohort) and non-primed (control cohort). The relation between these variables was found significant, $X^2$ (1, N = 51) = 7.596, p = .006. Non-Perfectionists were significantly more likely than Perfectionists to produced Communal Designs whilst being *Primed*. See **Table 66** for more information.

To further explore the effect of the priming, a series of two-tailed heteroscedastic t-test was computed to observe the differences in responses collected in Phase II (see **Figure 9**) across the primed and the non-primed (control) cohorts in intervention variation 3. Results (mean values and p-values) are displayed in ***Table 67***; emboldened p-values indicate significance and/or a tendency-to-be significant. In ***Table 67,*** results indicate that there were no significant differences in questionnaire responses of those who were primed compared to those who were not primed (i.e., the control group).

*Table 67 – A series of two-tailed heteroscedastic t-test on Primed Vs Non-Primed (Control) Cohort Questionnaire Responses – Intervention Variation 3*

| | p-value | Primed | Non-Primed |
|---|---|---|---|
| Prosocialness | 0.663 | 3.816 | 3.780 |
| Procialness Behaviour Intention | 0.748 | 5.693 | 5.738 |
| Self Consciousness | 0.712 | 38.0208 | 37.530 |
| Social Consciousness | 0.240 | 3.557 | 3.474 |
| Empathy: Empathic Concern | 0.816 | 3.844 | 3.819 |
| Empathy: Fantasy | 0.691 | 3.081 | 3.145 |
| Empathy: Perspective Taking | 0.651 | 3.685 | 3.636 |
| Empathy: Personal Distress | 0.734 | 2.643 | 2.596 |
| Empathy (Sum) | 0.880 | 13.253 | 13.196 |
| Self-Oriented Perfectionism | 0.647 | 23.375 | 23.831 |
| Other-Oriented Perfectionism | 0.721 | 21.010 | 20.711 |
| Socially Prescribed Perfectionism | 0.445 | 22.677 | 21.952 |
| ‘ Total MPS’ Perfectionism | 0.814 | 67.063 | 66.494 |
| Social Desirability | 0.447 | 6.823 | 6.506 |

Emboldened p-values indicate significance and/or a tendency-to-be significant

Pearson chi-quare tests were also computed to observe more closely the associations between the priming, Communal Design production, empathy, consciousness, prosocialness, prosocial behavioral intention, and social desirability scores of the civil engineering students, during their work on the human-centred designing initiative. Results obtained are displayed in **Table 111** to **Table 120**, in Appendix B**,** highlighting if indeed such associations are profound. Results displayed in **Table 111** to **Table 120** indicate that the priming had no significant association with (i.e., or influence on) any of the aforementioned characteristics (i.e., empathy, consciousness, prosocialness, prosocial behavioral intention, and social desirability) of the students, during Communal Design production, or work on the human-centred designing initiative; see **Table 111** to **Table 120**, in Appendix B, for more information.

*V3-RQ6. Reiterating on V3-RQ2 and V3-RQ3 for self-cross-check – Intervention Variation 3.*
*Recap on Research Questions V2-RQ2 and V2-RQ3:*

> V3-RQ2. How does perfectionism associate with Communal Design Production?
>
> V3-RQ3. How does perfectionism associate with other characteristics (like prosocial behaviour and intention, empathy, and consciousness) that are known to be positively associated with human-centred designing engagement and Communal Design production?

This reiteration is to research the association of Communal Design production and human-centred designing engagement, with perfectionism using the MPS-SF (Hewitt, Habke, Lee-Baggley, Sherry, & Flett, 2008) as opposed to the APS-R (Slaney, Rice, Mobley, Trippi, & Ashby, 2001) used previously, for self-cross-check.

Using the data obtained on the civil engineering undergraduates' perfectionism using the MPS-SF scale, I draw results that either support (or oppose), in concept, my previous findings.

Remark that the MPS-SF consists of items that tests for three dimensions of perfectionism – namely, Self-Oriented, Other-Oriented, and Socially Prescribed Perfectionism. In this section, I shall observe each of these dimensions individually, and as a sum (the 'Total MPS score') with regard to the human-centred designing engagement, Communal Design production, and the priming.

Using the MPS-SF, data on students' three dimensions of perfectionism was collected. To differentiate the perfectionist from the non-perfectionist in this case, the 67$^{th}$ percentile scores of the civil engineering undergraduate cohort was used as cut-off points. The 67$^{th}$ percentile, instead of the average (50$^{th}$ percentile), was used here as cut-off points to draw stricter findings. The 67$^{th}$ percentile scores of the students' Self Oriented Perfectionism was found to be 26, Other-Oriented Perfectionism was 23, and Socially Prescribed Perfectionism was 25; using data collected on the MPS-SF (Hewitt, Habke, Lee-Baggley, Sherry, & Flett, 2008) . The number of students achieving a score higher (and lower) than the 67$^{th}$ percentile scores stated, are displayed in **Table 68.**

*Table 68 - Distribution of Civil Engineers with MPS Perfectionism dimensions' score higher- and lower-than-67th Percentile score.*

| MPS-SF Perfectionism Dimension | No. of students with scores higher that the 67th percentile of the perfectionism score (%) | No. of students with scores lower that the 67th percentile of the perfectionism score (%) | Total No. of Civil Engineering Undergraduates (%) |
|---|---|---|---|
| Self Oriented Perfectionism | 66 (36.9%) | 113 (63.1%) | 179 (100%) |
| Other Oriented Perfectionism | 68 (38.0%) | 111 (62.0%) | 179 (100%) |
| Socially Prescribed Perfectionism | 70 (39.1%) | 109 (60.9%) | 179 (100%) |
| 'Total MPS' Perfectionism | 59 (33.0%) | 120 (67.0%) | 179 (100%) |

Results displayed in **Table 68** show that 33.0% of the civil engineering undergraduates appear to have a 'Total MPS' Perfectionism score higher than the 67th percentile score (thus, classify as perfectionists). Individually, it was observed that 36.9% of the undergraduates had Self-Oriented Perfectionism higher the 67th percentile (i.e., had 'high' self-oriented perfectionism), and similarly, 38.0% had high Other-Oriented Perfectionism, and 39.1% had high Socially Prescribed Perfectionism. Although these present findings do not support the previous findings on the majority of civil engineering students categorise as perfectionists (see ***Table 49*** to ***Table 51***), the present classification process shows that a prevalence of perfectionism in civil engineering undergraduates – i.e., more than a third of the students still showed to have high perfectionism scores (higher than the 67th percentile), and thus, strictly, classify as perfectionists. See **Figure 11** for better data visualisation. These findings also support those found by Louis & Kumar (2016), reviewed earlier, on the significant prevalence of perfectionism amongst engineering students.

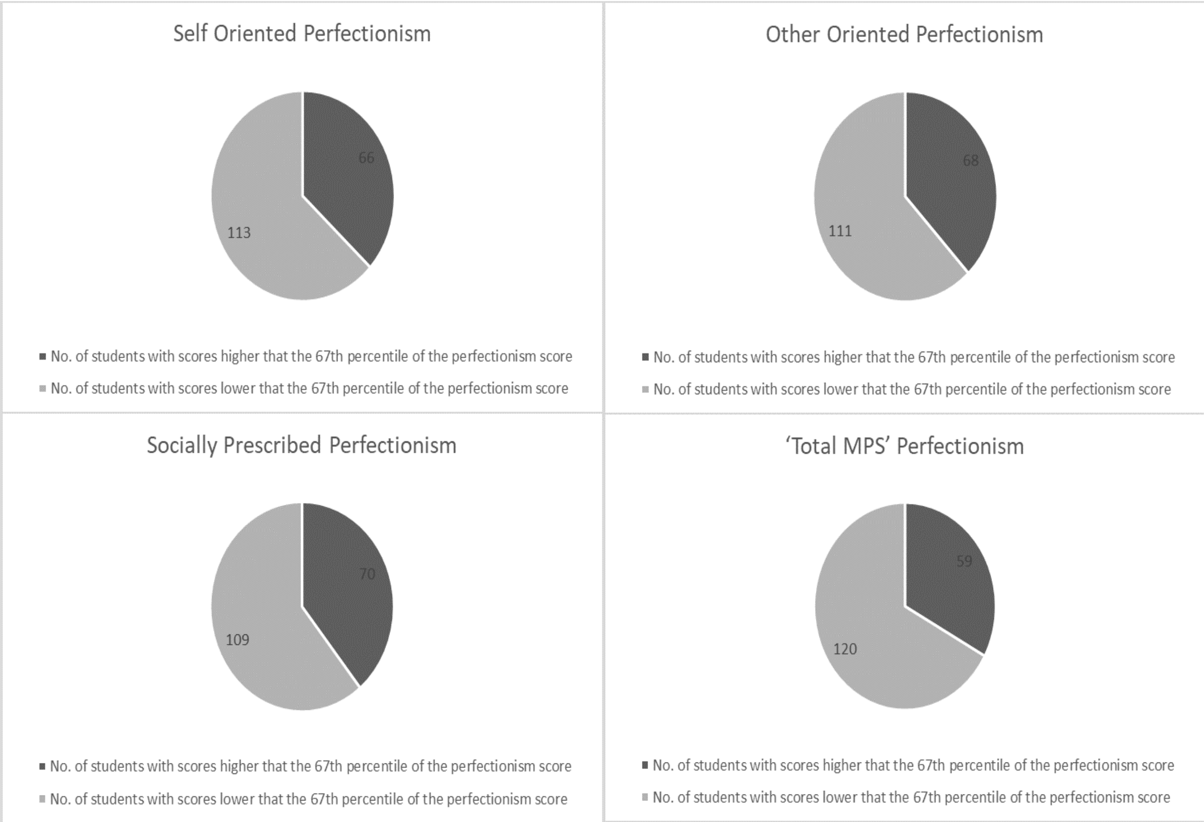


*Figure 11 – Distribution of 'Total MPS' Perfectionism scores of civil engineering undergraduates*

On the association of the MPS-SF perfectionism dimensions to the production of Communal Designs, a series of Pearson chi-squared tests of independence were computed. Results are displayed in ***Table 69*** to ***Table 72***.

*Table 69 - Association of Communal Design Production and Self Oriented Perfectionism*

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| No. of students with Self Oriented Perfectionism score higher than the 67th percentile. | 18 | 48 | 66 |
| No. of students with Self Oriented Perfectionism score lower than the 67th percentile. | 47 | 66 | 113 |
| Column Totals | 65 | 114 | Grand Total = 179 |

A Pearson chi-square test of independence was performed to examine the relation between Self Oriented Perfectionism and Communal Design production. The relation between these variables was found tending-to-be significant, $X^2$ (1, N = 179) = 3.695, p = .055. It was found that those with higher-than-67th percentile score of Self Oriented Perfectionism, were tending-to-be more likely to **not** produce Communal Designs. See ***Table 69*** for more information**.**

*Table 70 - Association of Communal Design Production and Other-Oriented Perfectionism*

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| No. of students with Other-Oriented Perfectionism score higher than the 67th percentile. | 20 | 48 | 68 |
| No. of students with Other-Oriented Perfectionism score lower than the 67th percentile. | 45 | 66 | 111 |
| Column Totals | 65 | 114 | Grand Total = 179 |

Moreover, a Pearson chi-square test of independence was performed to examine the relation between Other-Oriented Perfectionism and Communal Design production. The relation between these variables was found to not significant, $X^2$ (1, N = 179) = 2.258, p = .133; see **Table 70** for more information. Similarly, a Pearson chi-square test of independence was performed to examine the relation between Socially Prescribed Perfectionism and Communal Design production. The relation between these variables was also found to not significant, $X^2$ (1, N = 179) = 1.186, p = .276; see **Table 71** for more information.

*Table 71 - Association of Communal Design Production and Socially Prescribed Perfectionism*

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| No. of students with Socially Prescribed Perfectionism score higher than the 67th percentile. | 22 | 48 | 70 |
| No. of students with Socially Prescribed Perfectionism score lower than the 67th percentile. | 43 | 66 | 109 |
| Column Totals | 65 | 114 | Grand Total = 179 |

*Table 72 - Association of Communal Design Production and 'Total MPS' Perfectionism*

| | No. of '*Communal Designs*' Produced | No. of 'Not *Communal Designs*' Produced | Row Totals |
|---|---|---|---|
| No. of students with 'Total MPS' higher than the 67th percentile. | 16 | 43 | 59 |
| No. of students with 'Total MPS' lower than the 67th percentile. | 49 | 71 | 120 |
| Column Totals | 65 | 114 | Grand Total = 179 |

Further, a Pearson chi-square test of independence was performed to examine the relation between '*Total MPS'* Perfectionism and Communal Design production. The relation between these variables was found tending-to-be significant, $X^2$ (1, N = 179) = 3.217, p = .073. It was found that those with higher-than-67th percentile score of '*Total MPS'* Perfectionism, were tending-to-be more likely to **not** produce Communal Designs; see **Table 72** for more information. This finding, combined with the previous finding on those with high Self Oriented perfectionism scores also tending-to-be more likely to **not** produce Communal Designs (see ***Table** 69*), support my earlier findings on those who categorised as Perfectionists, as opposed to Non-Perfectionists, were significantly more likely to **not** produce Communal Designs (see ***Table 53***).

Further, a series of Pearson chi-square tests of independence were performed to examine the relation between MPS-SF perfectionism dimensions and Social Desirability scores in the civil engineering undergraduates. Results are displayed in **Table 121**, **Table 122**, **Table 127**, and **Table 128**, in Appendix B – as it was found that there were no significant associations between the MPS-SF perfectionism dimensions and the social desirability of civil engineering undergraduates.

For understanding the association of the MPS-SF perfectionism dimensions, the production of Communal Designs, and the priming, a series of Pearson chi-square tests were computed. Pearson chi-square tests of independence were performed to examine the relationships between the undergraduates' Self Oriented, Other-Oriented, Socially Prescribed, and 'Total MPS' Perfectionism scores (distinctively), and their production of Communal Designs whilst being Primed (i.e., primed cohort) or non-primed (i.e., control cohort). All relationships between the aforementioned variables were found not significant; see **Table 123** to **Table 126**, in Appendix B, for more information.

As a final set of results for this research question, and to further recognise the difference in characteristics of those who have high scores (higher than the 67th percentile) of MPS-SF perfectionism dimensions, as opposed to low scores (lower than the 67th percentile), a series of two-tailed heteroscedastic t-tests were computed. **Table 73** to **Table 76** display the results (mean values and p-values) found for each set of characteristics; emboldened p-values indicate significant or a tendency-to-be significant.

Results displayed in **Table 73** to **Table 76**, show that those with high scores of MPS perfectionism dimensions, have higher scores for prosocialness, empathy and consciousness, compared to those with low scores for MPS dimensions – see tables for more detail. The present findings therefore support my previous findings (displayed in ***Table** 54* to ***Table** 62***)** on the likelihood of those categorised as perfectionists to have higher empathy, prosocialness, and self consciousness scores whilst producing Communal Designs, compared to those categorised as non-perfectionists. This is interesting, as although the present findings show that high MPS-SF perfectionism are positively associated with empathy, prosocialness and consciousness, albeit them being negatively associated with Communal Design production (see ***Table 69*** and ***Table 72***). The aforementioned dissonance, of perfectionists seemingly having higher engagement the human-centred designing initiative (i.e., higher empathy, prosocialness, or consciousness) with, but simultaneously lower likelihood of eventually producing Communal Designs, is once more flagged again here.

*Table 73 – A series of two-tailed heteroscedastic t-test across responses of those with higher- vs. lower- than the 67th percentile of Self Oriented Perfectionism (SOP) score.*

| | p-value | High SOP | Low SOP |
|---|---|---|---|
| Standard Scale (Phase I) | **0.000** | 42.286 | 37.919 |
| Order Scale (Phase I) | **0.000** | 21.911 | 19.686 |
| APS-R Discrepancy (Phase I) | **0.034** | 53.464 | 48.477 |
| Prosocialness (Phase II) | **0.001** | 3.993 | 3.686 |
| Prosocial Behavioral Intention (Phase II) | **0.017** | 5.943 | 5.580 |
| Self Consciousness (Phase II) | **0.000** | 41.470 | 35.646 |
| Social Consciousness (Phase II) | 0.257 | 3.576 | 3.485 |
| Empathy: Empathic Concern (Phase II) | **0.000** | 4.121 | 3.664 |
| Empathy: Fantasy (Phase II) | **0.066** | 3.311 | 2.993 |
| Empathy: Perspective Taking (Phase II) | 0.165 | 3.769 | 3.600 |
| Empathy: Personal Distress (Phase II) | 0.315 | 2.716 | 2.566 |
| Empathy (Sum) (Phase II) | **0.007** | 13.917 | 12.823 |
| Self Oriented Perfectionism (Phase II) | **0.000** | 30.333 | 19.646 |
| Other-Oriented Perfectionism (Phase II) | **0.000** | 24.303 | 18.867 |
| Socially Prescribed Perfectionism (Phase II) | **0.000** | 26.258 | 20.053 |
| ‘ Total MPS’ Perfectionism (Phase II) | **0.000** | 80.894 | 58.566 |
| Social Desirability (Phase II) | 0.362 | 6.924 | 6.531 |

Emboldened p-value indicate significance or a tendency-to-be significant.

*Table 74 – A series of two-tailed heteroscedastic t-test across responses of those with higher- vs. lower- than the 67th percentile of Other-Oriented Perfectionism (OOP) score*

| | Low OOP | High OOP | p-value |
|---|---|---|---|
| Standard Scale (Phase I) | 38.761 | 41.260 | **0.007** |
| Order Scale (Phase I) | 19.565 | 22.400 | **0.000** |
| APS-R Discrepancy (Phase I) | 47.924 | 55.080 | **0.002** |
| Prosocialness (Phase II) | 3.700 | 3.962 | **0.004** |
| Prosocial Behavioral Intention (Phase II) | 5.687 | 5.757 | 0.641 |
| Self Consciousness (Phase II) | 36.306 | 40.221 | **0.006** |
| Social Consciousness (Phase II) | 3.517 | 3.522 | 0.943 |
| Empathy: Empathic Concern (Phase II) | 3.748 | 3.971 | **0.032** |
| Empathy: Fantasy (Phase II) | 2.919 | 3.423 | **0.002** |
| Empathy: Perspective Taking (Phase II) | 3.583 | 3.790 | **0.072** |
| Empathy: Personal Distress (Phase II) | 2.437 | 2.923 | **0.001** |
| Empathy (Sum) (Phase II) | 12.687 | 14.107 | **0.000** |
| Self Oriented Perfectionism (Phase II) | 20.910 | 27.956 | **0.000** |
| Other-Oriented Perfectionism (Phase II) | 17.505 | 26.368 | **0.000** |
| Socially Prescribed Perfectionism (Phase II) | 19.991 | 26.176 | **0.000** |
| ‘ Total MPS’ Perfectionism (Phase II) | 58.405 | 80.500 | **0.000** |
| Social Desirability (Phase II) | 6.838 | 6.412 | 0.320 |

Emboldened p-value indicate significance or a tendency-to-be significant.

*Table 75 – A series of two-tailed heteroscedastic t-test across responses of those with higher- vs. lower- than the 67th percentile of Socially Prescribed Perfectionism (SPP) score*

| | Low SPP | High SPP | p-value |
|---|---|---|---|
| Standard Scale (Phase I) | 38.264 | 41.818 | **0.000** |
| Order Scale (Phase I) | 20.138 | 21.236 | 0.105 |
| APS-R Discrepancy (Phase I) | 47.287 | 55.436 | **0.000** |
| Prosocialness (Phase II) | 3.683 | 3.980 | **0.001** |
| Prosocial Behavioral Intention (Phase II) | 5.601 | 5.889 | **0.057** |
| Self Consciousness (Phase II) | 35.633 | 41.157 | **0.000** |
| Social Consciousness (Phase II) | 3.492 | 3.560 | 0.369 |
| Empathy: Empathic Concern (Phase II) | 3.695 | 4.046 | **0.001** |
| Empathy: Fantasy (Phase II) | 2.846 | 3.521 | **0.000** |
| Empathy: Perspective Taking (Phase II) | 3.541 | 3.850 | **0.007** |
| Empathy: Personal Distress (Phase II) | 2.429 | 2.921 | **0.001** |
| Empathy (Sum) (Phase II) | 12.511 | 14.339 | **0.000** |
| Self Oriented Perfectionism (Phase II) | 20.890 | 27.786 | **0.000** |
| Other-Oriented Perfectionism (Phase II) | 18.734 | 24.200 | **0.000** |
| Socially Prescribed Perfectionism (Phase II) | 18.156 | 28.857 | **0.000** |
| ‘ Total MPS’ Perfectionism (Phase II) | 57.780 | 80.843 | **0.000** |
| Social Desirability (Phase II) | 6.761 | 6.543 | 0.612 |

Emboldened p-value indicate significance or a tendency-to-be significant.

*Table 76 - A series of two-tailed heteroscedastic t-test across responses of those with higher- vs. lower- than the 67th percentile of 'Total MPS' Perfectionism score*

| | p-value | High 'Total MPS' | Low 'Total MPS' |
|---|---|---|---|
| Standard Scale (Phase I) | **0.000** | 42.188 | 38.340 |
| Order Scale (Phase I) | **0.002** | 22.021 | 19.819 |
| APS-R Discrepancy (Phase I) | **0.006** | 54.938 | 48.149 |
| Prosocialness (Phase II) | **0.002** | 4.003 | 3.699 |
| Prosocial Behavioral Intention (Phase II) | **0.090** | 5.898 | 5.623 |
| Self Consciousness (Phase II) | **0.000** | 41.356 | 36.042 |
| Social Consciousness (Phase II) | 0.667 | 3.542 | 3.507 |
| Empathy: Empathic Concern (Phase II) | **0.001** | 4.072 | 3.715 |
| Empathy: Fantasy (Phase II) | **0.004** | 3.445 | 2.946 |
| Empathy: Perspective Taking (Phase II) | **0.057** | 3.826 | 3.581 |
| Empathy: Personal Distress (Phase II) | **0.017** | 2.877 | 2.496 |
| Empathy (Sum) (Phase II) | **0.000** | 14.220 | 12.738 |
| Self Oriented Perfectionism (Phase II) | **0.000** | 30.000 | 20.433 |
| Other-Oriented Perfectionism (Phase II) | **0.000** | 26.119 | 18.292 |
| Socially Prescribed Perfectionism (Phase II) | **0.000** | 28.254 | 19.433 |
| 'Total MPS' Perfectionism (Phase II) | **0.000** | 84.373 | 58.158 |
| Social Desirability (Phase II) | 0.692 | 6.797 | 6.617 |

Emboldened p-value indicate significance or a tendency-to-be significant.

*V3-RQ7. What are the differences in characteristics of those who produced Communal Designs as opposed to those who did not produce Communal Designs? – Intervention Variation 3.*

To differentiate the characteristics of those who produced Communal Designs, as opposed to those who did not eventually produced them, a series of two-tailed heteroscedastic t-test was computed. This was to observe if (and how) such differences are prevalent and presented. Results (mean values and p-values) are displayed in **Table 77**; emboldened p-value indicate significance or a tendency-to-be significant.

*Table 77 -A series of two-tailed heteroscedastic t-tests across responses of those who produced Communal Designs (CD) versus those who did not produce Communal Designs (N_CD) – Variation 3*

| | P-Values | CD | N_CD |
|---|---|---|---|
| ASP Standard Scale (Phase I) | **0.074** | 38.412 | 40.277 |
| ASP Order Scale (Phase I) | 0.251 | 20.020 | 20.830 |
| ASP Discrepancy Scale (Phase I) | 0.171 | 52.510 | 49.468 |
| Prosocialness (Phase II) | 0.853 | 3.810 | 3.794 |
| Prosocial Behavioral Intention (Phase II) | 0.521 | 5.773 | 5.680 |
| Self Consciousness (Phase II) | 0.670 | 37.415 | 38.009 |
| Social Consciousness (Phase II) | 0.854 | 3.510 | 3.523 |
| Empathy: Empathic Concern (Phase II) | 0.370 | 3.769 | 3.868 |
| Empathy: Fantasy (Phase II) | 0.747 | 3.146 | 3.090 |
| Empathy: Perspective Taking (Phase II) | 0.195 | 3.754 | 3.610 |
| Empathy: Personal Distress (Phase II) | 0.352 | 2.704 | 2.575 |
| Empathy (Sum) (Phase II) | 0.560 | 13.373 | 13.143 |
| Self-Oriented Perfectionism (Phase II) | **0.020** | 22.046 | 24.465 |
| Other-Oriented Perfectionism (Phase II) | 0.172 | 20.123 | 21.298 |
| Socially Prescribed Perfectionism (Phase II) | 0.408 | 21.815 | 22.640 |
| ‘ Total MPS’ Perfectionism (Phase II) | **0.078** | 63.985 | 68.404 |
| Social Desirability (Phase II) | 0.175 | 6.292 | 6.895 |

Emboldened p-value indicate significance or a tendency-to-be significant.

**Table** 77 display results indicating that those who did **not** eventually produce Communal Designs indeed had a tending-to-be significantly higher ASP-R Standards Scale Perfectionism scores ($p$ = .074), tending-to-be significantly higher ‘Total MPS’ scores ($p$=.078), as well as significantly higher Self-Oriented Perfectionism scores (p = .020). Supporting my previous results displayed in ***Table 53*, Table 77** further reassures the finding on the negative association between perfectionism and Communal Design production – i.e., the higher the perfectionism scores of the undergraduates (and/or being categorised as a perfectionist, as opposed to a non-perfectionists), increases the undergraduates’ likelihood of **not** producing a Communal Design.

To further observe the difference in characteristics of those who produced Communal Designs whilst categorised as *Perfectionists (CD_Perf)*, as opposed to those who produced Communal Designs whilst categorised as *Non-Perfectionists (CD_Non-Perf)*, a series of two-tailed heteroscedastic t-test was computed. This was to observe if (and how) such differences are prevalent and presented. Results (mean values and p-values) are displayed in **Table 78**; emboldened p-values indicate significance or a tendency-to-be significant.

*Table 78 – A series of two-tailed heteroscedastic t-test computed across those who produced Communal Design whilst categorises as Perfectionists (CD_Perf) versus those who produced Communal Designs whilst categorised as Non-Perfectionists (CD_Non-Perf).*

| | p-value | CD_Perf | CD_Non-Perf |
|---|---|---|---|
| Prosocialness | **0.016** | 3.935 | 3.566 |
| Prosocial Behavioral Intention | **0.091** | 5.958 | 5.487 |
| Self Consciousness | **0.006** | 40.100 | 32.789 |
| Social Consciousness | **0.016** | 3.683 | 3.368 |
| Empathy: Empathic Concern | **0.018** | 3.942 | 3.513 |
| Empathy: Fantasy | **0.001** | 3.525 | 2.421 |
| Empathy: Perspective Taking | 0.200 | 3.892 | 3.645 |
| Empathy: Personal Distress | 0.983 | 2.600 | 2.605 |
| Sum Empathy | **0.010** | 13.958 | 12.184 |
| Standard Scale | **0.000** | 24.933 | 17.263 |
| Discrepancy Scale | **0.095** | 20.933 | 18.211 |
| Self-Oriented Perfectionism | **0.000** | 25.567 | 17.105 |
| Other-Oriented Perfectionism | 0.104 | 21.033 | 18.368 |
| Socially Prescribed Perfectionism | **0.007** | 24.167 | 19.474 |
| Total MPS Perfectionism | **0.000** | 70.767 | 54.947 |
| Social Desirability | 0.840 | 6.700 | 6.526 |

Emboldened p-values indicate significance or a tendency-to-be significant.

When those who produced Communal Designs whilst categorised as perfectionists (CD_Perf) were compared to those who produced Communal Designs whilst categorised as non-perfectionists (CD_Non-Perf), significant (and a tending-to-be significant) differences emerged. CD_Perf showed to have had significantly higher Prosocialness (p=.016), Self Consciousness (p=.006), Social Consciousness (p=.016), Empathy: Empathic Concern (p=.018), Empathy: Fantasy (p=.001), Empathy (Sum) (p=.010), and tending-to-be significantly higher Prosocial Behavioral Intention (p=.091) scores, compared to CD_Non-Perf. See **Table 78** for more information.

Additionally, and most expectedly, CD_Perf showed significantly higher APS-R Standard Scale (p=.000), MPS-SF Self Oriented Perfectionism (p=.000), Socially Prescribed Perfectionism (p=.007), 'Total MPS' Perfectionism (p=.000), and an obscurely tending-to-be significantly higher APS-R Discrepancy Scale (p=.095). See **Table 78** for more information.

*V3-RQ8. How (if) does the intention-behaviour gap manifests in light of the Civil Engineering Undergraduates' Perfectionism?*

For observing and analysing how the intentions and motivations for producing Communal Designs are manifested, correlative Pearson tests have been computed. The 'communal intention' is observed in relation to other characteristics of the undergraduates (like empathy, consciousness and prosocialness – which are known to be positively associated human-centred designing and engagement). A series of two-tailed Pearson corelations were computed to examine how the civil engineering undergraduates' communal intentions associate with the rest of their characteristics. In this section, this is done via addressing the prosocial behavioral intention of the undergraduates, and what it correlated to in each of the independent factors (i.e., the different priming and perfectionism categories). These correlations will act as facilitators to grasp an understanding of what the students' communal intention translates to in each of the categories, and additionally, under the effect of the priming.

Results of these Pearson correlations are displayed in **Table 79** to **Table 81**. Embolden figures in the tables resemble significance; (*) indicates p≤.005 (2-tails, Pearson), and (**) indicates p≤.001 (2-tails, Pearson).

*Table 79* **-** *Addressing the 'Intention' to Produce the Communal Designs across the Perfectionism Categories.*

| Prosocial Behavioral Intention Correlation with: | Perfectionists Category | Non-Perfectionists Category |
|---|---|---|
| ASP-R Standard Scale | .020 | -.051 |
| ASP-R Order Scale | -.040 | .131 |
| ASP-R Discrepancy Scale | .013 | .182 |
| Prosocialness | **.470**** | **.574**** |
| Self Consciousness | .186 | .100 |
| Social Consciousness | .152 | **.409*** |
| Empathy: Empathic Concern | **.428**** | **.607**** |
| Empathy: Fantasy | .156 | .325 |
| Empathy: Perspective Taking | **.272**** | **.471**** |
| Empathy: Personal Distress | .094 | .125 |
| Empathy (Sum) | **.300**** | **.481**** |
| Self Oriented Perfectionism | **.255**** | -.008 |
| Other-Oriented Perfectionism | .036 | -.118 |
| Socially Prescribed Perfectionism | .141 | -.016 |
| 'Total MPS' Perfectionism | .173 | -.051 |
| Social Desirability | .098 | -.010 |

Embolden figures resemble significance (* indicates p≤.005 (2-tails, Pearson); ** indicates p≤.001 (2-tails, Pearson)).

**Table 79** shows that the prosocial behavioral intention scores (i.e., the communal intention) of the non-perfectionists correlated positively with Social Consciousness (r=.409*) whilst this association was not seen in the perfectionists' category.

The non-perfectionists also showed higher correlation between their communal intention and Prosocialness (r=.574**), Empathy: Empathic Concern (r=.607**), Empathy: Perspective Taking (r=.471**), and Empathy (Sum) (r=.481**), when compared to the perfectionists' category; whom showed a positive correlation with Prosocialness (r=.470**), Empathy: Empathic Concern (r=.428**), Empathy: Perspective Taking (r=.272**), Empathy (Sum) (r=.300**), but to a lesser extent. These findings support earlier ones, as it was indeed seen that those categorised as non-perfectionists were more likely than those categorised as perfectionists to produce Communal Designs (see ***Table 53***) eventually.

Additionally, perfectionists showed a positive corelation between their communal intention and Self-Oriented Perfectionism, whilst this was not seen in the non-perfectionist category. This is interesting, as self-oriented perfectionism, can be argued to be more agentic in nature. On this point, I refer to a notion made by Abele (2014) which discusses a notion along the lines of the road to a communion maybe paved with agency sometimes.

*Table 80 - Addressing the 'Intention' to produce Communal Designs across those who produced Communal Designs vs. those who did not – Intervention Variation 3.*

| Prosocial Behavioral Intention Correlation with: | Produced Communal Designs Cohort | Not Produced Communal Designs Cohort |
|---|---|---|
| ASP-R Standard Scale | **.345*** | -.020 |
| ASP-R Order Scale | **.315*** | -.101 |
| ASP-R Discrepancy Scale | .044 | .050 |
| Prosocialness | **.660**** | **.418**** |
| Self Consciousness | .288* | .063 |
| Social Consciousness | **.338**** | **.230*** |
| Empathy: Empathic Concern | **.456**** | **.415**** |
| Empathy: Fantasy | **.352**** | .105 |
| Empathy: Perspective Taking | **.442**** | **.273**** |
| Empathy: Personal Distress | .026 | .114 |
| Empathy (Sum) | **.419**** | **.281**** |
| Self Oriented Perfectionism | .230 | .167 |
| Other-Oriented Perfectionism | .095 | .021 |
| Socially Prescribed Perfectionism | .227 | .091 |
| 'Total MPS' Perfectionism | .219 | .112 |
| Social Desirability | -.034 | .132 |

Embolden figures resemble significance (* indicates p≤.005 (2-tails, Pearson); ** indicates p≤.001 (2-tails, Pearson)).

When addressing how the communal intention translates in the categories of those who produced Communal Designs as opposed to those who did not, it was found that those who produced Communal Designs showed positive correlations between their communal intention and ASP-R Standard Scale (r=.345*), ASP-R Order Scale (r=.315*), Empathy: Fantasy (.r=352**), whilst no such associations were seen in the other cohort (those who did not eventually produce Communal Designs); see **Table 80**.

Additionally, it was found that those who produced Communal Designs showed higher positive correlations between their communal intention and Prosocialness (r=.660**), Social Consciousness (r=.338**), Empathy: Empathic Concern (r=.456**), Empathy: Perspective Taking (r=.442**) and Empathy (Sum) (.419**), compared to those who did not produce Communal Design; whom showed positive correlations with Prosocialness (r=.418**), Social Consciousness (r=.230*), Empathy: Empathic Concern (r=.415**), Empathy: Perspective Taking (r=.273**), and Empathy (Sum) (r=.281**) to a lesser extent (see **Table 80**).

Further, those who produced Communal Designs showed a unique positive correlation between their communal intention, and their Empathy: Fantasy characteristic scores (r=.352**); this was not seen in the other category (i.e., those who did not produce Communal Design). See **Table 80** for more information. This is interesting as the role of Empathy: Fantasy in the intention and motivation for producing Communal Designs is therefore highlighted here.

*Table 81 - Addressing the 'Intention' to Produce the Communal Designs across the Priming Cohorts – Intervention Variation 3.*

| Prosocial Behavioral Intention Correlation with: | Primed Cohort | Non-Primed (Control) Cohort |
|---|---|---|
| ASP-R Standard Scale | .064 | .245 |
| ASP-R Order Scale | -.134 | **.294*** |
| ASP-R Discrepancy Scale | .170 | -.094 |
| Prosocialness | **.424**** | **.603**** |
| Self Consciousness | .123 | .170 |
| Social Consciousness | **.342**** | .190 |
| Empathy: Empathic Concern | **.389**** | **.477**** |
| Empathy: Fantasy | .184 | **.222*** |
| Empathy: Perspective Taking | **.291**** | **.392**** |
| Empathy: Personal Distress | .091 | .087 |
| Empathy (Sum) | **.304**** | **.371**** |
| Self Oriented Perfectionism | .117 | **.257*** |
| Other-Oriented Perfectionism | -.046 | .138 |
| Socially Prescribed Perfectionism | .178 | .085 |
| ‘Total MPS’ Perfectionism | .110 | .184 |
| Social Desirability | .010 | .131 |

Embolden figures resemble significance (* indicates p≤.005 (2-tails, Pearson); ** indicates p≤.001 (2-tails, Pearson)).

Results displayed in **Table 81** address the communal intention in light of the priming.

The control group showed higher positive correlations between their communal intentions and Prosocialness (r=.603**), Empathy: Empathic Concern (r=.477**), Empathy: Perspective Taking (r=.392**) and Empathy (Sum) (r=.371**), than the primed group; whom showed positive correlations with Prosocialness (r=.424**), Empathy: Empathic Concern (r=.389**), Empathy: Perspective Taking (r=.291**), and Empathy (Sum) (r=.304**), but to a lesser extent.

Additionally, it was found that the non-primed showed positive correlations between their communal intention and ASP-R Order Scale (.294*), Empathy: Fantasy (r=.222*), and Self-Oriented Perfectionism (r=.257*), whilst this was not seen in the primed cohort (see **Table 81**); this calls for another referral to Abele’s (2014) notion that runs along the line of the road to communion may be paved with agency sometimes.

Moreover, the primed cohort showed a unique correlation between their communal intention and Social Consciousness (r=.342**), whereas this was not seen in the non-primed cohort. Similar to what was seen and discussed under **Table 35** in intervention variation 2, this finding indicates indeed the presence of a subtle positive influence of the priming on the characteristics associated with better human-centred designing engagement (for example empathy, consciousness and/or prosocialness).

*V3-RQ9. Finally, can an equation be developed to predict students' likelihood of Communal Design production given students' perfectionism and other characteristics' scores?*

To produce a mathematical equation predictive of the students' likelihood of producing Communal Designs, based on their responses to questionnaires on perfectionism, empathy, consciousness (etc.), two analyses have to be calculated, a Factor Analysis and then a Binary Logistic Regression; both using SPSS. It was found that a sample size (N) greater than 25 is adequate enough to compute a regression analysis (Jenkins & Quintana-Ascencio, 2020).

V3-RQ9 (i): Factor Analysis

A factor reduction analysis has been computed to test for the suitability of the data collected, and to thereafter perform a logistical regression model that predicts students' production of Communal Design based upon their provided characteristics scores (i.e., scores of perfectionism, empathy, consciousness etc.) and their exposure to the priming. The suitability of sampling is tested via a Kaiser Meyer Olkin (KMO) test (Kaiser, 1974; Kaiser & Rice, 1974), whereas the strength of the relationship among variables is assessed through Bartlett's test of sphericity (Bartlett, 1954), which assesses the validity and adequacy of the responses collected to solve the research question proposed in this section (i.e., V3-RQ9). Both the factor reduction and the binary logistics tests have been computed using IBM SPSS.

The sampling is thought to be acceptable if the value of Kaiser Meyer Olkin is larger than 0.5 (see (Kaiser, 1974; Kaiser & Rice, 1974)). Whereas if significance (i.e., p-value<.05) was yielded from the Bartlett test, the data collected would then be accepted and be considered fit for further analyses (Field, 2018; Pallant, 2020) and is thus suitable for responding to the proposed research question. Accepted data on variables (i.e., characteristics) would then be fed into a binary logistic model to predict students' likelihood of producing of Communal Designs. The test was computed using SPSS.

**Table 82** displays all the variables entered into the factor analysis test for this intervention variation – displaying the count number, the means and standard variations for each of the characteristics of civil engineering students.

*Table 82 - Variation 3 Factor Analysis Descriptive Statistics*

| Descriptive Statistics | | | |
|---|---|---|---|
| | Mean | Std. Deviation | Analysis N |
| APS-R Standard Scale | 39.64 | 5.560 | 142 |
| APS-R Order Scale | 20.56 | 3.900 | 142 |
| APS-R Discrepancy Scale | 50.44 | 13.163 | 142 |
| Prosocialness | 3.79 | .545 | 142 |
| Procial Behavioral Intention | 5.76 | .882 | 142 |
| Self Consciousness | 37.59 | 8.897 | 142 |
| Social Consciousness | 3.56 | .453 | 142 |
| Empathy: Empathic Concern | 3.84 | .702 | 142 |
| Empathy: Fantasy | 3.06 | 1.119 | 142 |
| Empathy: Perspective Taking | 3.69 | .699 | 142 |
| Empathy: Personal Distress | 2.53 | .898 | 142 |
| Self-Oriented Perfectionism | 23.78 | 6.694 | 142 |
| Other-Oriented Perfectionism | 20.66 | 5.412 | 142 |
| Socially Prescribed Perfectionism | 22.54 | 6.422 | 142 |
| Social Desirability | 6.87 | 2.603 | 142 |

*Table 83 - Variation 3 Factor Analysis FMO and Bartlett's Test*

| KMO and Bartlett's Test | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .777 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 690.995 |
| | df | 105 |
| | Sig. | <.001 |

**Table 83** shows that the KMO measure of the characteristics addressed in **Table 82** for intervention variation 3 is .777 (i.e., KMO>0.5), indicating very good sampling acceptance (Kaiser, 1974; Kaiser & Rice, 1974) and adequacy. **Table 83** also shows that the Bartlett's Test of Sphericity indicates significance (i.e., p<.001), therefore indicating that the measures (or characteristics) specified in

**Table 82** are fit for further analyses (Bartlett, 1954) – i.e., input into a binary logistic model to predict Communal Design production.

As the variables (i.e., characteristics) displayed in **Table 82** were found fit for further analyses, they were input into a binary logistics regression model to predict the likelihood of production of Communal Designs using them.

V3-RQ9 (ii) Binary Logistics

Logistic regressions "estimate for the likelihood that an event occurs, given a set of conditions" (Sweet & Grace-Martin, 2003). When the output (or predicted event) is dichotomous in nature, then binary logistics regressions are computed. Logistic regressions do not claim to predict the behaviour of an individual, but it can, however, predict behaviour based on several given conditions to that individual (or inputs to a model) together (see (Sweet & Grace-Martin, 2003)).

Binary logistic regressions produce logistic coefficients ($\beta$) and exponentiated logistic coefficients (Exp($\beta$)) of the analysis. Logistic coefficients are observed to determine the direction of relationship (i.e., positive or negative) with the output, whereas the exponentiated logistic coefficients directly resembles the magnitude of change in the odds value, from which one can determine the probability of the output happening based on the corresponding characteristic. The following formula is used to calculate said probability: *Probability*= $\frac{Odds}{1+Odds}$ (see (Sreejesh, Mohapatra, & Anusree, 2014; Sweet & Grace-Martin, 2003) for more information). The outcome (y) on whether a Communal Design is to be produced (1) or not (0) is therefore calculated using the following formula: $y = \frac{Exp(\beta_0+\beta X_1+\beta X_2+etc.)}{1+Exp(\beta_0+\beta X_1+\beta X_2+etc.)}$ . Using the outputs of a logistic regression, one can determine a predictive equation for the production of Communal Designs using the variables (scores of characteristics) entered into the model. The present regression has been computed on SPSS.

**Table 84** to **Table 86** show descriptives of the number of counts (N) and the coding used for the present regression analysis. For this regression, the output 'Not Produced Communal Designs' is coded as 0; whilst 'Produced Communal Designs' is coded 1. Similarly, the independent variable (input) of those primed is coded as 1, whereas the non-primed is coded 0. "The Classification table indicates how many correct and incorrect predictions would be made for a wide range of probability cut-off points used for the model" (Sreejesh, Mohapatra, & Anusree, 2014). In the present case, 65.5% of the outputs are correctly predicted without the input of variables; i.e., in block 0 (the null) classification table (see **Table 87**). Data in block 0 will be compared against the block 1 classification table after the input of variables (characteristics) hypothesised to contribute to the output (production of Communal Designs), to see how the input of the variables makes a difference on the predictability of the model. This will be addressed in the next few paragraphs.

*Table 84 - Variation 3 Regression Cases (N)*

| Case Processing Summary | | | |
|---|---|---|---|
| Unweighted Cases[a] | | N | Percent |
| Selected Cases | Included in Analysis | 142 | 77.2 |
| | Missing Cases | 42 | 22.8 |
| | Total | 184 | 100.0 |
| Unselected Cases | | 0 | .0 |
| Total | | 184 | 100.0 |
| a. If weight is in effect, see classification table for the total number of cases. | | | |

*Table 85 - Variation 3 Coding of Dependent Variable: Produced Communal Designs (Y) vs. Not Produced Communal Designs (N)*

| Dependent Variable Encoding | |
|---|---|
| Original Value | Internal Value |
| No | 0 |
| Yes | 1 |

*Table 86 – Variation 3 Coding of Independent Variable: Primed (Y) vs. Non-Primed (N)*

| Categorical Variables Codings | | | |
|---|---|---|---|
| | | Frequency | Parameter coding |
| | | | (1) |
| Primed Group? | No | 62 | .000 |
| | Yes | 80 | 1.000 |

*Table 87 - Variation 3 Block 0 (i.e., before entering variables) Classification Table; Variation 3 Null Table*

| Classification Table[a,b] | | | | | |
|---|---|---|---|---|---|
| | Observed | | Predicted | | |
| | | | Produced Communal Design? | | Percentage Correct |
| | | | No | Yes | |
| Step 0 | Produced Communal Design? | No | 93 | 0 | 100.0 |
| | | Yes | 49 | 0 | .0 |
| | Overall Percentage | | | | 65.5 |
| a. Constant is included in the model. | | | | | |
| b. The cut value is .500 | | | | | |

**Table 88** shows how each variable (characteristic) independently influence the output (production of Communal Design); it shows that none of the characteristics can contribute to the output

independently (i.e., before considering their influence within a model, in combination with other variables) – although Self Oriented Perfectionism (p=.052) can be argued to be on the cusp of its ability to independently contribute to the output, as it is on the verge of significance. Characteristics contributing independently will be compared to those contributing all together (as a model). This will be addressed in the next few paragraphs, when discussing the *Omnibus Test of Model Coefficients*.

*Table 88 - Variation 3 Block 0 Variables Not in the Equation (i.e., weight of parameters in null model)*

| **Variables not in the Equation** | | | | | |
|---|---|---|---|---|---|
| | | | Score | df | Sig. |
| Step 0 | Variables | APS-R Standard Scale | 2.788 | 1 | .095 |
| | | APS-R Discrepancy Scale | 2.162 | 1 | .141 |
| | | Primed Group?(1) | .860 | 1 | .354 |
| | | Prosocialness | .001 | 1 | .980 |
| | | Procial Behavioral Intention | .013 | 1 | .910 |
| | | Self Consciousness | .101 | 1 | .750 |
| | | Social Consciousness | .002 | 1 | .961 |
| | | Empathy: Empathic Concern | .564 | 1 | .453 |
| | | Empathy: Fantasy | .068 | 1 | .795 |
| | | Empathy: Perspective Taking | 1.726 | 1 | .189 |
| | | Empathy: Personal Distress | .439 | 1 | .507 |
| | | Self-Oriented Perfectionism | 3.763 | 1 | .052 |
| | | Other-Oriented Perfectionism | 1.127 | 1 | .288 |
| | | Socially Prescribed Perfectionism | .065 | 1 | .799 |
| | | Social Desirability | .643 | 1 | .422 |
| | | APS-R Order Scale | 1.249 | 1 | .264 |
| | Overall Statistics | | 15.689 | 16 | .475 |

The Omnibus test is interpreted to show that, when all variables are considered together (as a model) to predict the output, the model is determined significant or not (i.e., fit to predict or not) by addressing its significance (i.e., p<.05).

**Table 89** shows that the model is not significant (p>.05), inferring that when all variables (i.e., characteristics) are considered together in a model, they do not significantly contribute to (or are influential on) the output.

*Table 89 - Variation 3 Omnibus Test of Model Coefficients*

| Omnibus Tests of Model Coefficients | | | | |
|---|---|---|---|---|
| | | Chi-square | df | Sig. |
| Step 1 | Step | 17.426 | 16 | .359 |
| | Block | 17.426 | 16 | .359 |
| | Model | 17.426 | 16 | .359 |

To assess the model's fit and predictive ability, the Nagelkerke $R^2$ value and the Hosmer and Lemeshow test are observed (Sreejesh, Mohapatra, & Anusree, 2014). The closer the value for Nagelkerke $R^2$ is to 1, the better the fit of the model, and it is observed in **Table 90** that the value of Nagelkerke $R^2$ is .159, indicating a relatively low fitness of the model. As for assessing the predictive ability of the model, observing **Table 91**, it is seen that the p-value of the Hosmer and Lemeshow test equals to .169 (i.e., $p>.05$), suggesting a that the present model has relatively (low) acceptable predictive value (Sreejesh, Mohapatra, & Anusree, 2014); this can also be seen in the last row presented in **Table 92**, where the predicted Communal Values (9.794) is close to those actual/observed Communal Designs collected (i.e., 14) – i.e., for every 14 observed/counted Communal Designs, the present model have correctly predicted 10 of them. These observations therefore indicate that the model composed of the variables listed in **Table 94** is a relatively low acceptable tool for predicting whether students will produce Communal Designs or not, based on data to be collected on their characteristics (listed in **Table 94**).

Moreover, after the input of variables, it was observed that 71.8% of the outputs are correctly predicted with the input of variables; i.e., in block 1 classification table (see **Table 93**); this means that with the input of the variables, the model became a better predictor of outputs when compared to the block 0 classification table (before input the variables), i.e., **Table 87** (which showed that only 65.5% of the outputs are correctly predicted without the input of variables into the model).

*Table 90 - Variation 3 Model Fitness*

| Model Summary | | | |
|---|---|---|---|
| Step | -2 Log likelihood | Cox & Snell R Square | Nagelkerke R Square |
| 1 | 165.567[a] | .115 | .159 |
| a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001. | | | |

*Table 91 - Variation 3 Model Predictive Ability*

| Hosmer and Lemeshow Test | | | |
|---|---|---|---|
| Step | Chi-square | df | Sig. |
| 1 | 11.625 | 8 | .169 |

*Table 92 - Variation 3 Contingency Table for Hosmer and Lemeshow Test*

| Contingency Table for Hosmer and Lemeshow Test | | | | | | |
|---|---|---|---|---|---|---|
| | | Produced Communal Design? = No | | Produced Communal Design? = Yes | | Total |
| | | Observed | Expected | Observed | Expected | |
| Step 1 | 1 | 13 | 12.838 | 1 | 1.162 | 14 |
| | 2 | 10 | 11.724 | 4 | 2.276 | 14 |
| | 3 | 10 | 10.919 | 4 | 3.081 | 14 |
| | 4 | 12 | 10.378 | 2 | 3.622 | 14 |
| | 5 | 11 | 9.672 | 3 | 4.328 | 14 |
| | 6 | 8 | 8.943 | 6 | 5.057 | 14 |
| | 7 | 8 | 8.025 | 6 | 5.975 | 14 |
| | 8 | 10 | 7.498 | 4 | 6.502 | 14 |
| | 9 | 9 | 6.797 | 5 | 7.203 | 14 |
| | 10 | 2 | 6.206 | 14 | 9.794 | 16 |

*Table 93 - Variation 3 Block 1 (i.e., after entering variables) Classification Table*

| Classification Table[a] | | | | | |
|---|---|---|---|---|---|
| | Observed | | Predicted | | |
| | | | Produced Communal Design? | | Percentage Correct |
| | | | No | Yes | |
| Step 1 | Produced Communal Design? | No | 84 | 9 | 90.3 |
| | | Yes | 31 | 18 | 36.7 |
| | Overall Percentage | | | | 71.8 |
| a. The cut value is .500 | | | | | |

**Table 94** shows the logistic coefficients (B) and exponentiated logistic coefficients (Exp(B)) of the analysis. Logistic coefficients are observed to determine the magnitude and direction (i.e., positive or negative) of relationship with the output or influence of the characteristic on the output, whereas the exponentiated logistic coefficients directly resembles the magnitude of change in the odds value; from which one can determine the probability of the output happening based on a single variable (see (Sreejesh, Mohapatra, & Anusree, 2014; Sweet & Grace-Martin, 2003)). The coefficients (i.e., perfectionism scales and other characteristics' scores) can be used to develop an equation predictive of the likelihood of producing Communal Designs (y=1), or not produce Communal Designs (y=0); see **Equation 3** on the following few pages.

*Table 94 - Variation 3 Block 1 Variables in the Equation (i.e., weight of parameters in the model after entering the variables)*

| Variables in the Equation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | B | S.E. | Wald | df | Sig. | Exp(B) | 95% C.I.for EXP(B) | |
| | | | | | | | | Lower | Upper |
| Step 1[a] | APS-R Standard Scale | -.051 | .049 | 1.091 | 1 | .296 | .950 | .863 | 1.046 |
| | APS-R Discrepancy Scale | .030 | .017 | 3.011 | 1 | .083 | 1.030 | .996 | 1.066 |
| | Primed Group?(1) | -.652 | .400 | 2.660 | 1 | .103 | .521 | .238 | 1.141 |
| | Prosocialness | .611 | .494 | 1.531 | 1 | .216 | 1.842 | .700 | 4.851 |
| | Procial Behavioral Intention | -.007 | .276 | .001 | 1 | .980 | .993 | .578 | 1.706 |
| | Self Consciousness | -.010 | .029 | .112 | 1 | .738 | .990 | .935 | 1.048 |
| | Social Consciousness | .374 | .487 | .589 | 1 | .443 | 1.454 | .559 | 3.779 |
| | Empathy: Empathic Concern | -.633 | .407 | 2.422 | 1 | .120 | .531 | .239 | 1.179 |
| | Empathy: Fantasy | .030 | .225 | .017 | 1 | .895 | 1.030 | .662 | 1.602 |
| | Empathy: Perspective Taking | .590 | .372 | 2.514 | 1 | .113 | 1.805 | .870 | 3.744 |
| | Empathy: Personal Distress | .096 | .268 | .130 | 1 | .719 | 1.101 | .652 | 1.860 |
| | Self-Oriented Perfectionism | -.053 | .048 | 1.258 | 1 | .262 | .948 | .863 | 1.041 |
| | Other-Oriented Perfectionism | -.049 | .055 | .806 | 1 | .369 | .952 | .856 | 1.060 |
| | Socially Prescribed Perfectionism | .031 | .044 | .478 | 1 | .489 | 1.031 | .945 | 1.125 |
| | Social Desirability | -.052 | .078 | .448 | 1 | .503 | .949 | .815 | 1.105 |
| | APS-R Order Scale | .001 | .059 | .000 | 1 | .987 | 1.001 | .892 | 1.123 |
| | Constant | -1.257 | 2.384 | .278 | 1 | .598 | .284 | | |

a. Variable(s) entered on step 1: APS-R Standard Scale , APS-R Discrepancy Scale , Primed Group?, Prosocialness, Procial Behavioral Intention, Self Consciousness, Social Consciousness, Empathy: Empathic Concern, Empathy: Fantasy, Empathy: Perspective Taking, Empathy: Personal Distress, Self-Oriented Perfectionism, Other-Oriented Perfectionism, Socially Prescribed Perfectionism, Social Desirability, APS-R Order Scale .

Observing **Table 94,** one could therefore determine a predictive equation for the production of Communal Design. With the logistic regression equation being **Equation 1** as seen in intervention variation 2:

$$y = \frac{Exp(\beta_0 + \beta X_1 + \beta X_2 + etc.)}{1 + Exp(\beta_0 + \beta X_1 + \beta X_2 + etc.)};$$

the present findings determine the equation for the likelihood production of Communal Designs (i.e., y (output)= between 0 (i.e., not produce Communal Design) and 1 (i.e., produce Communal Design)) as:

*Equation 3 - Intervention Variation 3 Equation Predictive of Communal Design Production*

$$y_{(intervention\ variation\ 3)} = \frac{\begin{gathered}Exp(-1.257 - 0.051X_1 + 0.030X_2 - 0.652X_3 + 0.611X_4 - 0.007X_5 - 0.010X_6 + 0.374X_7 - 0.633X_8 + 0.030X_9 \\ +0.590X_{10} + 0.096X_{11} - 0.053X_{12} - 0.049X_{13} + 0.031X_{14} - 0.052X_{15} + 0.001X_{16})\end{gathered}}{\begin{gathered}1 + Exp(-1.257 - 0.051X_1 + 0.030X_2 - 0.652X_3 + 0.611X_4 - 0.007X_5 - 0.010X_6 + 0.374X_7 - 0.633X_8 + 0.030X_9 \\ +0.590X_{10} + 0.096X_{11} - 0.053X_{12} - 0.049X_{13} + 0.031X_{14} - 0.052X_{15} + 0.001X_{16})\end{gathered}}$$

Where $\beta_0$ is the constant; and the $\beta_x's$ are the values displayed in the 'B' column in **Table 94**, in the same order, running from the top of the column (i.e., $\beta_1$) till the bottom of the column (i.e., $\beta_{16}$); see **Table 94**. In **Equation 3**, $X_1$= APS-R Standard Scale score, $X_2$= APS-R Discrepancy Scale score, $X_3$= Priming factor score, $X_4$= Prosocialness score, $X_5$= Prosocial Behavioural Intention score, $X_6$= Self Consciousness score, $X_7$= Social Consciousness score, $X_8$= Empathy: Empathic Concern score, $X_9$= Empathy: Fantasy score, $X_{10}$= Empathy: Perspective Taking score, $X_{11}$= Empathy: Personal Distress score, $X_{12}$= Self-Oriented Perfectionism score, $X_{13}$= Other-Oriented Perfectionism score, $X_{14}$= Socially Prescribed Perfectionism score, $X_{15}$= Social Desirability score, and $X_{16}$= APS-R Order scale score. This equation was primarily developed to show how, and to what extent, do each of the individual characteristics (like perfectionism, empathy, and consciousness, etc.) contribute to the likelihood of producing Communal Designs. Based on the data displayed in **Table 94,** and the coefficients of the factors displayed in **Equation 3**, it seems that the Priming factor, followed by the students' Empathy: Empathic Concern score, then followed by the Prosocialness score, were the most influential factors, or mindset characteristics (addressed in intervention variation 3), contributing to the production of Communal Designs (or not producing Communal Designs – as some were 'negative' coefficients (B)). It was interesting to observe that the Priming factor (intended to trigger and/or promote empathy), as well as Empathy: Empathic Concern scores contributed negatively, whilst simultaneously

Prosocialness scores contributed positively to the likelihood of producing Communal Designs. However, none of the characteristics displayed in **Table 94** had a significant p-value, indicating that the characteristics do not have a significant effect on the probability of Communal Design production; this could also be reassured by the results displayed in **Table 94**, under the '95% C.I.for EXP(B)' column, where all confidence intervals cross the value of 1, indicating that the data values entered into the model are equally suggestive of improving or decreasing the probability of Communal Design production (see (Field, 2018, p. 904) for more information). Further, the Nagelkerke $R^2$ value indicated that 15.9% of the variance in the production of Communal Design probability can be explained by variances in the predictive characteristics entered into the model (see **Table 90**), indicating a low fitness of the model, as a whole.

Comparing the models using the data collected in intervention variation 2 to the collected in intervention variation 3, it is seen that the model in intervention variation 2 is a better predictor of Communal Design production; or it can also be interpreted as the use of personal values scores contribute to better prediction of Communal Design production, compared to the use of perfectionism scores. **Equation 3** was found to be a relatively low acceptable model for predicting Communal Designs; unlike **Equation 2,** which was found to be a very highly acceptable model for predicting Communal Design production.

### 5.3.4 Summary

This intervention variation was also to research how perfectionism (as another facet of the mindset, and an influential driver of decision-making) is prevalent amongst civil engineering students and observe how it influences or associates with their engagement with human-centred designing, and the type of designs they produce. This was carried forward from the findings of intervention variation 1 for further research, and to serve by unpacking the 'subjectivity' of sustainable decision making in civil engineering (see **Figure 2 - 'PhD Track of Thought' Flowchart**, for more information). It was found that the majority (74.48%) of civil engineering students indeed classify as perfectionists (as opposed to non-perfectionists). It was also found that although the perfectionists were more likely to show higher engagement (i.e., scores of empathy, consciousness and prosocialness, for example) during their human-centred designing workshop, it was the non-perfectionists that were significantly more likely to produce Communal Designs eventually. These results fed into the cognitive dissonance addressed in intervention variation 2, where perfectionists were perhaps intending to (by showing higher engagement), but then later failed to produce Communal Designs. Reasons to this, as previously discussed in intervention variation 2, could be due to the perfectionists' incompetency to build upon their intention to produce Communal Designs, in engineering university programmes. Further, resuming back to the literature for sense making, it was found that perfectionism is positively associated with self-protecting and anxiety-avoiding motives, which thus loop back to the findings of the previous intervention variation 1. These findings will be discussed in further detail, in the Discussions chapter.

## Chapter 6: Discussions

Results are to be discussed and referred to the hypotheses made and addressed earlier. Discussions will therefore be in order of the intervention variations and hypotheses proposed. As previously mentioned, statistical analyses that resulted in p-values<.05 were considered statistically significant, whilst p-values<.1 are argued to be tending-to-be significant (Andrade, 2019; Thiese, Ronna, & Ott, 2016; Benjamin, Berger, Johannesson, & al., 2018); particularly when addressed in smaller studies of psychological nature.

### 6.1 Intervention Variation 1

#### 6.1.1 Overview

This intervention variation was delivered to explore the feasibility of the Priming in a Civil Engineering Human-Centred Designing Task. Relevant results are discussed with respect to the proposed hypotheses.

*V1-H1: Based on the literature promising a positive induction of empathy in responders via the use of priming, it is hypothesised that primed civil engineering undergraduates are to show higher scores of empathy-correlated characteristics (i.e., consciousness) compared to those non-primed.*

Although the priming was intended to have a positive influence of students' measurements of empathy, and by extension, consciousness, this intervention revealed surprising results. Unexpectedly, results displayed in **Table 7** and **Table 8** revealed a reversed influence of the priming, i.e., the influence of the priming performed opposite to what intended. The effect of the priming on the civil engineering undergraduates during their work on the proposed human-centred designing task, was shown to have significantly decrease (as opposed to increase) the students' social consciousness (and thus by extension, empathy) levels. These results therefore defied the first hypothesis (V1-H1).

To make sense of these findings, I resume back to the literature, and found studies showing that measured empathy records generally correlate negatively with values rooted in Self Enhancement, and correlate positively with values rooted in Self Transcendent (Myyrya, Juujärvi, & Pesso, 2010; Price V. , 2016), especially in interventions that involve priming. Additionally, Price (2016) and Balliet et al. (2013) predicted that highest levels of empathy are to be found positively correlated to Benevolence Values (i.e., a basic subset value of the Higher Order Value of Self Transcendence – see **Figure 3**), and lowest levels of empathy are to be strongly and negatively correlated with Power and Achievement values (i.e., both are basic subset values of the Higher Order Value of Self Enhancement – see **Figure 3**).

Moreover, Galinsky et al. (2006) studied the influence of priming the basic value of Power on rates of perspective taking (i.e., a form of empathy; see (Davis M. , 1983)). Their results revealed that "power was associated with a reduced tendency to comprehend how other people see, think, and feel." This, in other words, implies that those motivated by or have great value for Power, tend to display reduced empathy for others.

Further, Price, (2016, p. 131) stated that "people who were highly motivated by the self-protecting, anxiety- avoidant, self enhancement values experienced the emotions of others to a lesser extent, and were less able to correctly identify a person's emotional state". Interpreting this by resuming to the Circular Motivational Continuum of the Schwartz Value System (see **Figure 3**), it is understood that values that subset motives of Self-Protection and Anxiety-Avoidance are those rooted in the Higher Order Values of Self Enhancement and Conservation. This indicates that those with Higher Order Values rooted in Self Enhancement and/or Conservation, may experience hinderance in the ability to empathise, and thus by extension, properly engage with the human-centred designing initiative, and subsequently, Communal Design production.

On the other hand, studies (Diekman, Brown, Johnston, & Clark, 2010; Ramsey, 2017) discussed how values and motivators in STEM are more likely to be rooted in *Agency* (i.e., motive of individualistic advancement*;* those who prefer "getting ahead" (Hogan, 1983)), as opposed to *Communion* (i.e., motive of collective advancement; those who prefer "getting along" (Hogan, 1983)). Linking the Agency/Communion Value system to that of the PVQ-RR by Schwartz (et al.) (2012; 2012), Trapnell and Paulhus (2012) found associations between Agentic values and *Self Enhancement* and *Openness to Change* Higher Order Values of the Schwartz Value system, and between Communal values and *Self Transcendence* and *Conservation* Higher Order Values of the Schwartz Value System. Their exact findings were: "high loadings for achievement, power, hedonism, and stimulation: This factor clearly represents a superordinate agency dimension. The second rotated factor corresponds to a very broad communal dimension, combining vertical collectivist values such as conformity, tradition, and security, with horizontal collectivist values, such as universalism and benevolence. These results parallel the preceding findings for life goals by documenting superordinate A & C dimensions within the Schwartz value taxonomy" (Trapnell & Paulhus, 2012, p. 42).

Based on the above 'sense-making' and referral to the relevant literature, the reversed influence of the priming found in the present intervention variation, therefore, seems to be due to a *hidden dictator* of empathy engagement – namely, motivators of personal values, and particularly those of self-protecting and anxiety-avoiding nature. The priming can thus be called to be *unveiling* hidden characteristics that may be inhibiting human-centred designing engagement and social consideration in engineering. This therefore calls for further research – i.e., intervention variations 2 and 3.

*V1-H2: By extension to Variation1-Hypothesis1 (V1-H1), it is hypothesised that the primed groups are therefore more likely than the non-primed groups to produce more Communal Designs (which, in this research, are considered more metaphysically informed forms of human-centred designs).*

In intervention variation 1, production of Communal Designs (considered to be the *crowning* form, i.e., the most metaphysically, empathically, consciously informed form of the human-centred designing engagement initiative proposed in this research) was found not significantly associated with the priming; this, however, can be argued to be due to the small sample size. V1-H2 therefore remains under question for future research.

As a final remark on this intervention, it is argued that although the priming did not produce the results that were intended, it perhaps unveiled a more hidden underlying factor that should be further addressed in engineering and human-centred designing. These sets of results therefore compliment other studies (Cech E. A., 2014; Bielefeldt, 2018; Bielefeldt & Canney, 2016; Niles, Contreras, Roudbari, Kaminsky, & Harrison, 2018; Niles, Contreras, Roudbari, Kaminsky, & Harrison, 2020) which address engineering undergraduates' tendency to decline and resist socially considerate practices. These present findings therefore compliment the aforementioned studies by further indicating that such resistances may be deeper embedded and influenced by subconsciously underlying factors and motivators.

Therefore, in intervention variations 2 and 3, this project tested to address these underlying factors (those contributing to human-centred designing engagement and Communal Design production) in an undergraduate cohort of civil engineers, by researching the engineering students' characteristics that might subconsciously be dictating decision-making and empathy engagement in human-centred designing contexts. Similar to intervention variation 1, the influence of priming was also observed, but was delivered through different mediums and durations of delivery. By addressing the underlying factors (– i.e., the engineering mindset) that contribute to such decision-making processes and contexts, results will complement the gap proposed on addressing the subjectivity of sustainable decision making in engineering (and arguably, in STEM too).

### 6.1.2 Further Discussions

Priming has been shown to surface racial prejudice as a hidden bias contributing to emotionally related decision-making (Valla, et al., 2018), judgement (Brown Givens & Monahan, 2005; Johnson, Huffman, & Jasper, 2014), empathic responding related to prosocial behaviour (Johnson, Olivo, Gibson, Reed, & Ashburn-Nardo, 2009), empathy engagement (Johnson, Bushman, & Dovidio, 2008; Johnson, Jasper, Griffin, & Huffman, 2013), and willingness to help (Johnson, Bushman, & Dovidio, 2008; Taddei, 2007). Therefore, when addressing priming for the induction of empathy for a people of a different racial group, it is vital to address this feature, particularly in contexts of international projects of human-centred designing in civil engineering. This, along with the present findings on social consciousness (and by extension, empathy) significantly decreasing when primed, therefore call for further research. Moreover, as motives of anxiety-avoidance seem to have surfaced due to the exposure of the primes, it is worth noting that the nature of the primes used (i.e., pictures of people carrying day-to-day activities in unfit places like dumpsters) could have been disturbing to the receiver, and could have therefore potentially triggered anxiety-avoidance motives in particular, when students were exposed to them. This phenomenon, however, was not explicitly studied in the present project as it was outside the scope of it; which therefore calls for further research in future repetitions of the intervention, to understand if this was the case. This also calls for the necessity of understanding the students' mental health statuses before they engage with an emotionally (and cognitively) demanding design initiative, as their mental health may be influential on, or influenced by, the recently 'in-demand' human-centric, socially considerate designs and initiatives in engineering and engineering education. The mental health of the supervisors/workshop facilitators may have also had hidden influences on such initiatives, and therefore should be farther assessed.

On another note, as the present intervention variation involves the production of Communal Designs as a result of  group work (as opposed individual work), it is important to note that the present group designs produced are most likely to not reflect all students' opinions and mindsets equally, but rather be reflective of some to a few peers only (see (Freeman & Greenacre, 2011; Le, Janssen, & Wubbels, 2018) for more information); this is particularly important in the cases where student groups were multicultural, as this is also said to be a factor of an imbalanced contribution to group work (see (Popov, et al., 2012)). This notion is particularly interesting, as it calls for further research on understanding group dynamics within group work, particularly when producing solutions and designs in contexts of international sustainable decision-making, social consideration, and human-centred designing, in civil engineering.

Finally, as this intervention was the first of its kind (in terms of its non-technicality, and social intent), the first-year students were inadequately equipped with the skillset, or mindset, needed to work with such a human-centric approach; this perhaps calls for earlier implementation of relevant training on overcoming such hindrances, in pre-university initiatives. Moreover, it would be interesting to view how such transitions appear from a pre-university to first-year university initiatives (– and in between); capturing how students' skillsets and mindsets develop and transition incrementally can help capture students' intentions to produce Communal Designs more thoroughly, giving more concise findings rather than mostly relying on their eventual production of Communal Designs or not.

### 6.2 Intervention Variation 2

#### 6.2.1 Overview

This intervention variation was delivered to explore prevalent Personal Values in civil engineering undergraduates, and personal values' associations with human-centred designing and Communal Design production. Relevant results are discussed with respect to the proposed hypotheses.

Recapping; studies (Diekman, Brown, Johnston, & Clark, 2010; Ramsey, 2017) suggest that members of STEM disciplines are predominantly agentic, as opposed to communal, in personal value and motivation. Basing upon (1) the findings of intervention variation 1, on how personal values and motivators (especially those self-protecting and anxiety-avoidant) influence empathy engagement and by extension human-centred designing, and (2) the addressed gap in the literature on the prevalent subjectivity in sustainable decision-making in engineering, I researched personal values of civil engineering undergraduates and examined how personal values associates with human-centred designing in intervention variant 2. Such observations have also been made in light of priming as opposed to a control (non-primed) group.

*V2-H1: With existing literature indicating that members of the STEM community (and therefore, engineers and engineering students) are more likely to hold Agentic Values, as opposed to Communal ones, it is hypothesised that civil engineering undergraduates are most likely to hold dominant Self Enhancement and/or Openness to Change Higher Order Values as opposed to Self-Transcendence and/or Conservation values.*

First, contradicting with studies that suggest the commonness of a dominantly agentic personal value and motivator system in STEM (and thus by extension, engineering), this present study found that the majority (60.87%) of civil engineering undergraduates have dominant Higher Order Values rooted in the communal Self Transcendence (see **Table 13**), as opposed to an agentic Higher Order Value. The second highest majority (27.17%), however, showed to have dominant Higher Order Value rooted in the agentic Openness to Change (see **Table 13**).

Second, when comparing the value systems of first-year, as opposed to third-year, civil engineering undergraduates, it was found that the value system seems to transition (or change) over the course of the programme. The present findings show that third-year undergraduates hold a significantly higher value for Tradition, and a tending-to-be significantly higher value for Security Social and Conservation (minus Humility and Face) compared to first-year civil engineering undergraduates (see **Table 14**).

The Higher Order Value of Conservation is known to have underlying self-protecting and anxiety avoidant motives (see **Figure 3**), and is defined by its emphasis of "preserving the status quo:

commitment to past beliefs and customs (tradition), adhering to social norms and expectations (conformity), and preference for stability and security for the self and close others (security)" (Arieli, Sagiv, & Roccas, 2020). Conservation is thereby the reflection of the general preference for conformity, obedience, resistance to change, and maintenance of the generally present situation(s), traditions, and status quo (Arieli, Sagiv, & Roccas, 2020; Arsenijević, Bulatović, & Bulatović, 2012; Schwartz S. , 2003).

The increase in value for Tradition in civil engineering undergraduates over time, therefore, suggest that the civil engineering students are likely to be skewing more towards the Higher Order Value of Conservation. An increase in value for the Higher Order Value of Conservation, by substitution suggests that the students are simultaneously skewing away from the Higher Order Value of Openness to change (see **Figure 3** and (Schwartz, et al., 2012)). This is interesting, as the (positive) association were found between the Higher Order Value of Openness to Change and production of Communal Designs – these will be discussed in the following few paragraphs (under V2-H2). Moreover, it is important to note that the Higher Order Value of Openness to Change, and the seek for innovation and creativity, are argued to be challengers of status quo (Arieli, Sagiv, & Roccas, 2020) which are by extension underlying motives of the Higher Order Value of Conservation. The present findings showing students' transition towards Conservation with time parallel those by Alpay et al. (2008) where it was found that engineering students enter their programme with a strive to "invent something new" (i.e., an expression of creativity, and by extension, Openness to Change) and "make a difference in the world", but such aspirations then reduce to those associated with "financial security" (i.e., an expression of Conservation; see **Figure 3** for more information), with time.

Additionally, correlative studies have been computed to address how and what the value of Tradition associates with in each of the year groups. It was found that third-year civil engineering undergraduates' increased value for Tradition is more tied with the Higher Order Value of Self Enhancement (see ***Table 15***) compared to the first-year students – the agentic Higher Order Value of Self Enhancement is also known to have underlying self-protecting and anxiety-avoidant motives (see **Figure 3**).

The present findings on the 'transition of value' in engineering education complements other studies (Bielefeldt, 2018; Bielefeldt & Canney, 2016; Cech E. , 2014; Cech & Sherick, 2015) that address engineering students' tendency to decline in public welfare belief and social consideration over the years in engineering education. The present findings, therefore, may suggest reasonings as to why this may be the case.

*V2-H2: Based on the literature associating positively the Self-Transcending and Openness to Change Values to prosocial, altruistic, empathic traits, with Self Transcendence being the most aligned to Communal Value traits and outcomes, it is hypothesised that those with dominant Higher Order Values rooted in the communal Self Transcendence (as opposed to the agentic Openness to Change) are the most likely to engage (empathically and consciously) with the proposed Human-Centred Designing assignment (i), and subsequently, produce more Communal Designs (ii).*

On the association of Higher Order Values with human-centred designing engagement and Communal Design production, it was found that those with dominant Higher Order Values rooted in the communal Self Transcendence showed, higher engagement (i.e., by showing higher scores of characteristics known to be positively associated with human-centred designing; like empathy and consciousness for example) with the human-centred designing initiatives, as they were tending-to-be more likely to have higher Empathy: Perspective Taking scores whilst producing Communal Designs, compared to those with dominant Higher Order Value rooted in the agentic Openness to Change (see **Table 18**). These findings therefore support the first segment of the second hypothesis made for this variation (V2-H2(i)).

However, it was found that those with dominant Higher Order Values rooted in the agentic Openness to Change were significantly more likely to produce Communal Designs, compared to those with dominant Higher Order Values rooted in Self Transcendence (see **Table 16**). These findings then defied the second segment of the second hypothesis for this variation (V2-H2(ii)).

It was interesting to observe that the first segment of the second hypothesis was supported, whilst the second segment was defied, although both were projected from the same notion and were subsequent in concept.

As the first part of the second hypothesis was justified, and the second part was defied, this proposed scepticism in either the proclaimed personal values (via the responses provided in the PVQ-RR) of the engineering undergraduates, or the competency of acting upon them. It was skepticized that either

> (1) the majority of engineering undergraduates untruthfully stated/proclaimed their dominant Higher Order values to be rooted in the communal Self Transcendence, and were in fact holding more agentic motives and values like Self Enhancement (similar what was suggested in other studies (Diekman, Brown, Johnston, & Clark, 2010; Ramsey, 2017)), thus providing a more rational reason as to why Communal Designs were found significantly less likely to be produced by those who have dominant 'proclaimed values' to be rooted in the communal Self Transcendence (see **Table 16** for more information); and/or

(2) the proclaimed values of the civil engineering undergraduates may indeed be truthfully rooted in the communal Self Transcendence, however, these values may not necessarily be a direct prediction of the undergraduates' display of communal attributes (for example empathy, consciousness and prosocial behaviour) that would have lead or translated into their intention to produce Communal Designs. The scepticism here lies in whether those with dominant Higher Order Values of the communal Self Transcendence indeed have aligning communal intentions, and the intention to produce Communal Designs. This therefore skepticizes and negates previous research providing indications that such communal values may lead to more conscious, empathic, and prosocial display of characteristics; upon which the hypotheses made on such characteristics being more associated with human-centric engagement and design in civil engineering; and/or

(3) the engineering undergraduates were truthful in their PVQ-RR responses (i.e., their statement of their dominant Higher Order Values) and their communal intentions to produce Communal Designs, but were unaware of how to act upon these motives in the context of designing in civil engineering (could be due to lack or inadequate education or training of acting upon such intentions technically and/or empathically, in civil engineering), and produce Communal Designs as hypothesised. If this was the case, then this intervention highlights an apparent cognitive dissonance in civil engineering students perhaps intending to, but then failing to produce Communal Designs. Such a dissonance may be explained via the 'Intention-Behaviour Gap' theory by Sheeran and Webb (2016).

The *Intention-Behaviour Gap*, is a concept that addresses why and how values and intentions may not always align with subsequent actions and behaviour. Sheeran and Webb (2016) indicate that most people do not refrain from acting upon something because they have no value for it, but rather because they may lack the adequate methodological competencies to do so. To contextualise this, given if the majority of engineering undergraduates' dominant personal values were truly rooted in the communal Self Transcendence, the finding that they were significantly less likely to produce Communal Designs flags a dissonance – particularly, a dissonance in the engineering subjective decision-making process, especially in the context of sustainable decision-making in design. This therefore highlights that, given if the engineering students had motives to engage more human-centrically and/or produce Communal Designs, their lack of competency to act upon these intentions points out faults in the engineering education paradigm. This is interesting, as in understanding the intention-behaviour gap between civil engineering undergraduates' personal values and socially considerate, sustainable design decisions, it is relevant to consider the discussions on how the depoliticized nature of engineering education culture may be undermining and triggering declines in students' competency and interest to engage with humanitarian and communal related engineering with time (Bielefeldt, 2018; Bielefeldt & Canney, 2016; Cech E. , 2014; Cech & Sherick, 2015).

These criticisms also resonate with the present findings on engineering students' value systems' transition towards more Conservative (see **Table 14**) and Self-Enhancing (see ***Table 15*)** ones, with time. This transition towards Conservation implies that, by default, civil engineering students are transitioning away from Openness to Change, and thus by extension, away from their likelihood of producing Communal Designs – as present findings show that those with dominant Higher Order Values rooted in Openness to change were significantly more likely to produce Communal Designs (see **Table 16**) compared to those with dominant Higher Order Values rooted in Self Transcendence.

Moreover, studies (Cech E. , 2013; Cech E. , 2014; Leydens & Lucena, 2017; Mazzurco & Daniel, 2020; Nieusma, 2013; Riley, 2008; Trevelyan J. , 2010) criticise the lack of non-technical, socially considerate, and communal-related education and training in engineering. This can thus be argued to be a contributing factor of broadening the intention-behaviour gap in civil engineering undergraduates' possible intention to, but superseding incompetency to produce Communal Designs.

It is also worth noting here, that the shear demand from the competency and educational accreditation boards (AHEP 4, 2020; UK-SPEC 4, 2020) for engineers and engineering students to display more social consciousness and consideration in designs and project execution, whilst also not providing the technical competency and training to do so, is argued to be widening this cognitive dissonance and intention-behaviour gap even further. Additionally, this could be argued to be applicable to engineering educators, as well as engineers and engineering students– highlighting a call for unpacking and understanding how and to what extent are current engineering educators equipped with the personal intention or motive, and/or technical competency, to teach and train engineers and engineering students on such notions, when requested by the accreditation boards to do so. This highlights the necessity to understand if a similar potential intention-behaviour gap is indeed prevalent amongst engineering educators as well, when found in such socially-considerate contexts, particularly when it comes to intending to and acting upon one's intention to work and produce socially considerate design.

For addressing and interpreting this highlighted dissonance further, I examined how *Social Desirability* scores of the civil engineering undergraduates associated with their dominant personal values and their subsequent influence on human-centred designing and Communal Design production. Results displayed in **Table 22** show that those with dominant Higher Order Value rooted in Self Transcendence were tending-to-be more likely than those with dominant Higher Order Values rooted in Openness to Change, to have higher-than-average Social Desirability scores in general.

Social Desirability is defined by "the need of Ss [subjects] to obtain approval by responding in a culturally appropriate and acceptable manner" (Crowne & Marlowe, 1960, p. 353) of the responder. It can therefore be interpreted that those with dominant Higher Order Values rooted in Self Transcendence may likely have provided responses reflecting higher 'Empathy: Perspective Taking' scores whilst producing Communal Designs, compared to those with dominant Higher Order Value rooted in Openness to Change (see **Table 18**), due to their desire to deliver more ‘socially desirable’ and ‘acceptable’ responses, and not necessarily reflective of their intrinsic (more *truthful*) drive to do so. High Social Desirability scores associated with those who have dominant Higher Order Values of Self Transcendence therefore contributes to the initial scepticism in the truthfulness of the undergraduates’ PVQ-RR response and their ‘proclaimed’ dominant personal value systems.

This dissonance was farther examined by addressing how the ‘communal intentions’ of the undergraduates manifested during the human-centred designing initiative. This was done by observing how their Communal Value scores (using the Agency Communion Value Scale (Trapnell & Paulhus, 2012)) correlated with the rest of their characteristics (like empathy and consciousness, etc.), in light of the different categories – their dominant Higher Order Value categories, the priming, and across those who produced Communal Designs as opposed to those who did not.

It was found that those with dominant Higher Order Values rooted in Openness to Change correlated positively with Self Consciousness (r=.636*), however, this correlation was not seen in those with dominant Higher Order Values rooted Self Transcendence category (see **Table 33)**. This is interesting as Self Consciousness is known (and hypothesised) to be mostly associated with the communal Higher Order Value of Self Transcendence. Moreover, the communal intentions of those with dominant Higher Order Values rooted in Self Transcendence corelated with Universalism Concern (r=.373*) to a lesser extent than those with dominant values rooted in Openness to Change; those with Higher Order Values rooted in Openness to change showed higher positive correlation with Universalism Concern (r=.529*); see **Table 33**. This was similarly interesting, as the value of Universalism Concern is a subsidiary value to the communal Higher Order Value of Self Transcendence (see **Figure 3**), and is thus obviously mostly associated (in theory) with the Higher Order Value of Self Transcendence.

Additionally, those with dominant Higher Order Values rooted in the (communal) Self Transcendence showed a positive correlation between their communal intention and the Agentic Value score (r=.401*), whereas a similar correlation was not found in those with dominant values rooted in the (agentic) Openness to Change. This is interesting, as this reassures on the presence of apparent dissonance in civil engineering undergraduates’ motivation and intent for Communal Design production, and their ability to act upon that intention and/or production of Communal Designs – especially those who claim to have dominant communal values rooted in Self Transcendence, which were found to be the majority of civil engineering undergraduates (see **Table 13**). This therefore calls for further researching the truthfulness of those who claim to have dominant communal values rooted in Self Transcendence, their intentions’ alignment with producing socially considerate Communal

Designs, and/or their ability to act upon that communal intent, as mentioned earlier – i.e., questioning: 'are they practicing what they preach?'

When addressing how the communal intention translates in the categories of those who produced Communal Designs as opposed to those who did not, it was found that those who did not produce Communal Designs showed positive correlations between their communal intention and Self Direction Thought (r=.376* - a subset value to the higher order value of Openness to Change), Universalism Concern (r=.404*) and Benevolence Care (r=.372* - both are two subset values to the higher order value of Self Transcendence), social consciousness (r=.338*) and Empathy (Sum) (r=.346*); whilst similar correlations were not see in the other category (i.e., those who produced Communal Designs); see **Table 34** for more information. These correlations clearly indicate that communal intentions (i.e., high universalism and benevolence values and motives) were not translated into producing Communal Designs in an undergraduate cohort of civil engineers. This then clearly showcases an apparent intention-behaviour gap in engineering undergraduates perhaps intending to, but then failing to produce Communal Design. Reasons to the presence of such an apparent dissonance, or intention-behaviour gap, may include the inadequate training to act upon communal intentions in engineering practice and engineering, as previously reviewed in the literature.

Additionally, it was found that those who did not produce Communal Designs showed higher positive correlations between their communal intention and Empathy: Empathic Concern (r=.480**), compared to those who did not produce Communal Design; whom showed positive correlations with Empathy: Empathic Concern (r=.411*) but to a lesser extent (see **Table 34**). Moreover, it is important to recap here that those with dominant Higher Order Values rooted in the communal Self Transcendence (i.e., those who are known to be more empathic generally – see Literature Review), were found to be more likely **not** to produce Communal Designs as well (see **Table 16**) – both of which further adds to the emphasis of a dissonance.

To continue identifying the presence of an intention-behaviour gap, it is important to note that Self Direction Thought and Universalism were flagged as positively correlated to the communal intention in both **Table 33** and **Table 34,** under the categories of 'Self Transcendence' and 'Not Produced Communal Designs', respectively. Drawing from this, and tethering it to the previous findings on those with dominant Self Transcendence values being more likely to **not** produce Communal Designs (see **Table 16**) as opposed to produce them albeit their more communal and empathic nature (when compared to those with dominant values rooted in the agentic Openness to Change), therefore establishes an identification of the very likely present cognitive dissonance or intention-behaviour gap in engineering undergraduates, who may intend to, but then fail to produce socially considerate Communal Designs, due to reasons which call for future research.

On another note, a similar presence of a dissonance was found in the context of pro-environmental behaviour (i.e., another sustainability-related notion) by Henkel, Seidler, Kranz, & Fiedler (2019); Henkel et al. found that the persuasive technique of nudging was too weak of an influencer to overcome the intention-behaviour gap present in contexts of pro-environmentalist intentions and subsequent actions of people. This, therefore calls for further research, as addressing this sustainability-related intention-behaviour gap might be of benefit to people a wider spectrum.

*V2-H3: By extension to Variation2-Hypothesis2 (V2-H2), it is therefore hypothesised that those with dominant Higher Order Values rooted in the communal Self Transcendence to be most likely to positively engage with (or respond to) the priming (compared to those with dominant values rooted in the agentic Openness to Change).*

Observing the influence of the priming, and its association with Higher Order Value categories, the human-centred designing engagement, and Communal Design production, it was found that the priming showed no significant association with the likelihood of producing Communal Designs – both with regard to the undergraduates' Higher Order Values (see **Table 24**), and regardless of them (see **Table 23**). It was also found that the association between the priming, the social desirability scores, and the Communal Design production was not significant (see **Table 109**).

The priming, however, showed to have a subtle positive influence on the characteristics of empathy and consciousness, when a series of two-tailed heteroscedastic t-test on the primed versus the non-primed (Control) cohort responses was computed, Results of this showed that those who were primed (regardless of the other independent variable – i.e., Higher Order Value categories) held tending-to-be significantly higher scores of social consciousness (see **Table 25**). Similarly, whilst examining the correlation between the communal intention (i.e., communal value scores) and the rest of the characteristics of the undergraduates, it was observed that the primed cohort showed a subtle positive influence on characteristics hypothesised to be positively associated with human-centred designing and Communal Design production (for example, empathy and consciousness); the communal intention of the primed cohort correlated positively with Universalism Tolerance (r=.635** - a subset of the communal higher order value of Self Transcendence), the Higher Order Value of Self Transcendence (r=.421*), social consciousness (r=.338*), and Empathy (Sum) (r=.364*); whereas similar correlations were not found in the non-primed cohort (see **Table 35**). Therefore, as communal values of Self Transcendence, empathy and consciousness are known to positively associate with human-centred designing engagement and social consideration (see Literature Review), the present findings of **Table 35**, are thus indicators of a subtle positive influence of the priming, on characterising empathy (and its extensions, i.e., consciousness), acting in accordance to what was intended in the Methodology (unlike what was seen in intervention variation 1– reasonings to this, however, was not found, but it could be reckoned that the method and duration of the priming might have had an influence); however this calls for further research.

Summarising the influence of the priming in this intervention variation, it was shown to be not as prominent on consciousness and/or empathy scores in this variation, unlike what was seen in variation 1 of the project. This is argued to be due to the medium and the methodology of how the priming was introduced to the students, and into the assignment.

Unlike the physical priming pictures that were hung on the surrounding walls, at eye level whilst the students were seated (like in what was done intervention variation 1), the primes in this intervention variation were on a computer screen, surrounding the questions in a word document, as the assignment was forced to be shifted online due to COVID restriction on face-to-face meetings. Thus, with the primes on the screen instead of the surrounding walls, it is argued that they might have been more detectable, or even cognised by the students, especially when they were within much less (physical) proximity with the assignment questions during the workshop. Moreover, the workshop in variation 2 was set to be a two-week online assignment, where students were able to sign in and out of liberally, unlike the 4 continuous-hour in-class workshop that took place in intervention variation 1. It is thus argued that my incapability of controlling the intensity of the priming online might have been a factor as to why it showed no significant influence in intervention variation 2, as it did in variation 1. It is also argued that the liberalism of access to the assignment, whilst simultaneously surfing the internet, being exposed to more or other pictures (of Shatila or other), and logging in and out of the assignment over a relatively extended period of time, was a main source of interrupting the subconscious influence of the primes, and was impossible to control.

#### 6.2.2 Further Discussions

For self-cross-checking the above findings on the categorisation of the Personal Values, and how they relate to human-centred designing engagement, Communal Design production and priming, were repeated using responses collected by the Agency Communion Value (ACV) Scale designed by Trapnell & Paulhus (2012), as opposed to the Revised Personal Value Questionnaire (PVQ-RR) scale designed by Schwartz et al. (2012). It was found that, indeed, the majority of civil engineering undergraduates have dominant Communion values, as opposed to Agentic ones (see **Figure 10**). This supports my previous findings on the majority of the undergraduates have dominant personal values rooted in the Higher Order Value of Self Transcendence (see **Table 13**) – which is known to be communal in nature.

It was also found that those with dominant communal (as opposed to dominant agentic) values were tending-to-be more likely to hold higher Social Desirability scores (see **Table 28**), which also supports my previous finding on those with dominant Higher Order Values rooted in the communal Self Transcendence (as opposed to the agentic Openness to Change) were tending-to-be more likely to have higher Social Desirability scores (see **Table 22**). The interpretation of social desirability and its relation with the proposed existing cognitive dissonance or intention-behaviour gap in civil engineering undergraduates, and the scepticism that followed, was discussed above.

Further, when a series of two-tailed heteroscedastic t-test comparing those with dominant communal values to those with dominant agentic ones, it was found that those with dominant agentic values had a significantly higher value for Tradition (see **Table 30**). This further supports the initial finding and notion on how the value of Tradition is associated with the students' agentic Self Enhancement value, with programme progression in civil engineering (see ***Table 15***).

Further, as a result of a set of two-tailed heteroscedastic t-tests comparing those who produced Communal Designs as opposed to those who did not, it was found that those who produced Communal Designs showed a tending-to-be higher value for *Face,* and a significantly lower value for *Humility*, compared to those who did not produce Communal Designs (see **Table 31**). Meanwhile those who produced Communal Designs whilst being categorised as '*Open to Change'* showed significantly higher value for *Hedonism,* compared to those who produced Communal Designs whilst being categorised as '*Self Transcendent'* (see **Table 32**).

*Face* is defined by its motivation for "security and power through maintaining one's public image and avoiding humiliation" (Schwartz, et al., 2012, p. 669), is underlying personal motives (as opposed to social ones), and motives of Self-Protection and Anxiety-Avoidance (see **Figure 3**). *Humility,* is defined by its motivation for "recognizing one's insignificance in the larger scheme of things (Schwartz, et al., 2012, p. 669), is underlying social focus (as opposed to personal ones), and the cusp of both Self-Protection and Anxiety Avoidance, and Growth and Anxiety-Free sets of motives (see **Figure 3**). *Hedonism* is defined by its motivation for "pleasure and sensuous gratification" (Schwartz, et al., 2012, p. 669), and is underlying personal motives (as opposed to social ones), and motives of Growth and Anxiety-Free motives (as opposed to Self-Protection and Anxiety-Avoidance motives; see **Figure 3**). Hedonism is found skewing more towards values of agency, as opposed to communion, according to Trapnell and Paulhus (2012); and can be viewed to be opposing in nature to the Higher Order Values of Self Transcendence and Conservation Values (i.e., the communal values) on **Figure 3**.

Tying the definitions of Face, Humility and Hedonism, with the results displayed in **Table 31** and **Table 32**, the following can be interpreted:

I) Those who produced Communal Designs having tending-to-be significant higher Face (see **Table 31**) can be interpreted as the intentions behind the Communal Design production may be driven by personal, anxiety-avoidant, self-protecting ones in civil engineering design. And recapping from the discussions of intervention variation 1, self-protecting and anxiety-avoidant motives were shown to be negatively associated with empathy especially in empathy priming interventions (Price V. , 2016).

II) Those who produced Communal Designs having significantly lower Humility (see **Table 31**) interestingly suggests that the intentions behind the Communal Design production may be driven by personal pride and egotism in civil engineering design.

III) On the other hand, those who produced Communal Designs whilst having dominant Higher Order Values of Openness to Change (as opposed to Self Transcendence) having significantly higher Hedonism (see **Table 32**) can be interpreted as the intentions behind the Communal Design production of those 'Open to Change' may be driven by agentic personal values, as opposed to communal ones in civil engineering design. This personal, agentic drive to producing Communal Designs, may explain why those with dominant Higher Order Values rooted in Openness to Change were found significantly more likely (than those with dominant Self Transcendence) to produce Communal Designs (see **Table 16**), albeit them showing lesser likelihood (than those with dominant Self Transcendence values) to engage with the human-centred designing initiatives (i.e., by showing tending-to-be significantly lower Empathy: Perspective Taking scores during the Communal Design production; see **Table 18**).

Finally, the finding on those with dominant Higher Order Values of Openness to Change were significantly more likely to produce Communal Designs (see **Table 16**), whilst it was also seen that civil engineering undergraduates seem to be increasing in value of Tradition (and thus by extension, the Higher Order Value of Conservation) with time and progression in the curriculum (see ***Table 15***); it is thus predicted for students to be decreasing in Higher Order Value of Openness to Change, and with it, the likelihood of producing Communal Designs with time. This then complimenting studies (Bielefeldt, 2018; Bielefeldt & Canney, 2016; Cech E. , 2014; Cech & Sherick, 2015) that discuss how students tend to decline in public welfare belief and social consideration over the years in engineering education; and studies (Arsenijević, Bulatović, & Bulatović, 2012; Dollinger, Burke, & Gump, 2007; Kasof, Chen, Himsel, & Greenberger, 2007; Kurt & Yahyagil, 2015; Lebedeva, Schwartz, Van De Vijver, Plucker, & Bushina, 2019; Rice G. , 2006; Sousa & Coelho, 2011; Zhou, Shin, Brass, Choi, & Zhang, 2009) that highlight the inverse association of Conservatism values and creativity, which is known to be an important contributing factor to Design Thinking (and thus by extension, Communal Design production).

Recapping on the proposed concept of Communal Designs, and its alignment with the calls proposed by the Institute of Civil Engineers (ICE Community blog, 2021) and the UK Government (HM Government; Department for Digital, Culture, Media and Sport, 2018, pp. 36-45) for implementing strategies to 'design out loneliness' and achieve 'a connected society' (respectively), I drew and made connections with it to the concept of 'Placemaking'.

*Placemaking* is a form of architectural urban design that encourages communal interaction (Project for Public Spaces (PPS), 2018). I therefore suggest that Placemaking would be a useful concept to integrate into civil engineering design modules, since it overlaps both design and social science, addressing human behaviour and interaction with structures and spaces. Placemaking could therefore be useful as a way of bringing civil engineering students' attention to social interaction needs, by aiding the understanding of social interactions, and thus bringing in more human-centred, humanitarian values into design, and considering both the metaphysical as well as the physical needs of the people, engineers are to design for. How and to what extent Placemaking should be introduced in civil engineering curriculums should be further looked into.

Lastly, using the data collected from civil engineering students, on characteristics and traits (using the instruments), and Communal Design production (using qualitative analysis and declaration – see **Table 4**) a binary logistic regression analysis was computed. This was to develop an equation predictive of students' Communal Design production based on their responses to the instruments addressed in this intervention variation. The equation was also to view how different characteristics are weighted in terms of their influence on Communal Design production.

After **Equation 2** was developed, showing how different characteristics influence the production of Communal Designs, it was seen that Self Direction score, followed by the Power Resources score, then followed by the Conformity Rules score, were the most influential factors, or mindset characteristics (addressed in intervention variation 2), contributing to the production of Communal Designs (or not producing Communal Designs – as some were 'negative' coefficients (B)). It was interesting to observe that Self Direction Action and Conformity Rules contributed negatively, whilst Power Resources contributed positively to the likelihood of producing Communal Designs. With the highest (positive) odds being associated with Power Resources, these findings then highlight an apparent strong agentic motive (as opposed to a communal one) behind Communal Design production in civil engineering education – further elaborating on the presence of an apparent aforementioned cognitive dissonance.

Interestingly, the weight of the coefficients of Empathy (and its subsets) contributing to the production of Communal Designs were seen as minute compared to the weights of factors of Personal Values (and other characteristics), as these were seen to hold larger coefficients, i.e., indicating a higher influence on the likelihood of producing Communal Designs or not. This is interesting as the research discourse that revolves around human-centred designing primarily addresses the importance of empathy and not any other related characteristics that can contribute to such human-centric designs.

## 6.3 Intervention Variation 3

### 6.3.1 Overview

This intervention variation was delivered to explore the prevalence of Perfectionism in civil engineering undergraduates, and perfectionism's associations with human-centred designing and Communal Design production. Relevant results are discussed with respect to the proposed hypotheses.

Recapping; as sustainable decision-making in engineering was made known to be subjective in nature (see Literature Review), I proposed to address this subjectivity by researching the engineering mindset and its influence and associations with human-centred designing and Communal Design production. In intervention variation 2, a facet of this mindset has been addressed – the Personal Values of a cohort civil engineering undergraduates, and their associations with human-centred designing and Communal Design production. In intervention variation 3, another facet of the mindset was studied and to be discussed in the following section – Perfectionism and its associations with human-centred designing and Communal Design production. Similar to intervention variation 1 and 2, intervention variation 3 also involved priming with results to be discussed.

*V3-H1: Based on the notions addresses in the literature review, linking the positivistic manner of problem solving to that of perfectionism, it is therefore hypothesised that civil engineering undergraduates are more likely to be Perfectionists, as opposed to Non-Perfectionists.*

Studies address the positivistic nature of the engineering curriculum and paradigm (Downey & Lucena, 2003b; Erden, 2003; Johnston, Lee, & McGregor, 1996). I draw from that, and associate the problem-solving manner of positivism, to that of perfectionism, hypothesising that civil engineering students are therefore more likely to be perfectionists as opposed to non-perfectionists.

Supporting this hypothesis, it was found that indeed, the majority of the civil engineering cohort (first- and third-year student combined) classify as perfectionists, as opposed to non-perfectionists. It was found that 51.03% of the civil engineering undergraduates categorise as maladaptive perfectionists, 23.45% categorise as adaptive perfectionists, and 25.52% categorised non-perfectionists (see ***Table 51***). Disregarding the nature of the perfectionism, it was thereby found that 74.48% of civil engineering undergraduates categorise as perfectionists, as opposed to non-perfectionists (***Table 51***). The first hypothesis (V2-H1) is thereby justified.

To test for any changes in the perfectionistic traits over the years in civil engineering education, first-year and third year responses to the Revised Almost Perfect Scale (Slaney, Rice, Mobley, Trippi, & Ashby, 2001) were compared, and no difference were found – the majority of civil engineering undergraduates remained to be classified as perfectionists, regardless of their year group (see ***Table 49*** to ***Table 51***), and no significant differences in any subscales of perfectionism were found (see ***Table 51*** and ***Table 52***).

*V3-H2: Due to the existing literature on positivism rejecting metaphysical input (i.e., empathy-informed ones) to problem solving methodologies, and perfectionists being less likely to be display creative attributes in nature, it is therefore hypothesised that Perfectionists are less likely than Non-Perfectionists to 'fully' engage with Design Thinking approaches and thus with the human-centred designing assignment (i), and subsequently, are less likely to produce Communal Designs (ii).*

On the association of Perfectionism with human-centred designing engagement and Communal Design production, it was found that those categorised as perfectionists were significantly more likely to **not** produce Communal Designs (see ***Table 53***). These findings therefore support the second segment of the second hypothesis made for this variation (V3-H2(ii)). This was also verified via the results of computing a two-tailed heteroscedastic t-test across responses of those who produced Communal Designs versus those who did not. Result of this test revealed that those who did not produce Communal Designs indeed showed significant or tending-to-be significant, higher mean values for the Standard Perfectionism Scale (p=.074), Self-Oriented Perfectionism (p=.020), and 'Total MPS' Perfectionism (p=.078); see **Table 77**. Based on these findings, it can be interpreted that being categorised as perfectionist and/or scoring relatively high on perfectionism scales, is associated with a lesser likelihood of producing Communal Designs.

However, it was found that perfectionists showed higher engagement with the human-centred designing initiatives; as they were found significantly more likely than non-perfectionists to have higher scores of Empathy: Empathic Concern (see ***Table 55***)**,** Empathy: Fantasy (see ***Table 56***)**,** Self Consciousness (see ***Table 59***), Social Consciousness (see ***Table 60***), and Prosocialness (see ***Table 61***) during their production of a Communal Design. This, therefore, defies the first segment of the second hypothesis proposed for this study variation (V3-H2(i)).

The above is interesting, as it aligns with the cognitive dissonance, or the Intention-Behaviour Gap emerged and addressed earlier in intervention variation 2 – i.e., although Perfectionists were found significantly more likely to show more engagement (i.e. higher empathy, prosocialness and consciousness scores) whilst producing Communal Design (thus higher engagement with the human-centred designing initiative), they were also found significantly less likely to produce Communal Designs eventually, compared to the non-perfectionists. Again, this led to question the alignment of the intention and the subsequent competency, or acting upon the intention, to produce Communal Designs.

Similar to what was assessed in intervention variation 2, social desirability scores were researched in relation to the perfectionism categories, and the production of Communal Designs, in referral to a proposed cognitive dissonance, or intention-behaviour gap in civil engineering undergraduates. To recap, Social Desirability is defined by "the need of Ss [subjects] to obtain approval by responding in a culturally appropriate and acceptable manner" (Crowne & Marlowe, 1960, p. 353) of the responder. It was found that, indeed, perfectionists were tending-to-be more likely than non-perfectionists to have higher social desirability scores (see **Table 64**). This finding therefore led to skepticizing the truthfulness in the empathy, prosocialness and consciousness scores the perfectionists reported when producing Communal Designs, as these responses might have been driven by the perfectionists' intention to deliver more 'desirable' responses.

This dissonance was farther examined by addressing how the 'communal intentions' of the undergraduates manifested during the human-centred designing initiative, by observing how their Prosocial Behavioral Intention scores (using the Prosocial Behavioral Intentions Scale (Baumsteiger & Siegel, 2019)) correlated with the rest of their characteristics, and in light of the different categories – the perfectionism categories, the priming, and across those who produced Communal Designs as opposed to those who did not.

It was found that the prosocial behavioral intention scores (i.e., the communal intention) of the non-perfectionists correlated positively with Social Consciousness (r=.409*) whilst this association was not seen in the perfectionists' category (see **Table 79)**.

Further, the non-perfectionists also showed higher correlation between their communal intention and Prosocialness (r=.574**), Empathy: Empathic Concern (r=.607**), Empathy: Perspective Taking (r=.471**), and Empathy (Sum) (r=.481**), when compared to the perfectionists' category; whom showed a positive correlation with Prosocialness (r=.470**), Empathy: Empathic Concern (r=.428**), Empathy: Perspective Taking (r=.272**), Empathy (Sum) (r=.300**), but to a lesser extent (see **Table 79**).

The above correlations make sense, as they align with the earlier finding on non-perfectionists being significantly more likely that perfectionists to produce Communal Designs (see ***Table*** *53*) and hypotheses made on the positive associations between such characteristics and human-centred designing and Communal Design production. However, the above findings (displayed in **Table 79**) contradict with earlier findings on perfectionists being significantly more likely to produce Communal Designs whilst holding significantly higher Empathy: Empathic Concern (see ***Table 55*)**, Empathy: Fantasy (see ***Table 56*)**, Self Consciousness (see ***Table 59***), Social Consciousness (see ***Table 60***), and Prosocialness (see ***Table 61***), compared to the non-perfectionists. The latter therefore emphasises the prominence of a cognitive dissonance, or intention-behaviour gap in perfectionist civil engineering undergraduates in a human-centred designing context – i.e., the majority of civil engineering undergraduates (see ***Table 51*)**.

Additionally, perfectionists showed a positive corelation between their communal intention and Self-Oriented Perfectionism, whilst this was not seen in the non-perfectionist category (see **Table 79**). This is interesting, as self-oriented perfectionism, can be argued to be more agentic in nature. This may link back to earlier findings on the personal motive (as opposed to the social motive) behind Communal Design production in civil engineering undergraduates made in the discussions for intervention variation 2.

*V3-H3: By extension to Variation3-Hypothesis2 (V3-H2), it is therefore hypothesised that Perfectionists to be less likely than Non-Perfectionists to positively engage with (or respond to) the priming.*

Observing the influence of the priming, and its association with perfectionism categories, the human-centred designing engagement, and Communal Design production, it was found that the priming showed an obscurely tending-to-be significant association with the unlikelihood of producing Communal Designs (***Table 65***). This aligned with results found in intervention variation 1.

Moreover, it was found that non-perfectionists were significantly more likely than perfectionists to produce Communal Designs whilst being *Primed* (see ***Table 66***), verifying the third hypothesis (V3-H3). However, the associations between the priming, the Communal Design production, and the characteristics known to positively contribute to human-centred designing (i.e., empathy, consciousness, and prosocialness – each individually) were found not significant (see **Table 111** to **Table 119**). Similarly, the association between the priming, the Communal Design production and social desirability was found not significant (see **Table 120**).

The priming, however, showed to have a subtle positive influence on the characteristics of empathy, consciousness, and prosocialness. Whilst examining the correlation between the communal intention (i.e., Prosocial Behavioral Intention scores) and the rest of the characteristics of the undergraduates in light of the priming, the control (non-primed) group showed higher positive correlations between their communal intentions and Prosocialness (r=.603**), Empathy: Empathic Concern (r=.477**), Empathy: Perspective Taking (r=.392**) and Empathy (Sum) (r=.371**), than the primed group; whom showed positive correlations with Prosocialness (r=.424**), Empathy: Empathic Concern (r=.389**), Empathy: Perspective Taking (r=.291**), and Empathy (Sum) (r=.304**), but to a lesser extent (see **Table 81**). This made sense, as such characteristics were hypothesised to be positively associated with Communal Design production, and the non-primed were found obscurely tending-to-be more likely than the primed to produce Communal Design (see ***Table 65***).

Additionally, it was found that the non-primed showed positive correlations between their communal intention and ASP-R Order Scale (r=.294*), Empathy: Fantasy (r=.222*), and Self-Oriented Perfectionism (r=.257*), whilst this was not seen in the primed cohort (see **Table 81**). This is interesting, as it subtly refers back to the finding on perfectionists showing a positive corelation between their communal intention and Self-Oriented Perfectionism, whilst this was not seen in the non-perfectionist category (see **Table 79**); and thus, links back to earlier discussion made in intervention variation 2, on the likely prevalent personal motive (as opposed to the social motive) behind Communal Design production amongst civil engineering undergraduates.

Moreover, the primed cohort showed a unique correlation between their communal intention and Social Consciousness (r=.342**), whereas this was not seen in the non-primed cohort (see **Table 81**). Similar to what was seen and discussed under **Table 35** in intervention variation 2, this finding indicates indeed the presence of a subtle positive influence of the priming on the characteristics associated with better human-centred designing engagement (for example empathy, consciousness and/or prosocialness).

Summarising the influence of the priming in this intervention variation, it was shown to be not as prominent on consciousness and/or empathy scores in this variation, unlike what was seen in variation 1 of the project, but it was seen more influence compared to the results found in variation 2. This, similar to intervention variation 2, was argued to be due to the medium and the methodology of how the priming was introduced to the students, and into the assignment.

Unlike the physical priming pictures that were hung on the surrounding walls, at eye level whilst the students were seated (like in what was done intervention variation 1), the primes in this intervention variation were on a computer screen, surrounding the questions in a canvas quiz, as the workshop was forced to be shifted online due to COVID restriction on face-to-face meetings. Thus, with the primes on the screen instead of the surrounding walls, it is argued that they might have been more detectable, or even cognised by the students, especially when they were withing much less (physical) proximity with the assignment questions during the workshop. Unlike the workshop in variation 2 where it was set to be a two-week online assignment and students were able to sign in and out of liberally, this variation held this workshop as a one-off session, with 5 continuous-hour online-class workshop that took place with continuous live supervision on Zoom – i.e., more comparable to intervention variation 1. It is thus argued that the intensity of the priming was more controlled in variation 3 than in variation 2; but as it remained online, the intensity could not have been controlled as in variation 1 as students were simultaneously surfing the internet, being exposed to more or other pictures (of Shatila or other) whilst working on their assignment. This could be argued to have been a main source of interruption to the subconscious influence of the primes, and was impossible to control online.

### 6.3.2 Further Discussions

For self-cross-checking the above findings on the categorisation of the perfectionists and non-perfectionists, and how they relate to human-centred designing engagement, Communal Design production and priming, were repeated using responses collected by the Multidimension

Perfectionism Scale – Short From (MPS-SF) designed by Hewitt et al. (2008), as opposed to the Revised Almost Perfect Scale (APS-R) designed by Slaney et al. (2001).

It was found that more than a third of the civil engineering undergraduates (of both first- and third-year) had Self-Oriented, Other Oriented, Socially Prescribed, and 'Total MPS' (i.e. the sum of Self-Oriented, Other Oriented, and Socially Prescribed) Perfectionism scores higher than the 67$^{th}$ percentile score of the entire undergraduate sample (see **Table 68**, and **Figure 11**).

It was also found that those with higher-than-67$^{th}$ percentile (i.e., high score) of the Self Oriented and 'Total MPS' Perfectionism score were tending-to-be more likely to **not** produce Communal Designs, than to produce Communal Designs (see ***Table 69*** and ***Table 72***, respectively). These findings therefore support earlier ones on perfectionists being significantly less likely than non-perfectionists to produce Communal Designs (see ***Table 53***).

Further, it was found that;

- Those with high (i.e., higher than the 67$^{th}$ percentile score) scores of Self Oriented Perfectionism showed significantly higher Prosocialness (p=.001), Prosocial Behavioral Intention (p=.017), Self Consciousness (p=.000), Empathy: Empathic Concern (p=.000), Empathy (Sum) (p=.007), and tending-to-be significantly higher Empathy: Fantasy (p=.066) scores, compared to those with low (i.e., lower than 67$^{th}$ percentile score) Self Oriented Perfectionism (see **Table 73**).
- Those with high scores of Other-Oriented Perfectionism showed significantly higher Prosocialness (p=.004), Self Consciousness (p=.006), Empathy: Empathic Concern (p=.032), Empathy: Fantasy (p=.002), Empathy: Personal Distress (p=.001), Empathy (Sum) (p=.000), and a tending-to-be significantly higher Empathy: Perspective Taking (p=.072) scores, compared to those with low scores of Other-Oriented Perfectionism (see **Table 74**).
- Those with high scores of Socially Prescribed Perfectionism showed significantly higher Prosocialness (p=.001), Self Consciousness (p=.000), Empathy: Empathic Concern (p=.001), Empathy: Fantasy (p=.000), Empathy: Perspective Taking (p=.007), Empathy: Personal Distress (p=.001), Empathy (Sum) (p=.000), and a tending-to-be significantly higher Prosocial Behavioral Intention (p=.057) scores, compared to those with low scores of Socially Prescribed Perfectionism (see **Table 75**).
- Those with high scores of 'Total MPS' Perfectionism showed significantly higher Prosocialness (p=.002), Self Consciousness (p=.000), Empathy: Empathic Concern (p=.001), Empathy: Fantasy (p=.004), Empathy: Personal Distress (p=.017), Empathy (Sum) (p=.000), and a tending-to-be significantly higher Prosocial Behavioral Intention (p=.090) and Empathy: Perspective Taking (p=.057) scores, compared to those with low scores of 'Total MPS' Perfectionism (see **Table 76**).

The findings discussed above (on results from **Table 73** to **Table 76**) again, align with earlier findings on perfectionists showing higher engagement with the human-centred designing initiative – perfectionists were significantly more likely than non-perfectionists to have higher scores of Empathy: Empathic Concern (see ***Table 55*)**, Empathy: Fantasy (see ***Table 56*)**, Self Consciousness (see ***Table 59***), Social Consciousness (see ***Table 60***), and Prosocialness (see ***Table 61***) during their production of a Communal Design.

On another note, in attempt to connect the two facets of the mindset researched, and relating it back to the subjectivity of sustainable decision-making, and human-centred designing and engagement, I resume back to Literature. A study by Fermandel (2015) finds an association between perfectionism and personal values. Fermandel (2015) found that "higher perfectionism was related to Self-Enhancement and Conservation value priorities, with strongest relations to Achievement based values", and suggested that "perfectionism was related to value priorities that promote the self and the existing status quo, whilst being self-protective and serving to cope with anxiety." Fermandel's findings were the final pieces to complete this current PhD puzzle.

The motivators of self-protection and anxiety avoidance (i.e., mostly self enhancing and conservative – see **Figure 3**) seem to have a common theme in these discussions:

- In intervention variation 1, to make sense of the findings on the reversed influence of the priming, i.e., the decreased levels of social consciousness (and by extension, empathy) due to the priming (see **Table 7** and **Table 8**), a study's (Price V. , 2016) findings on the negative correlative associations between empathy levels and self-protecting and anxiety-avoidant motives was referred to. From there, it was suggested that the self-protecting and anxiety-avoidant motivators of the civil engineering students may have possibly been behind the reversed influence of the priming the students, and by extension, their inhibited ability to *properly* engage with human-centred designing initiatives.
- In intervention variation 2, it was found that those with dominant Higher Order Values of Openness to Change were significantly more likely to produce Communal Designs (see **Table 16**). Civil engineering undergraduates, however, also seem to be increasing in value of Tradition (and thus by extension, the Higher Order Value of Conservation) with time and progression in the curriculum (see ***Table 15*);** they are thus predicted to be decreasing in Higher Order Value of Openness to Change, and with it, the likelihood of producing Communal Designs with time – complimenting studies (Bielefeldt, 2018; Bielefeldt & Canney, 2016; Cech E. , 2014; Cech & Sherick, 2015) that discuss how students tend to decline in public welfare belief and social consideration over the years in engineering education. Moreover, there were additional findings discussed in intervention variation 2,

where motives of self-protection and anxiety-avoidance were flagged in (positive) association with Communal Designs production.

To recap: the Higher Order Value of Conservation is known to be underlying motivators of self-protection and anxiety-avoidance (see **Figure 3**), and is defined by its emphasis of "preserving the status quo: commitment to past beliefs and customs (tradition), adhering to social norms and expectations (conformity), and preference for stability and security for the self and close others (security)" (Arieli, Sagiv, & Roccas, 2020). The Higher Order Value of Openness to Change and the seek for creativity, on the other hand, act as challengers to status quo (Arieli, Sagiv, & Roccas, 2020), and thus to the Higher Order Value of Conservation.

- In intervention variation 3, it was found that the majority of civil engineering undergraduates categorise as perfectionists, as opposed to non-perfectionists (see ***Table 51***)**.** It was also found that perfectionists were significantly more likely than non-perfectionists to not produce Communal Designs (see ***Table 53***), and that non-perfectionists were significantly more likely than Perfectionists to produced Communal Designs whilst being *Primed* (see **Table 66**). According to Fermendel (2015), perfectionists are driven by self-protecting and anxiety-avoidant motives; this therefore loops back to the findings of intervention variation 1 discussed.

Motives of anxiety-avoidance and self-protection, therefore, seem to have been emerging as common theme to the inverse influence of the priming (i.e., a reflection of a decreased level of human-centred designing engagement), and/or the reduction of likelihood to produce Communal Designs (see Discussions of Intervention Variation 1 and 2 as well) – either way, such motives seem to be challengers to human-centred engagement, and Communal Design production, in civil engineering design. Moreover, self-enhancing motives and egocentrism were also flagged in the discussion of the finding on those who produced Communal Designs having significantly lower Humility (see **Table 31**), interestingly suggesting that the intentions behind the Communal Design production may be driven by personal pride and egotism in civil engineering design. In taking this forward, it is therefore suggested the motivators of anxiety-avoidance and self-protection prevalent in engineering and engineering students, should be further understood and mitigated to allow for better human-centred engagement and designing in civil engineering.

Further, using the data collected from civil engineering students, on characteristics and traits (using the instruments), and Communal Design production (using qualitative analysis and declaration – see **Table 4**) a binary logistic regression analysis was computed. This was to develop an equation predictive of students' Communal Design production based on their responses to the instruments addressed in this intervention variation. The equation was also to view how different characteristics are weighted in terms of their influence on Communal Design production.

After **Equation 3** was developed, showing how different characteristics influence the production of Communal Designs, it was seen that the Priming factor, followed by the students' Empathy: Empathic Concern score, then followed by the Prosocialness score, were the most influential factors, or mindset characteristics (addressed in intervention variation 3), contributing to the production of Communal Designs (or not producing Communal Designs – as some were 'negative' coefficients (B)). It was interesting to observe that the Priming factor (intended to trigger and/or promote empathy), as well as Empathy: Empathic Concern scores contributed negatively, whilst simultaneously Prosocialness scores contributed positively to the likelihood of producing Communal Designs.

When comparing the models using the data collected in intervention variation 2 to those collected in intervention variation 3, it is seen that the model in intervention variation 2 is a better predictor of Communal Design production; or it can also be interpreted as the use of personal values scores contribute to better prediction of Communal Design production, compared to the use of perfectionism scores. **Equation 3** was found to be a relatively low acceptable model for predicting Communal Designs; unlike **Equation 2,** which was found to be a very highly acceptable model for predicting Communal Design production.

Finally, the present studies and findings shed light on the importance of further exploring the influence of the engineering mindset and characteristics on engineers' design decision-making processes, especially in the context of sustainability and social consideration. The present studies show significant associations of two facets of the mindset (Personal Values and Perfectionism) and other characteristics of civil engineering undergraduates, to the type of designs they produce, and their engagement with human-centred, public-welfare-related initiatives.

Lastly, with the present findings showing that the majority of civil engineers are more likely to hold perfectionistic traits (– with a high percentage of them being maladaptive; see ***Table 51***) combined with the extensive, existing research on the negative associations of perfectionism to mental and physical wellbeing (Blatt, Quinlan, & Pilkonis, 1995; DiBartolo, Li, & Frost, 2008; Geranmayepour & Besharat, 2010; Molnar, Reker, Culp, Sadava, & DeCourville, 2006) this project sheds light on, and recommends, engineering curricula and cultures to actively seek and implement strategies that would tend to their students' and other subjects' (for example, employees') perfectionism and consequential wellbeing, and further consider mitigating perfectionism to aid with Design Thinking, engagement with human-centred, public-welfare-considerate initiatives, and Communal Design production. These recommendations also apply to other cultures and paradigms where positivism and/or perfectionism are known to be predominant. Specific strategies to such mitigations, however, were outside the scope of this study.

## Chapter 7: Conclusions and Future Work

A real-life case human-centred designing workshop assignment was designed to take part in a civil engineering undergraduate programme at Swansea University. Students were exposed to notions and competencies of designing *for* people of Shatila, Lebanon. The assignment involved students using the *Matrix of Human Needs and Satisfiers* (Max-Neef, Elizalde, & Hopenhayn, 1991) as a framework, and Shatila residents' quality-of-life reports, to inform their conceptual designs with as they were instructed to design *for* the people of Shatila, with the goal to positively impact Shatila residents' quality-of-life. Conceptual designs and quantitative data on students' empathy, self- and social-consciousness, prosocialness, personal values, perfectionism, and social desirability levels were collected before or during the interventions. Three interventions took place – each of which examining the associations of different combinations of the (aforementioned) characteristics with human-centred designing engagement and the production of what I termed *Communal Designs.*

Communal Designs are considered a specific form of human-centred, human-need based design, characterised by the particular attention to needs that involve and encourage end-users' communal engagement and interaction, sense of 'togetherness', and social identity. They are, therefore, the result and manifestation of the empathy, social consciousness, and communal values present in the engineers or engineering students.

In the present interventions, Communal Designs are characterised by the consideration of selected interaction-orientated human needs from Max-Neef et al.'s *Matrix of Human Needs and Satisfiers* (1991, pp. 32-33). If a design considered and addressed peoples' needs but did not address the interaction needs specified in **Table 4** (i.e., needs that involve communal interaction and social belonging, for example) it will be discounted as a Communal Design. Communal Designs are thus inclusive of both metaphysical human needs as well as their physical ones (e.g., shelter and sanitation). The concept of Communal Designs aligns with the calls proposed by the Institute of Civil Engineers (ICE Community blog, 2021) and the UK Government (HM Government; Department for Digital, Culture, Media and Sport, 2018, pp. 36-45) for implementing strategies to 'design out loneliness' and achieve 'a connected society', respectively.

During the interventions, the feasibility of 'priming civil engineering students into human-centred designing' was also examined. Conducting a method of subconsciously characterising empathy in engineering students during their work on the human-centred designing initiative was also researched; this was done via the exploitation of the psychological phenomena of priming. As studies (Bielefeldt & Canney, 2016; Cech E. , 2014; Downey & Lucena, 2003; Downey & Lucena, 2003b; Niles, Contreras, Roudbari, Kaminsky, & Harrison, 2018; Niles, Contreras, Roudbari, Kaminsky, & Harrison, 2020) show that engineering students seem to reject or resist empathy-informed or socially considerate initiatives in a positivistic and techno-centric engineering curriculum, it was therefore suggested that characterising empathy subconsciously via priming could bypass this possible resistance from students. Priming was also suggested to act as 'value-reinforcer' of such empathy- or socially-related initiatives in engineering, over time.

Three intervention variations were conducted:

> The first was to explore the feasibility of the priming in a civil engineering human-centred designing task;
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> The second was to explore the prevalent Personal Values in civil engineering undergraduates, and personal values' associations with human-centred designing and Communal Design production;
>
> And the third was to explore the prevalence of Perfectionism in civil engineering undergraduates, and perfectionism's associations with human-centred designing and Communal Design production.

Results were obtained, analysed, and discussed.

Result of the first intervention variation showed that, opposing to what was intended, social consciousness levels (and by extension, empathy levels (Thompson, 2001)), significantly decreased (as opposed to increased) due to the priming. It was suggested that personal values of the civil engineering students (being rooted in the agency and self-enhancement) might have contributed to their inability to engage empathically. The results of this intervention were collected from an in-class workshop and priming intervention.

Result of the second intervention variation showed that, contradictory to studies that show the prevalence of agentic values in STEM and engineering (Diekman, Brown, Johnston, & Clark, 2010; Ramsey, 2017), the present findings reveal that the majority (60.87%) of civil engineering undergraduates claim to have dominant values rooted in the communal Higher Order Value of Self Transcendence, with the second highest majority (27.17%) having dominant Higher Order Value rooted in the (more agentic) Openness to Change. The present study also finds that third-year students value Tradition (as subsidiary basic value to the Higher Order Value of Conservation) significantly more than first-year civil engineering students, suggesting that civil engineering students seem to skew and value Conservation more, with time.

With regards to the association of personal values to the students' engagement with the human-centred designing initiative and the production of Communal Designs, it was found that although those with dominant Higher Order Values rooted in the (communal) Self Transcendence showed a higher likelihood of having tending-to-be higher scores of empathy (i.e., a characteristic that is known to be positively associated with human-centred designing), it was those with dominant Higher Order Values rooted in the (agentic) Openness to Change that produced the most Communal Designs. From these findings, it was proposed that a cognitive dissonance, or an intention-behaviour gap, might have been prevalent amongst the majority of civil engineering undergraduates, as they may have intended to (due to them claiming to have dominant communal values of Self Transcendence), but then later failed to produce Communal Designs. In addressing the intention-behaviour gap, Sheeran & Webb (2016) indicate that most people do not refrain from acting upon something because they have no value for it, but rather because they may lack the adequate methodological competencies to do so. This resonates with other studies (Cech E. , 2013; Leydens & Lucena, 2017; Mazzurco & Daniel, 2020; Nieusma, 2013; Riley, 2008; Trevelyan J. , 2010) that criticise the lack of non-technical education in engineering curriculums.

Moreover, scores of Social Desirability were analysed in relation to the students' personal values, to address this cognitive dissonance further. It was found that those with dominant Higher Order Values rooted in Self Transcendence indeed were tending-to-be more likely to hold higher Social Desirability scores than those with dominant Higher Order Values of Openness to Change. Social Desirability is defined by "the need of Ss [subjects] to obtain approval by responding in a culturally appropriate and acceptable manner" (Crowne & Marlowe, 1960, p. 353) of the responder. It can therefore be interpreted that those with dominant Higher Order Values rooted in Self Transcendence may likely have provided responses reflecting higher 'Empathy: Perspective Taking' scores whilst producing Communal Designs, due to their desire to deliver more 'socially desirable' and 'acceptable' responses, and not necessarily reflective of their intrinsic (more *truthful*) drive to do so. High Social Desirability scores associated with those who have dominant Higher Order Values of Self Transcendence therefore induced scepticism in the truthfulness of the undergraduates' PVQ-RR response (i.e., their 'proclaimed' dominant personal value systems), and responses to other characteristics (i.e., empathy and consciousness) instruments, and designs produced.

The scepticism manifested in the following ways:

(1) The majority of engineering undergraduates untruthfully stated/proclaimed their dominant Higher Order values to be rooted in the communal Self Transcendence, and were in fact holding more agentic motives and values like Self Enhancement (similar what was suggested in other studies (Diekman, Brown, Johnston, & Clark, 2010; Ramsey, 2017)), thus providing a more rational reason as to why Communal Designs were found significantly less likely to be produced by those who have dominant 'proclaimed values' to be rooted in the communal Self Transcendence.

(2) The proclaimed values of the civil engineering undergraduates may indeed be truthfully rooted in the communal Self Transcendence, however, these values may not necessarily be a

direct prediction of the undergraduates' display of communal attributes (for example empathy, consciousness and prosocial behaviour) that would have lead or translated into their intention to produce Communal Designs. The scepticism here lies in whether those with dominant Higher Order Values of the communal Self Transcendence indeed have aligning communal intentions, and the intention to produce Communal Designs. This therefore skepticizes and negates previous research providing indications that such communal values may lead to more conscious, empathic, and prosocial display of characteristics; upon which the hypotheses made on such characteristics being more associated with human-centric engagement and design in civil engineering.

(3) The engineering undergraduates were truthful in their PVQ-RR responses (i.e., their statement of their dominant Higher Order Values) and their communal intentions to produce Communal Designs, but were unaware of how to act upon these motives in the context of designing in civil engineering, and produce Communal Designs as hypothesised. If this was the case, then this intervention highlights an apparent cognitive dissonance in civil engineering students perhaps intending to, but then failing to produce Communal Designs. Such a dissonance may be explained via the 'Intention-Behaviour Gap' theory by Sheeran and Webb (2016).

On the other hand, with the present findings revealing that civil engineering undergraduates that hold dominant Higher Order Values of Openness to Change being more likely to produce Communal Designs, and civil engineering students seem to value Tradition (i.e., by extension, the Higher Order Value of Conservation) more with time, it is thereby indicated that with the increased values for Tradition, the likelihood of Communal Design production is predicted to be decreased, with time – as the Higher Order Values of Openness to Change and Conservation are mutually exclusive and opposing in nature, thus as one increases, the other, by default, decreases (Schwartz, et al., 2012). This is interesting as it resonates with other studies in the field (Bielefeldt, 2018; Bielefeldt & Canney, 2016; Cech E. , 2014; Cech & Sherick, 2015) that discuss how the depoliticized nature of engineering education culture may be undermining and triggering declines in students' competency and interest to engage with humanitarian and communal related engineering with time.

The priming in the second intervention variation showed a subtle positive influence on enhancing characteristics known to promote human-centred designing; however, it seemed not to be as vividly influential as was seen in intervention variation 1. It was suggested that that was due to the intervention taking place online as opposed to in-person (which was the case in intervention variation 1). It was discussed that the medium of delivery of the intervention and the duration of it might have affected the influence of the priming, and complicated the control of the priming intensity.

Result of the third intervention variation showed that the majority (74.48%) of civil engineering undergraduates categorise as perfectionists, as opposed to non-perfectionists. It was also found that the degree of perfectionism does not significantly change over time in engineering education – the majority of both first- and third-year civil engineering students still remained to be categorised as perfectionists.

With regards to the association of students' perfectionism to their engagement with the human-centred designing initiative and the production of Communal Designs, it was found that non-perfectionists were significantly more likely than perfectionists to produce Communal Designs. Simultaneously, it was also found that perfectionists were significantly more likely to have higher scores of 'Empathy: Empathic Concern', 'Empathy: Fantasy', Self- and Social Consciousness, and Prosocialness during their production of a Communal Design. These characteristics are known to be positively associated with human-centred designing and were thus hypothesised to be positively associated with Communal Design production. These findings on perfectionists showing higher engagement with the human-centred designing initiative, whilst being found significantly less likely to eventually produce Communal Design signified to a cognitive dissonance or intention-behaviour gap, similar to what was seen in intervention variation 2 results. Perfectionists might have had the intention to deliver Communal Designs (as they showed higher empathy, consciousness and prosocialness scores during the human-centred designing initiative), but have failed to execute doing so. This refers back to notions on the engineering paradigm and education not equipping civil engineering students with non-technical competencies of acting upon communal intentions and human-centred design execution, for example.

Similar to what was done in intervention variation 2 to assess this cognitive dissonance further, social desirability scores of the perfectionists were tested, and were found to be indeed tending-to-be significantly higher than those of the non-perfectionists. This indicated that the perfectionists' responses showing higher empathy, consciousness and prosocialness might have been due to their motive to deliver more 'desirable' results, not necessarily reflecting the '*truthful'* intrinsic desire to do so. High social desirability scores therefore promote scepticism in the responses and/or communal intention of the perfectionists also.

In intervention variation 3, it was found that non-perfectionists were significantly more likely than perfectionists to produce Communal Designs whilst being primed. Other results in intervention variation 3 showed a subtle positive influence of the priming on enhancing characteristics known to be associated with human-centred designing. The priming in intervention variation 3 was found slightly more influential than that in variation 2, but less than that in variation 1. This was argued to be due to the medium of delivery being online (similar to that in intervention variation 2), but was set to be a 5-continuous-hour workshop (comparable to that in intervention variation 1) as opposed to the two-week online assignment set in intervention variation 2, where students were liberally allowed to sign in and out of the assignment over the course of two weeks. Therefore, it was argued that the delivery of the human-centred designing workshop and the priming in intervention variation 3 was more controlled than that of intervention variation 2, but not as controlled as that of intervention 1, as in-person as opposed to online workshops limited internet surfing, and thus being influenced by other pictures and cues online.

Finally, to assemble the findings on the intention (or motivation) to produce Communal Designs with regard of the two facets of the engineering mindset addressed (i.e., Personal Values and Perfectionism) in the human-centred designing context, a study by Fermandel (2015) was found to complete this current *puzzle*.

Fermandel (2015) found results that link the facets of the engineering mindset (i.e, personal values and perfectionism) discussed in this project. She found that "higher perfectionism was related to Self-Enhancement and Conservation value priorities, with strongest relations to Achievement based values", and suggested that "perfectionism was related to value priorities that promote the self and the existing status quo, whilst being self-protective and serving to cope with anxiety." Motivators of self-protection and anxiety-avoidance were discussed to have a common theme in the present findings, and across all intervention variations:

- In intervention variation 1, to make sense of the findings on the reversed influence of the priming, i.e., the decreased levels of social consciousness (and by extension, empathy) due to the priming, a study's (Price V. , 2016) findings on the negative correlative associations between empathy levels and self-protecting and anxiety-avoidant motives was referred to. From there, it was suggested that the self-protecting and anxiety-avoidant motivators of the civil engineering students may have possibly been behind the reversed influence of the priming the students, and by extension, their inhibited ability to *properly* engage with human-centred designing initiatives.
- In intervention variation 2, it was found that those with dominant Higher Order Values of Openness to Change were significantly more likely to produce Communal Designs. Civil engineering undergraduates, however, also seem to be increasing in value of Tradition (and thus by extension, the Higher Order Value of Conservation) with time and progression in the curriculum; they are thus predicted to be decreasing in Higher Order Value of Openness to Change, and with it, the likelihood of producing Communal Designs with time.
To recap: the Higher Order Value of Conservation is known to be underlying motivators of self-protection and anxiety-avoidance (see **Figure 3**), and is defined by its emphasis of "preserving the status quo: commitment to past beliefs and customs (tradition), adhering to social norms and expectations (conformity), and preference for stability and security for the

self and close others (security)" (Arieli, Sagiv, & Roccas, 2020). The Higher Order Value of Openness to Change and the seek for creativity, on the other hand, act as challengers to status quo (Arieli, Sagiv, & Roccas, 2020), and thus to the Higher Order Value of Conservation.

- In intervention variation 3, it was found that the majority (74.48%) of civil engineering undergraduates categorise as perfectionists, as opposed to non-perfectionists. It was also found that perfectionists were significantly more likely than non-perfectionists to not produce Communal Designs, and that non-perfectionists were significantly more likely than Perfectionists to produced Communal Designs whilst being *Primed*. According to Fermendel (2015), perfectionists are driven by self-protecting and anxiety-avoidant motives; which therefore loops back to the findings of intervention variation 1 discussed.

Motives of anxiety-avoidance and self-protection, therefore, seem to have been emerging as common theme to the inverse influence of the priming (i.e., a reflection of a decreased level of human-centred designing engagement), and/or the reduction of likelihood to produce Communal Designs – either way, such motives seem to be challengers to human-centred engagement, and Communal Design production, in civil engineering design. Moreover, self-enhancing motives and egocentrism were also flagged in the discussion of the finding on those who produced Communal Designs having significantly lower Humility, interestingly suggesting that the intentions behind the Communal Design production may be driven by personal pride and egotism in civil engineering design.

Moreover, equations predictive of Communal Design production were developed and discussed in intervention variations 2 and 3 – see **Equation 2** and **Equation 3**, respectively. Equations were developed using the data collected on civil engineering students' personal values, perfectionism and other characteristics, paired with their production of Communal Designs (or not Communal Designs). These equations were show and analyse how different personal characteristics and traits are weighted in terms of their influence on Communal Design production.

Lastly, the present studies and findings shed light on the importance of further exploring the influence of the engineering mindset and characteristics on engineers' design decision-making processes, especially in the context of sustainability and social consideration. The present studies show significant associations of two facets of the mindset (Personal Values and Perfectionism) and other characteristics of civil engineering undergraduates, to the type of designs they produce, and their engagement with human-centred, public-welfare-related initiatives.

To conclude, present findings show that priming can be a useful tool to promote empathy, and influence human-centred designing and engagement, provided the engineering mindset is priorly understood. Present findings also show that two facets of the engineering mindset and decision-making motivators, are highly associated with such socially considerate initiatives. This therefore suggests for further and deeper research of the topic.

In taking this forward, this project therefore suggests the following:

(1) Recapping on the proposed concept of Communal Designs, and its alignment with the calls proposed by the Institute of Civil Engineers (ICE Community blog, 2021) and the UK Government (HM Government; Department for Digital, Culture, Media and Sport, 2018, pp. 36-45) for implementing strategies to 'design out loneliness' and achieve 'a connected society' (respectively), I drew and made connections with it to the concept of 'Placemaking'.

> *Placemaking* is a form of architectural urban design that encourages communal interaction (Project for Public Spaces (PPS), 2018). I therefore suggest that Placemaking would be a useful concept to integrate into civil engineering design modules, since it overlaps both design and social science, addressing human behaviour and interaction with structures and spaces. Placemaking could therefore be useful as a way of bringing civil engineering students' attention to social interaction needs, by aiding the understanding of social interactions, and thus bringing in more human-centred, humanitarian values into design, and considering both the metaphysical as well as the physical needs of the people, engineers are to design for. How and to what extent Placemaking should be introduced in civil engineering curriculums should be further looked into.

(2) With the present findings showing that the majority of civil engineers are more likely to hold perfectionistic traits (– with a high percentage of them being maladaptive) combined with the extensive, existing research on the negative associations of perfectionism to mental and physical wellbeing (Blatt, Quinlan, & Pilkonis, 1995; DiBartolo, Li, & Frost, 2008; Geranmayepour & Besharat, 2010; Molenaar, Sobin, & Antillón, 2010) this project sheds light on, and recommends, engineering curriculums and cultures to actively seek and implement strategies that would tend to their students' and other subjects' perfectionism and consequential wellbeing, and further consider mitigating perfectionism to aid with Design Thinking, engagement with human-centred, public-welfare-considerate initiatives, and Communal Design production. These recommendations also apply to other cultures and paradigms where positivism and/or perfectionism are known to be predominant.

    Similarly, based on the present findings, it is suggested the motivators of anxiety-avoidance and self-protection prevalent in engineering and engineering students, should be further understood and mitigated to allow for better human-centred engagement and designing in civil engineering. Mitigation strategies to cope with motivators of self-protection and anxiety-avoidance in engineering (undergraduates, at least) should be promoted, as the present findings suggest that such detrimental motivators are acting as inhibitors to empathy-engagement, and thus by extension, *proper* human-centred designing and Communal Design production. Specific strategies to such mitigations, however, were also outside the scope of this project.

Nevertheless, it can be deduced from reviewing the literature, that such strategies lie in holding creativity-inducing workshops or lectures in engineering that would contribute to the 'openness to change' value and motive, as they, by concept, will challenge the anxiety-avoidant and self-protective motives of decision-making (i.e., the conservative and perfectionistic motives) and status quo (Arieli, Sagiv, & Roccas, 2020).

Further in future work, it would be interesting to research and understand where (such) motives originate or are derived from, how they develop in civil engineering, and whether they could be influenced or mitigated at an earlier stage.

Lastly, although this project works to promote empathy and socially considerate mindsets and initiatives in civil engineering classrooms whilst bypassing a possible resistance or backlash from students, it is worth questioning how this resistance may be of benefit to engineering students in contexts of human-centred designing or other. This call for future research to unpack and understand the resistance and possible backlash from students towards such non-technical notions further, to then perhaps understand how to work with it (instead of bypass it) towards better reflection and delivery of socially considerate engagement and intentions, in the civil engineering design context.

(3) Priming, as a tool of characterising empathy, should be further looked into and researched, as it stands as a promising tool to promote empathy whilst bypassing resistance and has the potential to act as a human-centred designing 'value reinforcer', as argued previously. Priming, however, is suggested to come sequential to prior understanding of the engineering mindsets, as in this project, it has been demonstrated how influential the mindset is on the interaction and association with the priming. Moreover, for future relevant work, it is also worth noting that the present studies took place in a single university in Wales, and as personal values may vary across different cultures and backgrounds (Schwartz S. , 2003), it is therefore recommended to collect data from multiple universities, to get a better understanding of civil engineering students' personal value systems across different demographical factors, and thus further observe how these personal values may change over time and demography. It would also be interesting to observe how these differences in demographic factors contribute to the influence of the priming, especially in the context of civil engineering human-centred designing, in the future.

Further, priming has been shown to surface racial prejudice as a hidden bias contributing to emotionally related decision-making (Valla, et al., 2018), judgement (Brown Givens & Monahan, 2005; Johnson, Huffman, & Jasper, 2014), empathic responding related to prosocial behaviour (Johnson, Olivo, Gibson, Reed, & Ashburn-Nardo, 2009), empathy engagement (Johnson, Bushman, & Dovidio, 2008; Johnson, Jasper, Griffin, & Huffman, 2013), and willingness to help (Johnson, Bushman, & Dovidio, 2008; Taddei, 2007). Therefore, when addressing priming for the induction of empathy for a people of a different racial group, it is vital to address this feature, particularly in contexts of international projects of human-centred designing in civil engineering. This therefore call for further research.

## Limitations

Statistical Limitations

Albeit the small studies' advantages (i.e., quick to execute, and can address hypotheses and research questions in a short time span) which are valuable to time bound and budget restricted PhD programmes, they are limited by their susceptibility to a large standard error in statistical analyses. Small samples designs are therefore recommended to be repeated, to gain a larger sample size and thus be able to draw 'stronger' and more definite statistical conclusions. On the other hand, small studies are argued to be of more benefit (compared to larger studies) particularly in the context of psychological interventions; Smith & Little (2018) compared large and small study designs and found results asserting the "the validity and legitimacy of the small-*N* design as a method for generating reliable psychological knowledge". They found results highlighting: "high power and inferential validity of the small-*N* design, in contrast to the lower power and inferential indeterminacy of the large-*N* design" when argued that "some of the most robust, valuable, and enduring findings in psychology were obtained, not using statistical inference on large samples, but using small-*N* designs in which a large number of observations are made on a relatively small number of experimental participant", and "if psychology is to be a mature quantitative science, then its primary theoretical aim should be to investigate systematic, functional relationships as they are manifested at the individual participant level and that, wherever possible, it should use methods that are optimized to identify relationships of this kind". Therefore, given the multidisciplinary nature of this PhD project, the small samples sizes of the present psychology-informed interventions can thus be argued to be acceptable to address the novel relationships between the priming, personal values and perfectionism, and human-centred designing in civil engineering design contexts. However, it is still recommended for the sample sizes to be larger when split 'quasi-randomly' (see Methodology) if and whenever possible, when repeating the present interventions, to produce more robust findings.

Moreover, the repetition of the priming exposure in all intervention variations, along with the proposal of Research Question 6 in both intervention variations 2 and 3 (i.e., V2-RQ6 and V3-RQ3, respectively; where specific research questions of intervention variations 2 and 3 were readdressed using a different approach for self-cross-check), is argued to be a form of validation of the findings and claims made, albeit the small sample sizes involved (especially in intervention variations 1 and 2).

Lastly, with regards to the models/equations predictive of Communal Designs (i.e., **Equation 2** and **Equation 3**), they could not have been tested using another sample, as the interventions could not have been repeated; nor could the samples used be split to test the models on parts of the samples. It could be argued, however, that the present equations were primarily to demonstrate the different characteristics' magnitudes of influence on the production of Communal Designs.

Methodological limitations

Human-centred designing involves community engagement, for it is considered a reiterative design approach to produce more effective human-centric designs (Giacomin, 2014), however, in the present project, students could not have engaged with the community they were instructed to design for (i.e., the people of Shatila). This was to ensure safety precautions (especially during time of COVID-19), and was out of the budget. However, with the present novel approach to considering the society being designed for (via the usage of the information brief, quality-of-life reports, and the Matrix of Human Needs and Satisfiers (Max-Neef, Elizalde, & Hopenhayn, 1991)), it is argued to be contributing to such a possible gap in the human-centred designing framework. Further, as for the classification process of Communal Designs, limitations to the present classification methodology include the fact that the judges classifying the designs as *Communal* or not, although blinded, could have imposed an unforeseen bias given that they were both from the faculty of civil engineering, and could have therefore contributed with a categorisation process extending purely from an engineering perspective, and possible skewed by an unforeseen anchored decision-making dynamic related to civil engineering. Therefore, in future repetitions of the present interventions, it is suggested that efforts to reduce or even prevent such a possible bias in the Communal Design categorisation process should be made; this could be done by involving a more diverse group of judges in the classification process (from different departments). Moreover, instead of adopting a binary output end-result of the classification process (i.e., Communal vs Not Communal design classification), it would have been interesting to observe if and how such a categorisation process could extend over a scale (i.e., from Not Communal (0) to very Communal (5) design classification) with the development of a bigger and diverse judging group – this was not executed in the present project as it was outside the scope and resources of the project. Moreover, creating a 'scale' of how 'communal' a Communal Design is, implies that a rubric (essentially a 'hierarchy of communion') should be established (– a hierarchy this project intended to bypass). The aforementioned requests for further efforts into analysing what (if) potential biases are to arise in such a rubric, and so would also require a deep level of the judges' reflection and consciousness, to prevent from further hidden bias influencing the classification process; all of which were outside the scope and resources of the present project.

Moreover, the delivery of priming could not have been replicated in the three intervention variations; this was to adapt to the COVID-19 restrictive implication on face-to-face lecturing. Additionally, the delivery of the human-centred designing workshop (including the priming) in intervention variation 3, differed to that of variation 2 (although both were online), as it was restructured due to the deduced negative implication of the extended duration of the online assignment on the feasibility of priming (after intervention variation 2), and for it to be more comparable to the human-centred designing workshop of intervention variation 1 (a one-off 4+ continuous hour workshop, as opposed to the two-week-long assignment of variation 2). Moreover, on the execution of priming, this project could not have debriefed the primed students on the priming. This was strictly due to the technical feasibility conditions for the priming to work; more on this was explained in both the Literature Review and Methodology. None of the interventions took place without the ethics committee's prior consent to proceed, however, it would have been interesting to test and observe how informing the primed students of the primes may influence their engagement with, and consequential output, of human-centric design. This, however, could not have taken place in the present project, as this would have required further resources in terms of lecturer/student cohorts/classroom availabilities, which was outside the scope of the present project.

A limitation to intervention variation 1, was that the SSA responses were anonymised, and therefore could not have been matched (the before and after responses). Additionally, the Primed (P3) and non-primed (control; P1) groups could not have been split and tested in two separate rooms due to room availability, and the middle (P2) group's responses were therefore disregarded; this further reduced the sample size response count for this intervention variation.

Further, in intervention variation 2, the human-centred designing assignment was set up for third-year, as well as first-year civil engineering undergraduates, however, Phase II of the third-year students was cancelled (see **Figure 8**). This limited the sample size involved in intervention variation 2, and the extension of the study on how personal values could associate with Communal Designs across the two year groups, especially when it observed that student were found to be shifting in value systems towards Conservation over time in engineering education (see **Table 14**), and that those with dominant Higher Order Values rooted in Openness to Change (i.e., opposite to Conservation) were found significantly most likely to produce Communal Designs (see **Table 16**).

It is also worth noting that these studies took place in a single university in Wales, and could not have expanded this research to other universities abroad. As personal values may vary across different cultures and backgrounds (Schwartz S. , 2003), it is therefore recommended to collect data from multiple universities, to get a better understanding of civil engineering students' personal value systems across different demographical factors, and thus further observe how these personal values may change over time and demography. It would also be interesting to observe how these differences in demographic factors contribute to the influence of the priming, especially in the context of civil engineering human-centred designing, in the future.

On another note, the influence of COVID restrictions on allowing for face-to-face lecturing proposed further limitations, and potential influencer to look out for in future repetitions of the interventions, on lectures' student attendance monitoring, and workshop supervision. Students' attendance monitoring (over Zoom) could not have been completely controlled, which therefore proposed the limitation of the inability to properly monitor students' reception of needed information for the assignment and/or priming; particularly in intervention variation 2 (where an hour lecture was held once, with a follow-up lecture for questions held the following week), more than in intervention variation 3 (which was a 5-hour continuous online workshop). The supervision of the online lectures in intervention variation 2 and 3 were also different (due to lecturer availability, especially during COVID), as in intervention variation 2, myself and another lecturer (from the Civil Engineering department) were available to supervise in the given lectures for the assignment; whereas in intervention variation 3, myself and another two lecturers (also from the Civil Engineering department) were present – i.e., providing more supervision per student online. Supervision in intervention variation 1 was in person: the same people that supervised in intervention variation 2, but not intervention variation 3. Moreover on the supervision's influence on the design process/workshop, 'design facilitation' and/or 'design expertise' (i.e., the personal influence of the facilitator/supervisor of the design process/workshop) has been reviewed to be heavily influential on design, and the interactive processes held amongst peers during the design process (see (Mosely, Wright, & Wringley, 2018; Mosley, Markauskaite, & Wrigley, 2021) for more information). This was not thoroughly addressed in the present methodology, as it required further resources and time/supervisor availabilities; it is therefore suggested that, in future repetition of the present intervention(s), to regard such notion with increasing detail to yield more concise results.

Further, the numerous questionnaires used in intervention variations 2 and 3 in particular, was to get an idea of students' engagement with the designed workshop; this was done by collecting data on characteristics known to be positively associated with human-centred designing – i.e., understanding students' empathy and its 'synonyms' (like consciousness, prosocialness, and communal intentions; see Literature Review), instead of just observing empathy. The numerous questionnaires therefore could have imposed a 'questionnaire fatigue' in students, and could have potentially influenced their responses, however this could not have been avoided due to time and resource restrictions, and student availabilities. In future work, this should be taken into consideration, where the data collection could be planned to be spaced out over a longer/extended period of time – i.e., data can be collected all throughout the academic year, before and after their engagement with the human-centred designing assignment/workshop, instead of immediately before or after, to avoid such a fatigue. On another note, the possibility of a 'Social Desirability Bias' was not accounted for experimentally in the present project; as there exists literature on a positive association between social desirability self-reporting and age (Soubelet & Salthouse, 2011), and on its connection to gender, where females were found more likely to respond in a socially desirable fashion (Bernardi R. A., 2006; Bernardi & T., 2008; Chung & Monroe, 2003). Reasons to this are argued to be the unequal distribution of females to males prevalent in the present civil engineering undergraduate cohorts (see Methodology for percentages of Females in each student cohort), and given that the students were undergraduate university students (Year 1 vs Year 3), it is argued that they belong to the same age group (i.e., do not distinctively vary in age). However, it is recommended to account for such a possibility of a social desirability bias when splitting groups ‘quasi-randomly’ (i.e., account for the age and gender in a more detailed manner, if and whenever possible), when repeating the present intervention variations, to obtain less biased results.

Finally, the complex underlying mechanism of priming and its intended triggered consequences are still undergoing extensive neurological research, on their complex relationship with personalities, personal values, intention, cognitive change, behaviour and decision-making (see (Cesario, 2014) for more information). Any further work expanding on this topic should be considered when priming in engineering settings, and should take note of contemporary psychological and neurological research as the field advances, when designing methodological approaches.

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## Appendix A – Systemic Literature Review ('In-Depth') Tables

*Table 95 - Reviewing how others in the field addressed the problem of characterising empathy, consciousness, design thinking, and/or human-centred designing in engineering classrooms - ASEE review.*

| Paper Name | Paper Citation | Paper Synopsis | Remarks on paper's relevance to the present literature review section |
|---|---|---|---|
| Integrating Teacher Empathy into the Engineering Classroom one Educator at a Time: An Action Research Study | (Sundaram & Kellam, 2022) | This study used Action Research (I.e., working *with* participant, as opposed to *on* participant) to integrate empathy in engineering classrooms. It, however, attempts to integrate empathy in engineering education faculty as opposed to students. Using data collected from interviews and reflective writing on discussions with participants identifying their choice of a specific empathic action to implement within the course, the researchers found that the faculty's use of empathy has increased in the classroom, this was due to their active adoption of the | Although this study attempts to promote empathy in an engineering classroom, it does not target students, but rather targets characterising empathy in faculty. This therefore does not resonate with the present project or review. However, it might be interesting to observe in future research, the outcomes of such a methodology if it were to be applied on engineering students, and in contexts of |

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| | | specified choices of empathic actions identified. | human-centred designing. |
| Scalable and Practical Interventions Faculty Can Deploy to Increase Student Success | (Hempel, Blowers, & Kiehlbaugh, 2019) | This study discusses interventions to integrate “low-cost, scalable interventions that span the affective domains of growth mindset, self-efficacy, metacognition, and belongingness” in engineering education. The authors found that by implementing a reflective process that extends throughout different teaching practices, it seems to show promising results in students’ personal and professional growth, and metacognition. | This a paper can be argued to contribute to notions of metacognition, and can thus be argued to be characterising a growth mindset, metacognition and belongingness within engineering education, which may overlap with the aforementioned characteristics and human-centric design thinking approaches. However, this study does not address an intervention that explicitly promotes empathy, consciousness, design thinking or human-centred designing. |

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| Engineering Empathy: A Multidisciplinary Approach Combining Engineering, Peace Studies, and Drones | (Hoople & Choi-Fitzpatrick, 2017) | This work in progress study employed a multidisciplinary project-based assignment learning approach, for engineering students (in collaboration with peace study students) to design a “drone for social good”. This, the authors argue, will facilitate mediums for empathy, technical and ethical challenges and wicked problem solving to be exercised. The intervention composed of group discussions, team exercises and collaborative workshops. The authors identified the challenges faced, which they hope to overcome in the future. The challenges they encountered included managing course logistics, identifying the proper technology ‘that matters’, identifying the role of external actors (I.e., clients, stakeholders, | This paper addressed an approach to explicitly promote empathy in students by having engineering students work collaboratively with peace study students, to put forward a collaborative design for a drone. |

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| | | and customers), measuring outcomes, and contemplating "Why not just do service learning?". These challenges are discussed and suggested to be resolved in future research. | |
| Faculty Interpretations of Sociotechnical Thinking in their Classrooms: Techniques for Integration | (Blacklock, Johnson, Cook, Plata, & Claussen, 2021) | This study identifies engineering educators' motivation (as opposed to the students') to promote sociotechnical thinking in their classrooms, and methods that could help other educators in integrating such thinking in their classrooms. Through qualitative analyses of reflective logs from the educators, they found that on "1. The Relationship of Motivation, Engagement, and Receptivity to Sociotechnical Integration:<br>1a. The Importance of Motivation: Engaging Students and Faculty<br>1b. Generating | This paper does not address an intervention designed to explicitly promote empathy or consciousness or design thinking, or human-centred designing approaches in engineering students – instead it promotes sociotechnical engagement and integration in engineering faculty. |

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| | | Motivation for Students and Faculty 1c. Student Engagement Leads to Receptivity";<br>and on:<br>"2. Successful Techniques for Sociotechnical Integration in Class: 2a. Relatively Small Integrations Throughout the Semester, 2b. Integrating with Real World Examples, 2c. [facing] Difficulties of Ambiguity or Open Problems, 2d. Creating an Emotional Connection [between the educators and students], 2e. Simple Integration [i.e., keeping in simple for both faculty and students], and finally 2f. Learning from Others and Sharing Knowledge". | |
| The Critic as Designer: How Metacognition Makes Transdisciplinarity Possible | (Schuman, McNair, Gray, & Ozkan, 2021) | This study implements transdisciplinary design education and critique to develop students' metacognitive abilities, and by extension, their problem-framing and | This study implements an intervention to explicitly promote consciousness via employing a pedagogical |

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| | | human-centred approaches. Employing "The Critical Response Process" as a framework (which, they argue, promotes students' self-reflection), this study found that critique as a pedagogical strategy indeed improved students' metacognition, self and social awareness, and the more considerate and collaborative manners of problem solving. | strategy of critique: "The critical response Process". |
| Engineering and Sustainability: The Challenge of Integrating Social and Ethical Issues into a Technical Course | (Andrade & Tomblin, 2018) | This study implemented two discussions - and [then] lecture-based, active learning interventions that emphasised the intersection of social issues, urbanization, and sustainable development, when addressing the topic of Sustainability in a sophomore class of Civil and Environmental Engineering programme. The interventions intended | This study implements interventions to explicitly promote social consideration and consciousness, by intentionally surfacing such notions in discussions and other practices in the classrooms. |

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| | | to "improve student learning outcomes, induce more thoughtful conversations among students, and invoke a deeper evaluation of the complexity of the current urban systems", and "intentionally brings social dimensions of sustainable technology to the forefront"; the second intervention also incorporated tasks that "emphasize a socio-technical systems framework, stakeholder value mapping, and empathy building". The exercises were found positively influential on the students' ethical and sociotechnical thinking of sustainable infrastructure design, as their results revealed that the interventions "increase[d] students' awareness of social impact of technologies and students' understanding of complexity in | |

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| | | infrastructure and technological changes”. | |
| “Drugs, Alcohol, Joblessness, and Lifestyle”: Engineering Students’ Perceptions of Homelessness and Implications for Social Justice Education | (Mejia, Chen, Chapman, & Fledderman, 2021) | This study explored how engineering students perceive social justice issues in the context of engineering. They addressed how engineering students framed issues of homelessness when set to design a solar-water heater for a mobile shower unit, analysing their opinions and the role of engineers in such a social justice issue. The authors explored so by analysing the students’ answers to four open-ended questions before and after the project. Their results revealed that 1) students tend to frame issues of homlessness in terms of deficit perspectives (e.g., inadequacies of the home) and sometimes adhere to meritocratic ideologies, 2) students adhered to the idea that engineering is a field dedicated to serve | Although this paper addresses topic of social consideration, it does not implement an intervention that explicitly promotes consciousness and consideration in engineering students. |

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| | | others by “fixing” problems but rarely mentioned their role in society as being contributors to a solution, 3) most engineering students do not see themselves as being agentic actors or agents of change – rarely mentioning their role as citizens.<br>The authors discuss the first two results as adhering to the existing discourse on how the heavily technocentric engineering tending to treat the non-technical, social aspects as “tangential to or separate from engineering”. They also discuss the third as “suggest[ing] that engineering educators that seek to address issues of social justice [should] need to first deconstruct the complexity of engineering practice and the nuances involved in technical work”, arguing that “decoding complex | |

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| | | social issues is important in order for students to see themselves as agentic actors that can contribute to social justice through engineering design”. | |
| Exploring Student Responses to Utility-value Interventions in Engineering Statics | (Ruiz, Trageser, & Lutz, 2021) | This study implemented Utility Value Interventions (UVIs), i.e., activities in which “students are given opportunities to express how course content is personally useful to them”. This was implemented in the context students’ performance and motivation in a set of introductory engineering mechanics courses (e.g., statistics and dynamics). This study aims to “examine how students make connections between their values and their learning in statics” by collecting and thematically analysing student responses on their personal values and their perceived connection with the | This study explicitly fostered empathy in engineering students by guiding them to understand their personal values and identify their connection with the course content (i.e., understanding how the values of the course resonate with their [students’] personal values, and motivation for the engineering work or practice). |

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| | | course content. As a result, three themes emerged: 1) Self-improvement; 2) Empathy/Kindness and 3) Helping. Discussing the results and the subsequent importance of aiding students' identification of their connection between their personal values and course contents, they argue that "given the abstract, decontextualized mode in which engineering sciences are typically taught, instructors can work to foster these personal connections and enhance student motivation and success in foundational areas of an engineering curriculum". | |
| Classroom Belonging and Student Performance in the Introductory Engineering Classroom | (Schar, et al., 2017) | This study examines the relationship between the students' sense of belonging' (i.e., social belonging, engineering self-efficacy, engineering identity and closeness to others), and their academic performance, | Although this study addresses notions of social consideration and belonging, it does not address university students, nor does it address an intervention to |

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| | | in an ‘engineering-specific' classroom. This study found that there exists a significant association between students’ sense of belonging and academic performance. The authors suggest that “social similarity, successful team experiences and a general sense of caring were also considered helpful to building social belonging in the classroom”. This study, however, involved post-secondary students, not university students. | explicitly promote empathy, consciousness, design thinking or human-centred designing in engineering students. |
| Real-world Examples and Sociotechnical Integration: What's the Connection? | (Erickson, Caussen, Leydens, Johnson, & Tsai, 2020) | This study discusses the application of sociotechnical integration in engineering curriculums, to prepare their undergraduates for the ’real world’.<br>The study attempts to analyse “the similarities and differences between real-world engineering examples and sociotechnical thinking while also | This study attempts to explicitly promote social consideration by implementing strategies of exposing students to real-life examples in engineering classes. |

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| | | investigating what is broadly considered a "real-world example" in the engineering education literature".<br><br>Amongst the study's findings, using qualitative data from focus groups, and data from an in-class assignment aimed at sociotechnical integration, this study found that junior-level students made far more connections between real-world problems and the sociotechnical thinking, compared to sophomore-level engineering students, and that real-world scenarios were more readily 'stuck in students' minds'. The authors then suggest that "effective sociotechnical integration requires more than just a simple mention as is commonly the case of real-world examples". | |
| Knowing and Caring about Sanitation | (Dodson, et al., 2017) | This study examines how engineering | This study discusses an |

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| | | students become motivated to care about the UN Sustainable Goals and social justice. They also discuss how engineering educators can aid in achieving that, and reports on the humanitarian engineering learning gains students experience. To tackle this, the researchers designed interventions challenging of students' assumptions about the developing world, emphasising the importance of integrating the human-context in engineering, and training students to "expect that their ideas and designs will adapt as their understanding deepens"; role-playing, solving real-world based technical questions (as opposed to decontextualised, hypothetical technical questions), and reflective writing were amongst the techniques | intervention designed to explicitly promote human-centred designing, design thinking, empathy, and other skills associated with achieving sustainable development goals in engineering students. This was achieved through students' exercise of role-playing and reflective writing. |

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| | | used in this study to tackle the issue.<br><br>The authors qualitatively analysed students' reflective essays and found that "many student reflective essays were exceptionally thoughtful", however, near project completion, students began to "to overlook gender and stakeholder concerns in their race to produce models and posters". Moreover, the authors found that "several teams failed to transfer their learning from earlier class sessions and written work to the more open-ended project work at the end of the course".<br><br>What was interesting that this paper summarises how the social context 'messes' the engineering technical competency in students; for example, this paper describes an | |

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| | | observation on how "students could do appropriate fluid flow calculations on well-defined homework and lab work. Yet, when faced with making very similar calculations about gravity flow of sewage in their project focused in Rocinha, Rio de Janeiro, they floundered with the lack of given information in this new context and they needed considerable coaching". This, they explain may be due to the students' "confusion associated with multiple instructors and teaching styles, insufficient amounts of practice in basic calculations, and lack of experience in dealing with ambiguous technical problems". In summary, this study showed that "students showed the will and competence to work toward the Sustainable Development Goals and to consider issues | |

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| | | of social justice. They demonstrated acceptable levels of engineering knowledge but [however,] within some contextual constraints". | |
| Embracing Diversity, Equity, and Inclusion in Our Classroom and Teaching | (Asgarpoor, et al., 2021) | This study reviews a curriculum designed for engineering educators to deliver 'beyond technical competency'. The programme was designed to integrate knowledge of fields such as "systemic racism, how bias can impact our solutions, and how engineers can lead and create teams that foster belonging and inclusivity" in engineering education. The authors qualitatively analyse the thoughts and reflections of the panel of educators putting these notions into practice, in engineering classrooms. Amongst their findings, was that "panelists described actions that support inclusive leadership with | Although this study addresses a method to promote social consciousness and consideration through reflections and surfacing notions relevant to diversity, equity and inclusivity in engineering classrooms, it was to promote such understandings in engineering educators, as opposed to engineering students. However, such practices can be argued to be useful in fostering similar results in engineering students if tested. |

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| | | examples such as intentional classroom design that include DEI [Diversity, Equity, and Inclusion] statements, perspective taking activities, and using DEI examples from the workplace"; and when such practices are exercised, then "behavioral outcomes of increased creativity, job performance, and reduced turnover" will flourish. | |
| Bringing Sustainable Development Challenges into the Engineering Classroom: Applying Human Centered Design Protocols to Artisanal and Small-Scale Mining | (Smith, Teschner, & Bullock, 2018) | This paper concentrated on integrating sustainable development projects into engineering design courses; The approach was to design an intervention, that follows the human-centred design (HCD) protocol (i.e., considerate of stakeholder engagement and feedback input), where interdisciplinary groups of engineering students work on "developing context specific, mercury-free, mineral | This study promoted socially considerate, human-centred designing skills by exposing students to a human-centred designing project infused with stakeholder engagement.  This intervention was said to inspire "deeper insights" in students, thus indicating the characterising of empathy as well. |

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| | | processing technologies for ASM [Artisanal and Small-Scale Mining] communities”. This methodology focused on real-world applications in engineering classrooms, and allowed students to engage with stakeholder. Through the analysis of student feedback, the following two main themes emerged: “First, integrating sustainable development projects into the engineering design classroom provides students with deeper insights regarding the challenges of sustainable development projects. Second, students are able to make a clearer connection between the social and technical aspects of engineering and sustainable development problems”. | |

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| Freshman Design Course: Device Design for Low-Resource Settings | (Frow, Smith, & Ankeny, 2017) | This paper reviews the implementation of a biomedical engineering design course that "focuses on global healthcare markets and device design for low-resource settings". Students were set into groups of 4 or 5, regularly guided by instructors through a biomedical device design, and encouraged to written reflections, and self-evaluations of their ability to work as a team, as well as self-identification of how well they are grasping different aspects of the design process. Analysing all the aforementioned activities and output, they found that the majority (55%) of the students were inspired to consider a career in biomedical engineering for low-resource setting. Moreover, although their students did not have the liberty to directly engage with the people they are | This study successfully promotes social consideration and wicked (real-world) problem solving, despite the limitation of students being unable to meet with the end-user. This was done via guiding groups of students through a biomedical device design, whilst encouraging them to reflect, self-evaluate their ability to work in a team, and self-identify how well they comprehend different aspects of the design process. |

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| | | designing for, many of them reflected the awareness of the criticality and importance of doing so in a design process. The analysis also points out that students showed reasonable problem definition, and exposure to 'real-world' engineering problem solving. They have an early opportunity in their engineering program to grapple with the challenge of identifying a clear problem to work on, and to identify what kind of problem is amenable to solutions that include biomedical engineering approaches. | |
| Designing a Course for Peer Educators in Undergraduate Engineering Design Courses | (Quan, Turpen, Gupta, & Tanu, 2017) | This paper addresses a model seminar designed to highlight and emphasise design thinking in engineering Learning Assistants (LA; i.e., undergraduates peer educators), and examining the consequential influence | This study does not address characterising designing thinking skills in students, but rather in teaching assistants.<br><br>This study addresses a |

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| | | of such adaptation on engineering students. This seminar aims to support LAs in developing knowledge of design thinking and how to teach design thinking; it helps LAs recognise and value a breadth of positive outcomes of such approaches, and supports LAs in noticing and attending to students ideas by creating space for them to share and enact teaching moments. Results were found concurrent to aforementioned aims: “using surveys, instructor reflections, and coursework, we found some evidence that LAs found these activities helpful. | method of characterising design thinking skill in teaching assistants, which will consequentially influence students’ design thinking skills. It educates teaching assistants the value of such skills, mechanisms on how to attend and support students’ ideas, and provide space for engagement with the student. |
| Development and Application of the Sustainability Skills and Dispositions Scale to the Wicked Problems in Sustainability Initiative | (Hess, Brownell, House, & Dale, 2015) | This study developed a survey (named, The Sustainability Skills and Dispositions Scale (SSDS)) that assesses sustainability-related objectives. Consisting of 28 items, the survey | Though this study develops a scale to assess skills related to design thinking and social consciousness and consideration, it does not address |

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| | | was found effective when tested as a part of an engineering course aimed to develop students' confidence in solving wicked problems, ethical and professional responsibilities, and the global, social, and environmental contexts of their discipline; and through the analysis of open-ended questions to support the finding. | an intervention designed to promote these characteristics and skills. |
| Advancing Engineering Education Using a Teaching Focused Plan For Creating an Inclusive Classroom | (Hammond, et al., 2021) | This study discusses techniques in which engineering educators support to encourage inclusivity and diversity in their classrooms. The initiatives including 1) educational seminars for the educators, and encouragement to experiment with inclusive practices, 2) faculty weekly meetings for the educators to share successful techniques, and 3)weekly reading group for engineering students and faculty to | This study attempted to promote notions of social consciousness and consideration through training engineering educators on how to introduce related topics in classrooms; and by holding weekly meetings for engineering students to meet and discuss matters of race and inclusivity, and methods to |

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| | | discuss "how race and inclusion can be better integrated into the classroom". The findings reveal that the initiative was successful in nature, emphasising that "success breeds success, and the more faculty that attempt changing their engineering classroom to be more inclusive, the more other faculty are willing to attempt similar techniques in their own classrooms". | integrate such socially-considerate and inclusive notions in engineering classrooms. |
| Patient Centered Design in Undergraduate Biomedical Engineering | (Allen & Chen, 2018) | This study revolves around characterising empathy in biomedical engineering students (via an elective course) to produce more patient-centred designs. Through either directly engaging with the patients, or shadowing and interviewing the clinicians of the patients for at least 10 hours, students were encouraged to "focus on observation and needs identification, followed by the | This study explicitly promotes empathy and human-centred designing skills in biomedical engineers by allowing for direct engagement with the patients that students are designing for, or by shadowing and interviewing clinicians of the patients. |

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| | | development of initial concepts and prototypes", through which, empathy can be exercised and developed. Amongst their findings was that the focus on specific patients rather than a more impersonal clinical observation, resulted in increased empathy in the design process; moreover, such an approach increased student experience satisfaction and motivation. | |
| An Introduction to the Integrated Community-Engaged Learning and Ethical Reflection Framework (I-CELER) | (Fore, et al., 2018) | This paper argues for the need of "a lens that we [the authors] describe as ethical becoming" in STEM practitioners. Through reviewing and drawing literature from fields of social science, anthropology, and psychology, the synthesis of The Integrated Community-Engaged Learning and Ethical Reflection (I-CELER) framework was created. In a university, faculty from | This paper discusses a programme established to allow for more ethical reasoning to take place in engineering classrooms. This programme consisted of multidisciplinary faculty members, and by encouraging students' reflection at time the faculty |

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| | | different departments were encouraged to regular meet up, where pedagogical approaches to teaching philosophical ethics and community engagement are discussed and reflected. Fundings, as incentives, for each department of this I-CELER group was also provided to help in achieving the goals of this framework. By the end of this exercise, “faculty participants have the autonomy to engage with community partners of their choosing; to incorporate ethical theory that they perceive relevant to their course context; and to have students reflect at times that they perceive as most opportune to reach course goals for student learning”.<br>It was aimed for the findings of this project to “support models for infusing STEM ethics | members “perceive as most opportune to reach course goals for student learning”. This paper does not intervene with a methodology to explicitly promote empathy, consciousness, design thinking or human-centred designing skills in engineering students, however. |

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| | | education across our institution and others"; and inform "a largely lacking ontological discourse about the ethical becoming of STEM students and faculty. Many prominent pedagogies in STEM ethics focus on ethical reasoning or sensitivity of students, but rarely have scholars investigated how the enactment of care practices and an authentic engagement with diversity influences the ethical subjectivities of STEM students and educators." | |
| Contextualization as Virtue in Engineering Education | (Stettler Kleine, Zacharias, & Ozkan, 2021) | This review paper analyses and critiques practices of contextualisation and encouragement of public welfare consideration in engineering. As a result, they encourage an "alternative approach to contextualizing engineering". Such approach would | This review paper does not intervene with a methodology to promote empathy, consciousness, design thinking or human-centred designing in engineering students; and therefore is irrelevant to the |

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| | | encourage “engineers’ civic responsibilities and, crucially, the integration of their intersectional roles as citizens and professionals”. The authors elaborate further with: “this mode of contextualization embraces the idea of sociotechnical thinking but encourages engineers to work towards public welfare as an end goal”. | present project section. |
| Ethical Reasoning in First-Year Engineering Design | (Hedayati Mehdiabadi, James, & Svihla, 2019) | This study investigates opportunities for ethics education in engineering design, where such opportunities are scattered throughout the engineering curriculum, as opposed to having a one-off ethics education opportunity. Outputs of two design challenge groups - namely, those in the entrepreneurial design challenge (i.e., OPE challenge, as opposed to those in the community-based design challenge (AMD | This addresses a study that promisingly promotes ethical reasoning; however, it does not address an intervention to promote empathy, consciousness, design thinking or human-centred designing in engineering students, and therefore is also considered irrelevant to the present project section. |

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| | | challenge) – were compared. Engineering students' responses on ethical reasoning (i.e., nonmaleficence, beneficence, stakeholder agency and just distribution of risks and benefits) were also qualitatively analysed. As a result, this study found that "the entrepreneurial challenge prompted significantly more teams to use beneficence in their arguments", and that "even with limited prompting to do so, a realistic design challenge can support students to employ ethical reasoning". | |
| Design the Future Activities (DFA): A Pedagogical Content Knowledge Framework in Engineering Design Education | (Ali & Maynard, 2021) | This paper argues that to convey the future trends of technology with engineering, skills relevant to Artificial Intelligence (AI) should be encourage in engineering curriculums. The authors developed a multidisciplinary programme, with | Although this study addresses an intervention to promote AI relevant skills in engineering (which could argued to be loosely associated with creative thinking), the intervention did |

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| | | scholarships implemented, to encourage students into developing AI understandings and competency. This, they argue, would enhance students' understanding and analysis of technology, value chain (i.e. making the *appropriate* decisions or solutions), and responsible innovation (i.e., reasoning behind choosing the *appropriate* decision or solution). | not explicitly attempt to promote empathy, consciousness, design thinking or human-centred designing in engineering students. |
| Designing a Multi-Cycle Approach to Empathetic Electrical Engineering Courses | (Shannon, Jones, & Mina, 2019) | This paper builds upon the notions on engineering students' tendency to decrease in empathy and public welfare concern over time, and proposes to address the point of "when engineering students are entering an empathetic cycle" – particularly examining "how engineering students can enter, sustain, and improve their cycles of empath". | This paper identifies 'where' empathy is first triggered, or takes place, in a design process. It also discusses the association between self-awareness and empathy. However, this study does not address and intervention designed to explicitly promote |

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| | | This paper therefore proposes a "multi-cycle model of empathy in engineering that identifies self-awareness as the first step to empathy through the cycle of inquiry". This model incorporates existing models of empathy in engineering (for example, those proposed by Rasoal, Danielsson, & Jungert (2012) and Kouprie & Visse (2009)). Post-implementing this multi-cycle model and thematically analysing students' reflective writing, this paper "identifies self-awareness as the first step to empathy through the cycle of inquiry", and that engineering students showed "little empathy in their reflections but showed self-awareness of their learning habits and how they could do better". "This self-awareness", they elaborate, "[they] | empathy, consciousness, design thinking or human-centred designing in engineering students, it just identifies where empathy usually takes place. |

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| | | believe is transferable as shown in our proposed model" – indicating that self-awareness can develop into empathy with enough inquiry. | |
| The Theatre of Humanitarian Engineering | (DiBiasio, et al., 2017) | This study implements role-playing and in an interdisciplinary design course choreographed by faculty from engineering and humanities departments. The course attempted to target and engage students' empathy when designing a waste management solution for residents in the 19th century. In the study, all student teams were informed with a scenario brief to design for, along with photo of the scenery of where the design to take place. Students were instructed to "determine what they could about the conditions of this family [the family they are designing for] in order to recommend | This study promotes empathy by providing enough context for the designers (students) to imagine and role-play the characters that would be of concern in the design process. The intervention was found to promote empathy in some engineering students. |

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| | | interventions that would improve their lives". Students were instructed to role-play the characters that would be of concern to the design process. The intervention was purposely left open-ended to encourage students' creativity. Findings revealed that the role-playing intervention yielded an induction of empathy and interpersonal skills in (some, but not all) engineering students. | |
| Strategic Disruptions Toward a More Liberatory Engineering Education | (Koh & Rossmann, 2021) | This paper explores the existence of an association between the values found in engineering and those found in fascist regimes, making an argument of a prevalent authoritarian, confirmative and rigid nature of the two. It therefore examines weather there exists a relation between fascism and engineering education. The authors contribute with a "circular | This paper addresses social consideration through proposing an intervention to eliminate rigid, fascistic and authoritarian thinking and systems in engineering. However, this paper does not propose an intervention explicitly to promote empathy, consciousness or |

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| | | intervention" intended to aid engineering students to "repoliticize and recontextualize their engineering knowledge, and encourage more free, critical, and creative thought within the engineering culture, in order to weaken the link between engineering and authoritarianism". Albeit the oppositions evoked whilst doing so, this interventions found promising positive shifts in engineering students and education, of which, they argue can aid with the dismantling of the existing rigid, confirmative, and socially inconsiderate nature found in engineering. | design thinking in contexts of human-centred designing. |
| Preparation of the Professional Engineer: Outcomes from 20 Years of a Multidisciplinary and Cross-sectoral Capstone Course | (Favaloro, Mantey, Petersen, & Vesecky, 2018) | Via implementing interventions aimed to enhance an 'entrepreneurially-minded learning' atmosphere in engineering, this paper argues its contribution | This paper addresses an intervention to foster an entrepreneurially-minded learning, and not an intervention |

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| | | towards preparing the 'next generation of engineering professionals' for more collaborative, ethically, environmentally and socially responsible knowledge and skillsets.<br>The fostering of the entrepreneurially-minded learning was cultivated via the curriculum's implementation of weighted (in terms of academic points) inclusivity of ethics and disciplinary communications (technical writing) – therefore, "putting them both [ethics and disciplinary communication] in their proper context of team-based engineering design".<br>As a result, the authors found, that this has enabled for the development of "the fundamentals of entrepreneurially-minded engineering" as it was done over "a | designed to explicitly promote empathy, consciousness, design thinking or human-centred designing. |

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| | | natural progression" of a semester with slight input of [other] human-centred designing activity. After analysing students' capstone projects, the researchers found positive results highlighting the manifestation of the "entrepreneurially-minded learning", conjured via the implementation of weighted technical writings on ethics and disciplinary communications. | |
| Tell/Make/Engage: Design Methods Course Introduces Storytelling-based Learning | (Eskandari, Karanian, & Taajamaa, 2015) | This paper uses storytelling and audience engagement as a method to induce and promote empathy in engineering classrooms. They argue that personal storytelling, showing vulnerability and imperfection in experience, as opposed to objective narrative of engineering disasters, help students to better understand the impacts and intents of | This study develops an intervention to explicitly promote empathy in engineering students. This was done via storytelling and audience engagement. |

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| | | engineering design. Reflections and strategy factors of social influence were analysed. Amongst their findings was the following:<br>1) Interestingly, repeating for perfection may in fact counteract the authenticity of storytelling and engagement, hindering the understanding and empathy when communicating; elaborating with, “accurate storytelling techniques allow start-up teams to communicate the meaning and intent of their mission while being comfortable feeling uncomfortable”. This perhaps emphasises the hindering role of perfectionism in empathy engagement in engineering design.<br>2) “Applying a template to tell and memorize one story”, this, they are would counteract the purpose | |

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| | | to narrate the story, elaborating with, “there are reasons to start in the middle of the story to find a new and powerful beginning”. This emphasises the role of intent and engagement, perhaps also demonstrating authenticity of the responsibility held by engineers to *truly wanting* to positively influence via their design.<br>3)Designing for, or describing a generic user story may counteract the process of empathy and social consideration, as it may include stereotypes and de-personalisation. This, will evidently hinder empathy, reducing diversity to a singularity, and thus hinder social consideration. The authors add: “in fact, both young and well established entrepreneurs prefer hearing a personal and emotional story that | |

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| | | invites them to step right into the storyteller's shoes".<br>4) Finally, the authors found that "genuinely expressed vulnerability in start-up storytelling amplifies engagement"; thus, genuinely expressed vulnerability amplifies humanitarian consideration and empathy in engineering design processes. | |
| Intersections of Design Thinking and Perceptions of Success for Electrical, Computer, and Software Engineering Students | (Rodriguez, Doran, & Hengesteg, 2019) | This paper examines engineering students' perception of design thinking, examining their experiences of such framework, and their understanding of an association between design thinking and successful engineering. Engineering lectures and labs were observed, interviews and a review of relevant research discourse were analysed. It was found that "students described a disconnect between design thinking elements of the course and their perceptions of what it meant to be a | This study does not address a intervention or methodology to explicitly promote empathy, consciousness, design thinking, or human-centred designing. |

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| | | successful electrical, computer, or software engineer". Moreover, it was found that "it was often difficult for engineering students to see beyond the technical content of their course and conceptualize elements of design thinking as essential to their successful performance as engineers", albeit that being based on students' agreement that empathy in design thinking was to properly identify the needs to design for. This study adds value by addressing the need to further investigate how such design frameworks and practices should be introduced in engineering classrooms for optimal successful integration. | |
| The Development of a Texas A&M University Faculty of Engineering Education | (Hammond, et al., 2021b) | This paper discusses the authors' initiation of a collaborative faculty in their institute, designed to address how each member (of | This paper addresses the reflections of the initiation of a multidisciplinary collaborative |

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| | | different faculty) practices and contributes to the newly collaborative frameworks of work and design, especially when social consideration is first introduced to engineering students. Through reflection analysis, they found positive results on such a collaborative initiation, and continue to advocate for further similar practices, to provide support for such an inclusive community, and for continuous reflection from both faculty and students. | faculty in an institute; it does not address a methodology or intervention that explicitly promotes empathy, consciousness, design thinking, human-centred designing in engineering students. |
| Many Hands on the Elephant: How a Transdisciplinary Team Assesses an Integrative Course | (DiBiasio, et al., 2018) | This paper addresses the transdisciplinary methods (from faculties of humanities and engineering) and role-playing in engineering human-centred designing context – specifically in designing waste management systems. Student project reports, reflective essays, in- | This study promotes empathy in engineering students through transdisciplinary collaboration (with humanities students and faculty) and in-class role-playing, in contexts of engineering |

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| | | class role-plays, surveys and presentations were analysed to observe students’ attitudes and perceptions of the framework. Initial findings highlight the subjectivity in students’, and educators’, reception of information – this was reflected in their portfolios produced and understandings. The authors further elaborate on their findings with: “the humanists and engineers working on this project each bring the strengths and limitations of our [the educators] own points of view… It has helped to have representatives of different disciplines in the same room, watching and discussing classroom dynamics and explaining to each other what we [the educators] are seeing…”. They conclude with: “the representatives of | human-centred designing. |

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| | | different disciplines explaining their different disciplinary methods to each other, so that a shared approach emerges at the intersections of disciplinary knowledge". | |
| Techno-economic Modeling as an Inquiry-based Design Activity in a Core Chemical Engineering Course | (Gomez & Svihla, 2019) | This paper argues that the positivistic framework of problem solving (i.e., in search of a single correct answer) fails to guide students' ability to frame and solve real world problems. This paper therefore develops a techno-economic modelling tool, as a computer-based pedagogical tool, to guide students in real-world problem framing and solving. This tool, they argue can enhance engineering students' "reasoning within a collaborative environment". Researching the tool's feasibility of enhancing the students' ability to empathise with the | This paper develops a tool that was found to aid with engineering students' contextualising and understanding of real-world problems, and enhancing students' ability to empathise with the communities they are designing for. |

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| | | communities they are designing for, they found that students indeed were able to grasp the effects of constraints, “used cost and environmental impact as critical decision criteria to make informed decisions about the various process technologies”, and were more “attentive to decisions that could adversely affect a community”. In conclusion, their model was found to guide students’ decision-making to more sustainable and socially considerable ones. | |
| Transforming an Engineering Design Course into an Engaging Learning Experience Using ePortfolios | (Tucker, et al., 2020) | This study draws from literature on ePortfolios as “powerful vehicle[s] for students to display their individual competencies, and for faculty to provide personalized assessment”, and employs it as a measure of reflection on students’ reflection, academic progress, and | This paper does not address an intervention or a methodology designed to explicitly promote empathy, consciousness, design thinking or human-centred designing in engineering students. |

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| | | ‘holistic learning’. Promising results were found suggesting that such a tool can add value to personalised, reflective education in engineering curriculums. | |
| Successes and Challenges in Supporting Undergraduate Peer Educators to Notice and Respond to Equity Considerations within Design Teams | (Turpen, et al., 2018) | This study ran a seminar designed to integrate design thinking, engineering epistemology, teamwork, and equity in an engineering classroom – via focussing on educating Learning Assistants on how to successfully transfer such knowledge, and via students’ roleplaying activities to ““try on” various ways of responding to teamwork troubles”. Albeit some of the LAs displayed scepticism and/or retention towards some of the social science ideologies and social dynamics in the classroom, results obtained by this study argue a promising | This paper addresses an intervention designed to promote design thinking in engineering classrooms – this was done via educating the learning assistance (to transfer the knowledge), and by choreographing role-playing activities for students. |

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| | | potential in which equality and less oppressiveness may be attained in future engineering teamwork. | |
| An Emancipatory Teaching Practice in a Technical Course: A Layered Account of Designing Circuits Laboratory Instructions for a Diversity of Learner | (Vanasupa, Schlemer, & Zastavker, 2020) | The authors of this paper argue that “our enculturation in engineering and science has “bound” our thinking to conform to masculine norms”. Drawing from this, this study designs interventions intended to ‘serve’ engineering faculty and students. This intervention involved the ‘caring’ for engineering students, via “linguistic, epistemic and aesthetic shifts in the existing laboratory documentation”, arguing that “these actions transcend what are normally hidden engineering and science education values and norms; they are in the “invisible” causal domains of intent, and design”. Using quasi-autoethnography as a method to qualitatively | This study promotes empathy to cultivate a more inclusive engineering education atmosphere – this was done via “linguistic, epistemic and aesthetic shifts in the existing laboratory documentation”. This study, however, does not explicitly cultivate empathy in contexts of human-centred designing in engineering. |

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| | | analyse student focus groups after the intervention, they found that "that the interventions served to disrupt the distorted messages that learners normally receive about themselves from traditional engineering and science education settings" – this then triggered a discussion of the hidden influence of subjective understanding in engineering. Further, this study's findings reiterate on the prevalence of masculine and confirmative thinking styles in engineering education. | |
| Toward Interdisciplinary Teamwork in Japan: Developing Team-based Learning Experience and Its Assessment | (Misaki, Ge, & Odaka, 2020) | This study examines "how to best enable science-focused, disciplinary-divided engineering students in Japan to learn to work in groups of people from diverse backgrounds and specialties". Researchers here test to analyse the | This study examines the physical reaction of students whilst working on a real-life design project. This is interesting, as bodily reaction can be interpreted as reflections of emotions felt. This study, |

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| | | biopsychology (i.e., psychological changes via observing skin conductance) of engineering students whilst working on a real-life design project. This study still remains a work in progress, and the method is found novel and promising. | however, only analyses the reactions, and not necessarily design and intervention to explicitly promote them – i.e., like characterising empathy or other. Therefore, this study does not discuss an intervention that explicitly promotes empathy, consciousness, design thinking or human-centred designing in engineering students, and is therefore irrelevant to the present literature review section. |
| A Scaffold and Competency-Based Learning Approach to Innovation-Related Thinking Frameworks | (Bosman & Arumugam, 2019) | This paper developed a framework to encourage students' development of transdisciplinary thinking and doing (i.e., their vocational competency) and innovation. | This study addresses a framework that would cultivating creativity (which is a prerequisite to design thinking) and human-centred designing |

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| | | Their proposed framework intends to guide students through and from (a) Systems Thinking approach (i.e., starting from the 'big picture' and holistic perspective), to a (b) human-centred designing approach for problem solving, to (c) a Problem-Market Fit Analysis approach (i.e., identifying the value of the product in relevance to the customers' needs), to (d) business model development where students get to identify and analyse key factors required in launching a new product in the market. | thinking, during phases of a 4-step framework that would ultimately reach business model development. |
| Stuck on the Verge or Perpetually Reinventing? What Papers from the 2018 Annual Conference Tell Us about Change and Continuity in Liberal Education for Engineers | (Neeley, 2019) | This review paper seeks to philosophically address why "the terminology of soft versus hard skills has been so persistent, why it is problematic, and how we might be able to move beyond it". After addressing the problematic (mis)understanding of what soft skills are in | This review paper does not address a methodology or intervention that would explicitly promote empathy, consciousness, design thinking, or human-centred designing in engineering students. |

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| | | engineering, they state that “what has become clear is that, whatever these “soft skills” are, they are significant predictors of future success both inside and outside of engineering”. Additionally, suggesting that integrative individuals [i.e., those who “form integrative teams and design integrative educational experiences”] are the ones with the most potential to bring about ‘change’, the author further elaborates that “perhaps our most important imperative moving forward is to cultivate and increase the numbers of integrative individuals”. | |
| Diseases, Devices, and Patients: Exposing BME Students to the Patient Experience | (Cavanagh & Tranquillo, 2017) | This paper addresses an elective (i.e., not compulsory) course developed to encourage instructors to help their biomedical engineering students to extensively comprehend patients’ experience, to therefore | This paper addresses a method of characterising student human-centricity in design and empathy through gaining |

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| | | produce more ‘customised’ and efficient designs. This was done by guiding students to gain information from “flow-chart diagrams, written summaries of disease processes, rubrics for evaluating interventions, and dialogs between a patient and a physician or a family member”, and “consider the individual patient perspective of innovations in health care alongside the broad technical, economic, and business perspectives”. This was said to also enhance students’ innovation. | information using “flow-chart diagrams, written summaries of disease processes, rubrics for evaluating interventions, and dialogs between a patient and a physician or a family member”, and through “consider[ing] the individual patient perspective of innovations in health care alongside the broad technical, economic, and business perspectives”. This method is also said to enhance student’s innovation. |
| Incorporating a Milestone-Based Project Based Learning Method in a Foundry Course | (Trueba & Torres, 2022) | This paper analysed the impact of integrating group-work, milestone-based, project-based learning workshop in a metal casting course. Students who were guided by instructors’ information targeted to | This paper does not address an intervention or methodology that would explicitly promote empathy, consciousness, design thinking, or human-centred |

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| | | complete each milestone in a timely manner, were found to have improved in their perception of learning, and in semester grades. | designing in engineering students. This paper is therefore irrelevant to the present literature review section. |
| What Can We Learn from Character Education? A Literature Review of Four Prominent Virtues in Engineering Education | (Koehler, et al., 2020) | This review paper explores how virtues are incorporated in engineering education; four virtues were regarded: 1) critical thinking (an intellectual virtue); (2) empathy (a moral virtue); (3) service (a civic virtue); and (4) teamwork (a performance virtue) (Koehler, et al., 2020). Finding that engineering educators do not treat the aforementioned as virtues but rather as 'skills', the authors then identify advantages to remodelling and fostering these capacities as virtues, rather than skills. The emerged conceptual distinctions between | This paper addresses a methodology to cultivate virtues (which are associated with social consideration and empathy) in engineering education. |

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| | | considering these capacities as virtues, as opposed to skills, comprise of the following:<br>1) virtues, unlike skills alone, are necessarily ordered to morally good ends;<br>2) virtues have a motivational component that skills often lack;<br>3) virtues involve evaluating and addressing potential conflicts among values; and<br>4) virtues are interconnected and mutually reinforcing in ways that skills often are not (Koehler, et al., 2020).<br>These distinctions were argued to "have practical implications for undergraduate engineering education", and "help students consider their values and develop the most relevant virtues across a four-year curriculum". The authors then suggest that adopting | |

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| | | the "more comprehensive and holistic approach empowers students and future engineers to better navigate the complexity of real-world ethical decision-making and develop the virtues needed to serve the greater good". | |
| Measuring Students' Interdisciplinary Competence and Entrepreneurial Mindset based upon Exposure to a Holocaust Narrative | (Ritz, Bodnar, & Montalbo-Lomboy, 2022) | This study researches the association between narrative-based interdisciplinary case study and engineering students' entrepreneurial mindset. Engineering students were exposed to "narratives that included testimony, biography, photos, and data related to the Holocaust [i.e., the case instructed to design for] in a story-like format", and were engaged with the narrative through "reflections, discussions, and other activities used to promote students' curiosity and critical thinking". Part of this study's findings was | This paper designed an intervention to expose students to narratives of a case through mediums of testimonies, biographies, photos, and data related to the design case, in a 'story-like format'. Student were also encouraged to reflective writing and discussion to enhance students' curiosity and critical thinking skills. The findings of this paper suggested that |

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| | | that "the interdisciplinary narrative case study increased students' perception of their altruism, ideation skills, interdisciplinary skills, and recognizing disciplinary perspectives to the point of statistical significance". | exposure to such narratives concludes in enhanced social consciousness and consideration in engineering education settings. |
| Kindness in Engineering Education | (Bielefeldt, 2021) | In line with the call for faulty to become more accommodating of student issues (especially post COVID-19), this paper researches and explores "issues of kindness in engineering and engineering education", comparing kindness to constructs of care, empathy and compassion. Arguing that although cognitive empathy plays a key role in engineering practices of community engagement, it poses difficulties in practice when different cultures, experiences and backgrounds are | This paper calls for incorporating kindness (as opposed to empathy in engineering curriculums), arguing the positive outcomes of doing so. This paper, however, does not address an intervention or methodology designed to explicitly promote kindness, or empathy, or design thinking or human-centred designing in engineering students, and so is |

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| | | considered. Therefore, this paper argues that acting with kindness does not necessarily involve empathy, suggesting that "Empathy's most important role, though, is to inspire kindness"(p. 4). Arguing that kindness is more useful in engineering practices, this paper suggests that "exploring kindness as a distinct concept provides some benefits over the related concepts of empathy, compassion, and care". Findings of this paper include that "the hidden curriculum through engineering courses that do not seem to embody kindness or caring might convey to students that a lack of kindness of part of the culture of engineering itself". Moreover, "while the notion of kindness is not normally described as a trait associated with engineers or | therefore irrelevant. |

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| | | engineering, incorporating kindness into our teaching practices may yield positive results for our students, our colleagues, and ourselves". This paper then suggests that "applying a lens of kindness to our decisions about how we design our courses and engage with our students may provide affordances in facilitating student learning". | |
| Qualitative Analysis of Boundary-Spanning Implications within Interviews of Engagement Stakeholders | (Delaine, Cardoso, & Walther, 2015) | This paper examines the role Boundary Spanning (or boundary spanners) in stakeholder and community engagement practices in engineering education and STEM. Boundary spanners are the individuals who "act as knowledge and power brokers to help establish reciprocal relationships between a university and community", and are argued to be "fundamental for | This paper addresses the potential contribution 'boundary spanning' has on societal consideration in fields of STEM; however does not provide a methodology to explicitly promote societal consideration, empathy, consciousness, design thinking or |

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| | | providing pathways for collaboration between the academy and society". Thus, this can be argued to be contributing to societal consideration. This paper finds supportive results showing that boundary spanning is indeed a "key strategy for strengthening pathways for broadening participation in STEM through community engagement". | human-centred designing in engineering students. |
| How Engineering Educators Use Heuristics When Redesigning an Undergraduate Embedded Systems Course | (Fila, McKIlligan, & Abramsky, 2018) | This paper identifies key heuristics in industrial design and engineering disciplines – on a side note, Heuristics are cognitive strategies used to generate a quick judgement or decision (Nisbett & Ross, 1980). Using data collected from audio recordings, written notes from team meetings, design artifacts, interviews with team members, and reflections, 22 heuristics were identified in an | The paper identifies 22 heuristics that are suggested to encourage educators to "build empathy with the students to understand their struggles with certain content and adjusting the content to meet the needs and capabilities of the students". This paper, however, does not address a methodology or |

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| | | engineering course design, describing "how educators explore and iterate upon the problems and solutions in course design". The 22 heuristics were then grouped into 6 categories. The heuristics captured in this paper were however found to be more focussed on "the practice and immediate application, rather than relying on the mental models of practice". The heuristics found were: 1)Allow/encourage failure; 2)facilitate solution space exploration; 3)add collaboration; 4)check for understanding; 5)restructure physical environment to support peer-to-peer learning; 6)connect to the real world; 7)promote professional formation; 8)demonstrate connections between topics; | an intervention to explicitly promote empathy, consciousness, design thinking or human-centred designing in engineering students. |

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| | | 9)translate past experience;<br>10)align learning objectives and pedagogy with student earning capabilities;<br>11)identify bid rocks [i.e., larger, key topics];<br>12)change order of learning skills;<br>13)use point distribution to communicate priorities;<br>14)modularize the course structure;<br>15)increase activity within lecture;<br>16)combine content;<br>17)present content visually;<br>18)integrate new content to existing course structure;<br>19)use various media to facilitate student understanding;<br>20)map course withing the entire curriculum;<br>21)introduce evidence based practice;<br>22)expose students to multiple contextual elements (Fila, McKIlligan, & Abramsky, 2018). | |

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| | | The paper therefore argues that the findings contribute to the called-for enhancement of empathy and consideration in engineering as "the heuristic, align learning objectives and pedagogy with student learning capabilities, urges the educator to build empathy with the students to understand their struggles with certain content and adjusting the content to meet the needs and capabilities of the students". | |
| STS Postures: Changing How Undergraduate Engineering Students Move Through the World | (Tomblin & Mogul, 2022) | This paper developed a new framework for students to encounter intellectual problems with emotions. They did so by conducting a so-called *techno-ableism* intervention – i.e., instructed engineering students to wear bracelets for 24 hours to remind them to "imagine they are hosting a friend from high school that day, and the friend is using a | This study addresses a method designed to explicitly promote empathy in engineering students in a human-centred designing context. It addresses the use of a *techno-ableism* intervention, instructing engineering students to wear |

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| | | knee scooter to get around because of a sports injury". This was essentially to trigger empathy towards that imaginary individual, and acknowledgement of how surrounding areas might be problematic for that person. Acknowledging that students and professors "need continual practice to embody any habit or skill", this method was argued to be the "most successful". The techno-ableism module, has helped expose "challenges around teaching students not simply how to have empathy, but to practice cultivating situations in which they will gain empathy". Arguing that "empathy itself is not the destination", the authors reiterate on them wanting students "to be able to design their own experiments to change perspective and cultivate empathy". | bracelets to remind them of stay conscious of the experience an imaginary disable host might encounter in their surrounding place. This method is ultimately to remind students to stay conscious (i.e., enhancing societal consideration) and empathic (by putting themselves in the shoes of that imaginary visitor). Authors declare this method as promising and have helped expose "challenges around teaching students not simply how to have empathy, but to practice cultivating situations in which they will gain empathy". |

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| Results of a Pilot Effort with First-year Students | (Tallman, et al., 2020) | Building upon the industries' call for leadership qualities in engineering, this paper designed a framework to cultivate leadership skills in engineering education, and encourage diverse learning styles and extra-curricular engagement. Studying freshman engineering students, using a combination of their qualitative and quantitative responses, along with the engineering leadership identity theory, findings revealed that students seemed to focus on technical skills for problem-solving more than on exercising leadership (i.e., where social consciousness or consideration may arguably be exercised). This finding, the authors argue, "agrees with typical perceptions of engineering values". The authors discuss this finding by stating: "this may reflect either the | This paper does not address an intervention or a methodology designed to explicitly promote empathy, consciousness, design thinking or human-centred designing skills in engineering students, as is therefore irrelevant to the present section of the literature review. |

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| | | influence of the ubiquitous focus on technical competence in school, or it may reflect personal values engineering students have about practicing their profession. This paper also discusses that "students who have had these two [i.e., the technical and professional competencies] types of experiences are better able to navigate professional communities and expectations, if industry voices are to be believed". Moreover, this paper points out that "participant frequent discussion of self-efficacy in both technical and interpersonal fields reflect the high level of competency they expect of themselves. This can be problematic as a barrier to student growth in non-technical areas", suggesting that "the Community of Practice model is | |

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| | | useful, as it foregrounds communal recognition as the currency through which belonging is conferred". | |
| Uncovering Strategies to Improve Student Engagement and Enhance the Engineering Education Curriculum | (Shittu, Hirsh Bar Gai, LeBlanc, Wortham, & Konya Tannon, 2021) | This paper reviews an initiative held within an education community, where a diverse group of experts (inclusive of: stakeholders including professional engineers, engineering faculty, psychologists, pedagogy and educational scientists, students, curriculum developers, entrepreneurial evangelists, the diplomatic community and the industry) encountered in a workshop to identify the main themes needed to be integrated into the engineering curriculum. This was intended to cultivate community engagement and innovation in engineering students. The paper suggests that the initiative hold | This paper addresses an initiative held by faculty members to identify characteristics that would cultivate community engagement and innovation in engineering student. It does not, however, address an intervention designed to explicitly promote empathy, consciousness, design thinking and human-centred designing in engineering students. |

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| | | promising contributive results. | |
| Engineering Students' Self-Reflections, Teamwork Behaviors, and Academic Performance | (Anwar, Menekse, & Kardgar, 2019) | This paper discusses an initiative of integrating collaborative teamworking and reflection in engineering classrooms. This was to explore the association between students' academic performance, self-reflection, and teamwork. The findings reveal that teamwork performance acts as a strong predictor of academic performance. | This paper does not address interventions designed to explicitly promote empathy, consciousness, design thinking and human-centred designing in engineering students. |
| Exploring engineering students' critical consciousness using an ill-structured, project-based learning unit in an engineering mechanics course | (Castaneda, Merritt, & Mejia, 2022) | This paper integrates methods of human-centred designing in a project-based learning initiative. It explored "the extent to which critical consciousness manifested in engineering learners and how the ill-structured nature of the PBL unit and the HCD for communities design framework impacted that manifestation". Students were instructed to work on a "team-based | This study successfully designed an intervention to cultivate and address empathy with reference to the Carlson et al.'s (2006) 4-stage understanding of Critical Consciousness. Although students were later found to have displayed *superficial* empathy engagement, this |

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| | | exploration of an engineering mechanics-based design problem in a sociocultural context", and to provide a reflection after every deliverable. Results revealed that "students used empathy in performative ways to inform their engineering problem solving efforts and that students' critical consciousness was mostly manifested at lower-levels of the 4-stage model". The model referred to is the Carlson et al.'s (2006) 4-stage understanding of Critical Consciousness. The model addresses three distinct, hierarchal levels of cognitive-emotional interpretations of engagement: 1) emotional engagement, 2) cognitive awakening, and 3) intentions to act. The lowest level in the 4-stage model, passive adaptation, occurs when no CC [i.e., | study is relevant to this literature review section, as it is explicitly designed to promote or influence empathy in engineering students, in human-centred designing contexts. |

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| | | critical consciousness] is realized (as stated by (Castaneda, Merritt, & Mejia, 2022)). The authors discuss this finding suggesting that “relying upon the ill-structured characteristic in PBL alone is insufficient in developing engineering learners’ critical consciousness”. Of those with the lowest CC levels, the authors also found that these students were engaging “in superficial empathic effort or relegate empathy as a step in the design process”. This form of ‘emotional detachment’, the authors discuss, was “separating the role that engineers have in understanding stakeholders as persons – conveys superficial care toward others yet is undergirded by emotional apathy (i.e., not my problem)” – i.e., which is the lowest level of the CC model, where no CC is | |

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| | | acknowledged. The *superficial* empathy engagement found in engineering students suggestively imply the inauthentic social consideration in engineering students. | |
| Real Engineering: Space – Experiential, Community Engaged and Sustainable Learning in Space Engineering | (Newland, El-Shebiny, & Alsop, 2022) | This paper reviews an initiative where engineering students were instructed to "design, build, launch and operate a CubeSat mission, with a community, every 4 years, to address a societal need in a sustainable way". CubeSat refers to "a space mission concept to change the power dynamics around water quality in northern Canada, giving communities direct control of data to measure their water quality and quantities". This initiative was implemented to allow for more sustainable and social consideration to take place in the decision-making processes at | This study addresses an initiative that was found to have successfully promoted students' societal and sustainable considerations, and grasp the concept of social justice. Community engagement and reflections were common practices in this initiative. This characterisation of consciousness was also in the context of human-centred designing in engineering. |

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| | | every stage of the 'mission'. Results obtained from implementing this strategy include a success in providing an opportunity for students "to try to have impact with and for the community and society", and to engage with social consideration and sustainability, allowing for "transparent decision-making throughout the mission with stakeholders". Another important result was that student teams were able to recognise hidden biases through the process; this was done through team reflection practices. Moreover, students recognised the "role of community in determining the intended outcome of any mission, with appropriate compensation for the community members for their time and efforts, with the student | |

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| | | team being responsible for mission feasibility"; this therefore arguably indicates, that students were able to recognise the concept of social justice in engineering contexts. | |
| How are Issues of Diversity, Equity, Inclusion, and Justice Reflected in Engineering Societies' Written Communications? A Review | (Hedayati Mehdiabadi & Atadero, 2022) | This paper reviews how, and to what extent, engineering fields and engineering education have been involved with notions of DEIJ (diversity, equity, inclusion, justice), across different professional engineering societies – namely, American Society of Civil Engineers (ASCE), the American Society of Mechanical Engineers (ASME), the Institute of Electrical and Electronics Engineers (IEEE), the American Institute of Chemical Engineers (AIChE), and the Association for Computing Machinery (ACM). Results obtained revealed that "although professional societies | This review paper addresses notions of diversity, equity, inclusion and justice in engineering. However, it does not address an intervention designed to explicitly promote empathy, consciousness, design thinking and human-centred designing in engineering students; this paper is therefore irrelevant to the present section of the literature review. |

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| | | are committed to benefiting humanity and improving the quality of life, they did not explicitly mention justice or equity in their vision, mission, or goal statements". Moreover, results revealed that although valuable notions of DEIJ were found, they were limited in content, across the different professional societies. The update codes of ethics, however, encompassed a pattern of more DEIJ content. It can therefore be argued that the scarcity of these notions, however valuable, is suggestive to be marginalising them, and thus hindering their cultivation in engineering paradigms. | |
| Virtual Globalization: An Experience for Engineering Students in the Education 4.0 Framework | (Caratozzolo, Friesel, Randewijk, & Navarro-Duran, 2021) | This paper reviews a development of a programme intended for students to expand on skills of *global citizenship* (i.e., "building awareness about the wider world | This paper reviews an initiative designed to cultivate engineering 'global citizenship' in engineering |

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| | | and playing an active role in the global community”), *collaborative learning* (i.e., “requiring peer collaboration and move close mirroring the future work”), and *innovation and creativity skills (i.e.,* “including complex problem-solving and analytical thinking.”). This was done via the implementation of a project with the concept of providing a space for “international cooperation, negotiation, leadership, empathy and broad perspective”. Using a remote “hands on” (via VPN; i.e., virtual private network, for example Zoom lectures) approach, the paper finds that “international virtually collaboration could be an effective strategy to train students with international skills and to develop certain personal attitudes such as enthusiasm, | students – which implies cultivating social consciousness and consideration. This was done via holding ‘hands-on’ online international collaborative sessions, which would give space for students to cultivate skills of “international cooperation, negotiation, leadership, empathy and broad perspective”. |

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| | | motivation and intellectual engagement". Moreover, this paper reveals findings that support the notions of "Active Learning and Challenge-based Learning approaches are highly effective for the development of several skills in engineering students, including: Global citizenship; Collaborative learning; Innovation and creativity, Complex problem-solving and Analytical thinking". | |
| Negotiating Belongingness: A Longitudinal Narrative Inquiry of a Latina First-generation College Student's Experience in the Engineering Culture | (Verdin, 2021) | This paper addresses the gap in understanding how "non-traditional students' sense of belonging is promoted within the engineering culture". By using interviews to review how one "Latina, first-generation college student, and a nontraditional student (i.e., age greater than 25, parental responsibilities, and | Although this paper addresses notions of social consideration and empathy, it does not address an intervention designed to explicitly promote empathy, consciousness, design thinking or human-centred designing in engineering or |

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| | | part-time student) negotiated ways of belonging in engineering", it was found that this student have always been denied a sense of belonging in engineering, continuously. | engineering education. |
| Fostering Entrepreneurship in Project-based Software Engineering Courses | (Buffardi & Rahn, 2020) | This paper reviews an adopted 'Tech Startup" intended to cultivate entrepreneurship and intrapreneurship skills in software engineering education. This was to encourage collaboration on novel software ideas (between engineering and entrepreneurship students), and understanding students' motivation for generating innovative, entrepreneurial ideas in software engineering. The study hypothesized that (H1): "after priming students with a presentation on emergent technologies, software engineers would be more likely to propose entrepreneurial project ideas". | This paper addresses an intervention developed to promote entrepreneurial and intrapreneurial skills. However, this study does not address an intervention designed to explicitly promote empathy, consciousness, design thinking or human-centred designing in engineering students. |

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| | | Some students were primed via an exposure to a presentation on innovative technologies like Virtual Reality (VR), Augmented Reality (AR) and Internet of Things (IoT), for ten minutes. After priming students with a presentation on emergent technologies, it was found that “only 3% of software engineering students took the initiative to propose their creative ideas among their peers and business students”. However, when compared to entrepreneurship students, it was found that “software engineers’ pitches increased more than sevenfold in semesters when the emergent technology intervention was applied” – therefore supporting the study’s first hypothesis (H1). Additionally, it was found that “engineering students identified that a desire | |

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| | | to learn a new programming language, framework, or technology was the most common motivation for project selection. Students also reported motivation from how interesting they find the problem and whether they would personally use it". | |
| Examining a Novel Theory-to-practice Effort in Engineering Education through Multiple Theoretical Lenses of Systems and Change | (Secules, Bale, Sochacka, & Walther, 2018) | This study developed an anthropological-inspired approach to explore how "institutional artifacts, structure, and guiding philosophies" associate with the institutions' "explicitly stated or implicitly enacted theories". The approach is also said to "explore both planned intentions and enacted realities"; in other words, this study intended to understand "the underlying purpose for the discipline of engineering education". By connecting the guiding theories to specific aspects of a program, the approach | This paper does not address an intervention to explicitly promote empathy, consciousness, design thinking, or human-centred designing in engineering students. |

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| | | clarifies the "purpose and implicit assumptions embedded inside institutional practices". This paper therefore suggests that "this approach can build contextualized and embodied theory, and can lead to surprising productive outcomes. While we do not suggest that this exact approach will be embraced by existing programs perhaps already built on other foundations and philosophies, it may yet provide a new lens for conceptualizing a role for the discipline". | |
| Work in Progress: Personalizing Engineering Ethics through the Individual Stories of Engineers and People Impacted | (Bielefeldt A. , 2022) | This paper argues how engineering courses should develop personalised stories in ethics education (as it has more emotional effect on the students), as opposed to the numerical and depersonalised evidence or reasonings behind any socially impactful (positive or | This study promotes emotional responses in students via exposing them to personalised stories in ethics education, with the intent to heighten ethical reasoning and awareness in |

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| | | negative) case of engineering. This paper argues that the traditional way in which the code of ethics has been introduced into engineering has often led to engineers treating disaster cases from a "very numerical approach, rather than sharing the stories of individuals who have been harmed and naming the engineers responsible". This paper therefore argues the necessity to develop a more personal approach when addressing such topics. This, the author suggest, should be brought about by "bring[ing] in the personal stories of both individual engineers and the people who have been impacted by engineering in positive and negative ways". Hypothesising that such an approach "may be more effective in activating emotions and | engineering education. |

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| | | aligns with Bratton's (2004) Model of Affective Morality and Scholl et al.'s (2016) core affect mode", and that "emotional responses may be heightened by seeing the individuals tell their own stories rather than reading text-based narratives". Engineering students were then exposed to interviews and personal stories of cases that have had an effect on community, after which they had to reflect on the interaction. As a result, this paper finds that "including personal stories when teaching engineering ethics holds promise for impacting the ethical awareness and reasoning abilities of students". | |
| A Systematic Review of Student Entrepreneurial Failure in Engineering Education | (Katona, Zappe, & Tranquillo, 2020) | This review paper examines how engineering students interact with (or respond to) failure in engineering, arguing that engineering | This paper does not address an intervention that explicitly promotes empathy, consciousness, |

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| | | educators should teach students how to "fail fast and fail forward". This, the authors argue, is associated with developing entrepreneurship within engineering education. This paper finds that engineering education lacks research on how engineering educators teach students how to cope with failure, or 'fail forward'. | design thinking or human-centred designing skills in engineering students; it is therefore irrelevant to the present literature review section. |
| Using Nursing Theory to Improve the Teaching of Engineering Practice | (Oerther, 2017) | This cross-disciplinary paper compares and researches how the collaboration between environmental engineers and community health nurses may influence communal behaviour, prevent diseases and promote wellness – in essence, elevate human-quality of life as a result of a (human-centric) project. The author of this paper promoted communal value in engineering by the application of Florence Nightingale's Environmental [i.e., a | This study promotes communal value in engineering by integrating the Florence Nightingale's Environmental [i.e., a nursing] Theory in the engineering context, and by allowing for engineers and nurses to co-work and both learn from each other's approaches and expertise. |

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| | | nursing] Theory, and by exposing engineers to collaborations with nurses – this was for nurses to become more detail-oriented and engineers to become more holistic. As a results, the engineers benefitted from the following:<br>(a) “understanding that a holistic view of a community must include “not only a detailed study of the trees but also an understanding of the forest””;<br>(b) the introduction and evaluation of the value cultivated from using a guiding theory (in this case, it was the Nightingale’s environmental theory, in both engineering teaching approaches and students’ professional training). The author suggests that the “similarities among ‘practice’ from diverse – yet strangely similar fields – including nursing – | |

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| | | offer a unique opportunity for engineering faculty to train our students as ‘practitioners’”. | |
| Ethical Decision-Making Frameworks for Engineering Education: A Cross-Disciplinary Review | (Subbian, Shaw, & halpin, 2022) | This paper reviews and discusses how to best “prepare students to make good ethical decisions, particularly when confronted with modern complex ethical dilemmas”. This was done by comparing engineers’ to other disciplines’ practices, and reviewing “existing theoretical schema and frameworks in use within the social sciences, business, non-discipline specific frameworks, and engineering”.<br>As a result, the paper proposes ten elements argued to enhance teaching and developing ethical decision making in engineering students and engineering education. Specifically addressing the elements that associate with targeting the | This review paper does not address an intervention that explicitly promotes empathy, consciousness, design thinking, or human-centred designing skills in engineering students. |

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| | | characterisation of empathy, consciousness, design thinking or human-centred designing, i.e., element numbers 3-8 and 10, are the most relevant; however, this paper does not address a framework explicitly designed to promote such notions (i.e., empathy, consciousness, design thinking or human-centred designing).<br><br>The elements relevant to the targeted topic, extracted from (Subbian, Shaw, & halpin, 2022):<br>3. The framework should include steps designed to help students understand and incorporate the perspectives of others, both on an individual and societal level, who are affected by their decision(s);<br><br>4. The framework should incorporate deliberate self-reflection regarding | |

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| | | biases based in culture, prior experiences, and values, as well as external pressures;<br><br>5. … framework should seek to scaffold presumed “soft skills” elements (e.g., empathy training, interpersonal responsibility, ethics of care) in a manner that is seen as highly relevant to the priorities and work of an engineer;<br>6. The framework should incorporate easily accessible problem-solving strategies, presented in language used to describe engineering processes (e.g., design, verification, continuous improvement);<br><br>7. The framework should be easily employed in addressing complex, modern ethical challenges that are increasingly confronted in the field and practice of engineering;<br><br>8. Ethics of Caring can be made highly relevant | |

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| | | within the framework by focusing on current concerns of the typical undergraduate cohort (e.g., relating decisions to climate change or social justice movements).<br><br>10. The framework should be applicable to existing ethics education strategies such as ethical heuristics, case studies, community-based projects, debates, and co-curricular activities (Subbian, Shaw, & halpin, 2022). | |
| Inworks: Making Things that Matter | (Goodman, Underwood, & Bennett, 2016) | This paper reviews a programme (called 'Inworks') developed to encourage innovation, ill-defined or complex problem-solving, empathy, global consideration, leadership, teamworking and entrepreneurial skills, design thinking, and huma-centred designing – and have found promising results. The programme involved student, staff | This paper addresses an intervention that explicitly promotes empathy, design thinking, and human-centred designing skills in engineering education, and is therefore relevant to the present literature review section. This characterisation was achieved |

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| | | and faculty from University of Colorado Denver (engineering) and the Anschutz Medical Campus (medicine), entrepreneurs, leaders from industry, the government, education, and the community to report and discuss "problems of importance to human society". Amongst their approaches to successful launching of a 'hands-on' human-centred designing project, was the establishment of a (literal) 'space' on site, for such notions to be encouraged and surfaced. Suggesting that the provision of physical space not only allows for collaboration, experimentation and communication to take place, but also acts as a 'tool' to "bring people from different backgrounds together'. | through implementing a multidisciplinary approach contributing to such notions, and working on relevant assignments, and by creating the space (literally) for people across disciplines to meet and work on 'things that matter' to human society. |

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| | | The space was also said to express “a sense of ownership”. The struggles faced with launching this approach was that some community members “saw Inworks as just another “Maker Space,” albeit, and very well-equipped one”. The authors then explain that “it took a while for us [them] to articulate the message that while Inworks is indeed a Maker Space, it is a place where people make things that matter, rather than just making something for the sake of making it”. The authors then elaborate on this and state: “our new approach to community engagement provides increased project evaluation and scaffolding, as well as an intense human-centered focus”. Resulting from such an implementation, students were found to display more | |

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| | | innovative and collaborative skills, interdisciplinary and complex problem-solving skills, and provide “potential solutions using a variety of prototyping techniques”. Reiterating, the Inworks Minor in Human-Centered Design and Innovation (MHCDI) was said to enhance students’ interdisciplinary, innovative designing skills (with integrated human-cantered design thinking and collaborative problem solving), critical and conceptual thinking, development of teamwork and entrepreneurial skills, use of both qualitative and quantitative methods of analysis, and “implement potential solutions using a variety of advanced prototyping techniques”. | |

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| Developing Real-life Problem-based Learning (PBL) Activities through Partnership with Industry | (Mativo, Sochacka, Youngblood, Brouillard, & Walther, 2017) | This study developed a real-life, ill-structured, industry-inspired problem-based learning intervention activities, aimed to teach students how to overcome challenges when working on complex problems, in an engineering programme. Another aim of the study was to "build a portfolio of "real-world" problems that will be shared on a web portal; making the problems, and the process for developing the problems, widely accessible to engineering faculty and students". Developing the problems for said activities was accomplished by the collaborative efforts of educational researchers, instructors, and industry partners, where a real-life case was developed to be solved, and evaluated in-terms of its impact | This study promoted wicked problem solving skills (associated with design thinking skills) via exercising collaborative efforts of educational researchers, instructors, and industry partners in preparing real-life cases for student to work on. |

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| | | on student learning. Students were then given the opportunity to choose between (1) designing and studying their own problems (i.e., problems they propose) using relevant topics (in this case, concepts of dynamics); or (2) choosing and engaging with one of the pre-proposed problems; where instructors and industry members served as 'immediate resources', and materials were provided to the students for assistance. Impact on students' learning was then deduced qualitatively from the students' end-of-semester feedback. Said intervention activities were found resulting in students' enhancement of overcoming difficulties when solving for real-life problems – i.e., by (1) developing relevance between their abstract principle and application; (2) | |

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| | | overcoming the resistance to problem-based learning motivation, as to some students, the open-ended nature of the problem was a source to their demotivation and distress, regardless of their prior display of interest in such problem cases; and (3) developed students' elaboration and application of dynamic principles, as such principle was presented in a more thorough manner.<br>Students' skills of creativity and teamworking were therefore also developed as a result, and so did their critical thinking, as "the real-life nature of the problems also seemed to allow students to have a better grasp of what answers seemed right or wrong".<br>By expanding on complex, real-life problems, this paper can be argued to then | |

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| | | be addressing of a methodology that develops skills related to design thinking and wicked problem-solving. | |
| Assessing a Scaffolded, Interactive, and Reflective Analysis Framework for Developing Ethical Reasoning in Engineering Students | (Kisselburgh, Hess, Zoltowski, Beever, & Brightman, 2016) | This study developed a scale to identify and report how characteristics relevant to ethical reasoning, changes over the design and development of an engineering project. Building upon previous work of the authors, the authors explore the research question: "Which characteristics of the SIRA [Scaffolded, Interactive, and Reflective Analysis] approach contribute to changes in ethical reasoning" in this paper, and develop a scale that measures how such characteristics/ ethical reasoning scores range over the period of project development. The authors therefore built and tested a 12-item scales and | This paper does not address an intervention that explicitly promotes empathy, consciousness, design thinking or human-centred designing skills in engineering students. It is therefore irrelevant in the present literature review section. |

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| | | subscales questionnaire, and found it to be "statistically significant in predicting ethical reasoning scores". The authors also found the strongest predictor of ethical reasoning was the reflective components, and that the top two factors contributing to engagement, understanding, critical thinking, and guiding decision-making, was the "integration of novel multimedia presentations of the case studies and the case study discussions". | |
| Work in Progress: Collaborative Environments in Architecture and Civil Engineering Education – Case Study | (Guerra, Guerra, Gallardo, & Ubidia, 2022) | This study addresses the importance of interdisciplinary efforts for the development of complex infrastructure; however, the coordination of such collaborations proposes some challenges. Suggesting that the "most important cohesion that needs to happen within said projects is between | This paper addresses a successful mechanism said to enhance students' development of 'soft skills' (i.e., communication and teamwork skills, and empathy), and understanding of others' perspectives; the |

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| | | architects and civil engineers", the authors study the interaction between engineering and architecture students, in a designed 3-module intervention, in which interdisciplinary teams are to work on a hands-on group project, for four weeks. Students' self-reported perspectives on collaboration were then collected through an open-ended survey. Results suggest that "students working together from early stages have the opportunity to develop soft skills, expand their networks, and, most importantly, appreciate their counterpart's perspectives". In more depth, the development of 'soft skills' was deduced from the students' reporting of the benefit of developing communication and teamwork skills, and empathy, from working | latter can also be argued to be hinting towards exercising empathy. This was done via organising collaborative team working (between students of architecture and civil engineering) on infrastructure projects. |

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| | | in such interdisciplinary collaborative teams. | |
| An Educational Framework to Promote Self-Authorship in Engineering Undergraduates | (Fiss, Meadows, Raber, Henquinet, & Berkey, 2019) | This study discusses that students should develop skills in order to keep up with the 'future of rapid change'. The authors specify that developing skills and knowledge on the skills of the students' chosen fields, along with knowledge about themselves as individuals, and capabilities necessary to handle uncertainty, is vital, especially when students enter the post-graduate world as 'contributors'. This, the authors suggest, requires students to (1) build their own self-concept; (2) learn to develop meaningful and rewarding relationships; and (3) mature their capacity for deep learning (Fiss, Meadows, Raber, Henquinet, & Berkey, 2019). | This study addresses an intervention designed to explicitly promote consciousness (of the self) in engineering students. This was done via exercising a strategy rooted in Robert Kegan's theory of adult development (1994), reflective writing, collaborative working efforts, and students' assessment against Bloom's Taxonomy framework of educational objectives – both in cognitive and affective contexts. Students were found to be able to articulate their feelings, values, and goals", |

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| | | By implementing a strategy they developed, rooted in the psychologist Robert Kegan's theory of adult development (1994) to develop student self-authorisation, as opposed to simply reacting and dependent on external authorities/decisions made, the authors provide students with a "foundation in the competencies needed to advance their ability to become flexible professionals, and also balance their knowledge across the technical and social worlds". Rubrics developed include reflective wringing to assess students' self-authorship and self-determination, students' assessment against Bloom's Taxonomy framework of educational objectives – both in cognitive (Bloom, Englehart, Furst, Hill, | established "intrinsic motivation, a driving force for deep learning", and were said to be more encouraged to "think beyond their majors, and even their careers, in defining their goals", as a result of this intervention. |

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| | | & Krathwohl, 1956) and affective (Krathwohl, Bloom, & Masia, 1973) domains, and the integration of a "Learning Partnership Model across a series of developmental seminars, a set of required co-curricular activities with structured reflection", and provision of advising support to develop on self-authorship (based on rubrics of interpersonal, intrapersonal, and cognitive domains; and students' encouragement to "collaborate with faculty during seminars to explore concepts related to personal and social identities, cultural maturity, empathy, mindfulness, collaboration, and communication via dialogue") . Four students were assessed, longitudinally – three of them were engineering majors, the other was a non- | |

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| | | engineering STEM major. Promising results emerged. It was found that the students reported a better ability to "articulate their feelings, values, and goals", as result of this programme. Moreover, students, through their reflective writing, showed a developing sense of self-authorship and self-direction, as they advanced in the programme. Students also showed progressive capacity to developing 'meaningful' and 'rewarding' relationships, as they searched for "finding value in exploring differences of culture and identity" and exhibited abilities for "intrinsic motivation, a driving force for deep learning", personally addressing to themselves what success 'looks like', investigating their own ideas and passions, rather than relying on | |

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| | | socially constructed (extrinsic) image of success. The authors therefore suggest implementing such strategies in other disciplines of STEM, as they show promising results to equip students with the competency required for the future, rapidly-changing world. Moreover, the authors state that such a framework also "encourages students to think beyond their majors, and even their careers, in defining their goals". | |
| The Development of Ethical Reasoning: A Comparison of Online versus Hybrid Delivery Modes of Ethics Instruction | (Hess, Kisselburgh, Zoltowski, & Brightman, 2016) | This paper argues the necessity of improving online learning in higher education, specifically in fields of engineering ethics, it therefore proposes a study to compare mediums of teaching ethics (i.e., in-person, compared to hybrid and online). The proposed 'multi-phased study' examines students' development of reasoning and course | This study addresses and analyses the characterisation of ethics education across different learning mediums; however, it does not address an intervention explicitly designed to promote empathy, consciousness, design thinking, or |

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| | | perception, comparing these attributes across the different cohorts of learning mediums. Results revealed that "on-line ethics interventions can be designed to be as impactful in developing ethical reasoning as formats that include an in-class component, although students may be more satisfied with ethics education when they have the opportunity for face-to-face, in-class interaction with peers and instructors". With such results, the authors then suggest that "our [their] findings optimistically support the transferability of this ethics educational intervention (and others that are similar in nature) to online learning environments, although we would emphasize that we need to conduct future investigations in order | human-centred designing. |

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| | | to bolster this suggestion". | |
| Community Engagement and Service Learning: Putting Faces to a Community to Create Better Engineers | (Schulte Grahame, Freeman, & Levi, 2019) | This paper addresses a service-learning programme designed to help engineering students "grow their concept of community", by bringing them closer to the community, both emotionally and cognitively. The programme proposes students to "complete mandatory service with community partners outside of class hours as part of their course assessment". Throughout the programme student were learning about social matters and "societal norms outside of the immediate boundaries of their university". Assessing how the engagement with such a programme affects students' assumptions of the surrounding societies, along with students' post-site-visit | This study addresses an intervention that was found to have influenced or promoted students' communal engagement skills. This was said to be done by bringing them closer to the community, both emotionally and cognitively, in a mandatory public-serving programme. |

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| | | reflections, this study found that<br>(1) “that news and word of mouth stories played a large role in students’ impressions of the surrounding neighborhoods”;<br><br>(2) “the majority of students had not frequented a business or even ventured into the neighborhood, despite its close proximity to campus” – i.e., they were not knowledgeable of the surrounding communities pre-programme engagement;<br><br>(3) “students frequently answered questions with an emotional distance between themselves and statements about the neighborhood” – i.e., implying that empathy was not engaged;<br><br>4) “reflection entries generally showed the majority of students | |

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| | | reporting seeing the community differently, with significantly less negative commentary" – i.e., implying raising social consciousness;<br><br>5) and post programme engagement, students were starting to negate the concept that surrounding urban communities are distinct from the university community" – i.e., implying raising union or communal perspectives or values of 'oneness'. Moreover, one could argue that this could trigger a global perspective in students, with time and practice.<br><br>Concluding, the authors state such a service-learning programme "forces our [their] students out of their comfort zone, helping them to grow as engineers who are better prepared for future challenges". | |

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| Field Investigations: An Overlooked Form of Laboratory Experience | (Radcliffe & Pilotte, 2018) | Arguing that identifying "what counts as a "laboratory"", as well as being considerate of socio-cultural, economic, and ethical, as well as the technical factors and impact of an engineering project, this paper implements a one-week study abroad course informed by a "novel Study Abroad program". This is to exemplify the design and implementation of a 'socio-technical laboratory' which is suggested to imitate 'an experience of global engineering fieldwork', as students become exposed to a "set of technical and cultural experiences", which are suggestive to provide "an authentic context in which the students could develop observational, analytical and interpretive skills that [go] beyond that feasible in a | This paper addresses a successful mechanism found to have promoted social consciousness and human-centric designing skills in students. This was done via proposing a "novel Study abroad programme" where students were set to experience a 'socio-technical laboratory' which is suggested to imitate 'an experience of global engineering fieldwork'. Students' reflective writing was also encouraged in this programme. |

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| | | conventional laboratory setting". Eight American students were flown to Australia to partake in a "Global Design class" that was already ongoing at Swinburne University of Technology in Melbourne. Student reflections were collected. From analyses, students were shown to acknowledge the influence of factors like user acceptance related to 'bodily function taboos', and religion, on their design. Moreover, it was found that "several students were forced to set aside their "ideal" designs"; that was when students realised that producing an 'ideal' design (i.e., technically sound) cannot be implemented to become of use, if societal needs, preferences and risks were not taken into consideration. | |

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| | | Reflections also showed that student developed other skills including those with creative problem solving, data collection, analyses and sense making, proposing and finalizing designs. However, students were also found not being able to "go deep to elaborate upon their observations, inferences, and pivot points of decision making throughout the project", when presented with a "structural methodology for documenting their experiences"; this, the authors suggest, "highlights the need in engineering education for greater explanation of how and why engineering professionals find value in engaging in such reflective exercises". Concluding, the authors state that "the novel study abroad course described provides an | |

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| | | instance of how to emulate practices natural to global engineering fieldwork and develop essential technical and professional skills such as problem identification, decision making and reflection”. | |
| Just Add Context? Analyzing Student Perceptions of Decontextualized and Contextualized Engineering Problems and their Use of Storytelling to Create Context | (Mogul, Tomblin, & Reedy, 2019) | This paper aims to identify strategies to better promote successful social engagement in engineering science contexts and problems. Analyses to this paper were drawn from two assignment of two engineering ethics courses, and a ‘story telling assignment’ (where students wrote “context for a decontextualized problem” – i.e., for identifying the strategies students used to construct context, and their difficulties in doing so). Student choice of scenarios, relevant stakeholders, and the extent to which social justice is | This study assesses and analyses students’ ethics assignment proposals and outcomes of a story telling assignment (where students wrote “context for a decontextualized problem” – i.e., for identifying the strategies students used to construct context, and their difficulties in doing so). The latter was thought of a “scaled down approach to adding context”. Findings show that such practices have enhanced students’ |

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| | | integrated into technical problems were analysed. Amongst this study's findings were: (1)"students expressed support for a scaled down approach to adding context, especially as it improves professional skills, student understanding of engineering identity and the meaning of engineering, understanding of real world applications, and even skills related to empathy";<br><br>(2)"most students that embraced some aspects of contextualized problems argued that they would help them understand the importance of real world experiences to engineering work";<br><br>(3)"most stories focused on individual agency and didn't consider the larger social structure in which the story takes | understanding of the professional identity and the "real world application" and empathy. |

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| | | place (e.g., company influences, issues of power, etc.), which is consistent with the emphasis on micro-ethical framing of ethical issues in engineering". This, the authors elaborate, was exemplified by the several students' use of the strategy of 'blame' to tackle ethical, contextualised problems, reducing the problem to the individual agency of the engineer involved (to the micro-ethical framing of the ethical issue), and disregarding the macro-ethical framing (i.e., the wider context like company influences, issues of power etc.).<br><br>Moreover, there were findings revealing that some students found that such notions are "detrimental to mastering the technical fundamentals of engineering". | |

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| Ethics Education as Philosophical History for Engineers | (Biezad, 2015) | This study employs a method of integrating "bursts of weekly storytelling that last approximately ten minutes with the intent of showing the evolution of ethics from antiquity to the present day", in a senior level engineering class; suggesting that "true stories, myths, and interesting cultural situations can highlight how prevailing norms of morality have emerged episodically in Western culture", of which have now resulted in the present codes of ethical standards. Analysing surveys given to students before and after the intervention, it was found that "engineering students appreciated the historical mathematical and philosophical focus on ethics, and that they felt better prepared for significant ethical challenges they may encounter". | This study does not address an intervention designed to explicitly promote empathy, consciousness, design thinking or human-centred designing skills. |

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| | | Additionally, students labelled this approach as “both unique and interesting”, demonstrating their liking and enjoyment of such initiative, and suggested it to be positively contributing to the training for an “ABET [i.e., Accreditation Board for Engineering and Technology] visit”. | |
| How (Inter)national Engineering Faculty Members Perceive and Teach Creativity: A Cultural Perspective | (He, Hunt, Burgoyne, & Saboorizadeh, 2022) | This study analyses the influence of faculty members’ backgrounds on their “understanding of creativity”, and consequentially, on their lecturing methods aimed to cultivate engineering students’ creativity (i.e., “for innovation-driven workforce”).<br><br>Interviews were conducted to compare the ‘understandings’ and methods of international faculty members, to those of local (US) faculty members. | This study addresses the notion of cultivating creativity in engineering classrooms, and the influence of the educators’ background on that. However, it does not address an intervention designed to explicitly promote empathy, consciousness, design thinking, or human-centred designing skills. |

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| | | The study found that all faculty, regardless of background, expressed the importance of the creativity, agreeingly defined it as “a competency to demonstrate a “different thinking” mindset or to propose novel ideas, methods, or solutions”, and believed that “free discussion helped students open their minds and would be beneficial to foster students’ creativity”. Although they mentioned similar methods to fostering creative thinking and practices in the classroom, the U.S. faculty members mentioned using lecture slides presentations more than Asian faculty members. “The Asian faculty members, although suggested by the authors to be “traditionally believed to be more used to a teacher-centered teaching preference”, | This study did not experiment with an intervention designed to explicitly cultivate creativity either, however, it did mention from the analyses of the educators’ interviews, that creativity can be fostered via “free discussion”, as it is said to have “helped students open their minds”, which would therefore “be beneficial to foster students’ creativity”. |

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| | | were found keen to exhibit "how creatively they can teach". | |
| Student Paper: Study of COVID-19 Impact on Aviation Maintenance Training in Indonesia | (Swastanto, Putri, Keller, & Faith, 2022) | This paper discusses aviation training in Indonesia – comparing the in-person, to hybrid to online training, and analysing the consequences of such shifts in medium of training. The authors also develop a survey to assess how students respond to the training methods. Analysing semi-structured interviews with aviation maintenance instructors, and survey responses from students, this study finds and lists the " most effective teaching methods that can improve practical skilled aviation maintenance professionals in Indonesia during the pandemic situation". | This study does not address an intervention designed to explicitly promote empathy, consciousness, design thinking, or human-centred designing skills. |
| Curricular and Strategic Changes in mathematics to Enhance Institutional STEM Education | (Han, Kostadinov, Liou-Mark, & Thiel, 2022) | This study implements a project to "create transformative changes in the STEM Education" at a | This paper mentions a study which lead to the students' |

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| | | Hispanic-serving institution. The study intends to 'revamp' the mathematics curriculum and redesign courses with the intention to increase participation and diversity in computing; the strategies for such changes include implementing "hands-on active and collaborative learning pedagogy, experiential learning with real world relevance and applications, and curriculum that incorporates data analysis, data visualization and computational thinking".<br><br>As a result, the study accomplished three main areas of project development:<br>1) Restructuring the first-year mathematics courses at the college algebra level using a corequisite model;<br>(2) designing and implementing active | advancement of real-world problem-solving in a STEM computational mathematics classroom; however, it did not address an intervention designed to explicitly promote empathy, consciousness, design thinking, or human-centred designing, therefore making it irrelevant to the present literature review section. |

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| | | learning and problem-solving oriented curriculum in Calculus; (3) building a student support system of peer-tutoring and mentoring through peer-led team learning (Han, Kostadinov, Liou-Mark, & Thiel, 2022) .<br><br>Moreover, this paper found that "integrating real-world computational problem-solving and coding provided students with important 21st century skills for STEM success". | |
| Curricular and Non-Curricular Factors Impacting Development of Leadership Competencies in Undergraduate Civil Engineering and Construction Students | (Ostadali Makhmalbaf & Simmons, 2015) | This review paper discusses the call for, and importance of developing leadership skills in engineering; as this is said to prepare students for "complex projects that include various stakeholders". This paper researches the curricular (i.e., course experience) and non-curricular (i.e., mentoring networks and internships) factors that influence the | Although this study addresses the notion of development of emotional intelligence as a key factor to developing leadership skills, it does not address an intervention designed to explicitly promote empathy, consciousness, design thinking or |

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| | | advancement of leadership competencies for undergraduate civil engineering and construction students. Critically reviewing relevant literature, the paper summons and addresses the influential curricular and non-curricular factors as: (1) instructor's knowledge; (2)course assignments and activities, (3)course content (e.g., emphasis on the development of technical competencies vs. development of emotional intelligence skills in the course); (4) access to resources (e.g., instructional technologies, guest speakers); and (5) ability to enroll in courses outside of required curriculum (e.g., courses in management, leadership and law) (Ostadali Makhmalbaf & Simmons, 2015) . | human-centred designing skills, and is therefore irrelevant to the present literature review section. |

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| Lessons Learned: Designing an Empathy Workshop for Engineering Faculty to Promote Equity-Focused Teaching | (Wang, 2023) | This paper addresses a workshop designed to promote empathy as a “vehicle to promote equity-focused teaching in engineering” and to “engage faculty in role-playing scenarios, self-reflection, and discussions”. It was found that such a workshop allowed for faculty to practice engaging in empathic manner, in a “low stake environment”. | Although this paper addresses a workshop to explicitly promote empathy in engineering classrooms, it was to promote empathy in engineering educators, as opposed to engineering students; therefore, this paper has no relevance to the current literature review section. |
| Integrating Technical and Social Issues in Engineering Education: A Justice Oriented Mindset | (McAlister & Lilly, 2023) | This paper reviews how integration of social aspects of engineering have been integrated in engineering curricula, asking: “How might social and technical aspects of engineering be effectively integrated in undergraduate engineering education and what are the benefits of such integration?”. The paper addresses reviews on how such | This review paper does not address a method designed by the researchers to explicitly promote empathy, design thinking, or human-centred designing in engineering students, and is therefore not relevant to the present literature review section. |

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| | | notions can be integrated by engineering educators. | |
| Learning the Impact of Diversity, Equity, and Inclusion Modules in an Undergraduate Electrical Engineering Classroom | (Telang, Annaluru, Julien, & Santacruz, 2023) | This paper addresses the results of implementing diversity, equity and inclusion (DEI) modules in an engineering classroom. The objective was to "ensure that engineering undergraduate students, who are not historically exposed to DEI content, are introduced to these important topics in the context of their technical coursework and that they understand the relevance of DEI to their careers". Modules were implemented to inform students on "history of computing and algorithms, identity and intersectionality in engineering, designs from engineering that have high societal impact, the LGBTQ+ experience in engineering, engineering and mental health, and cultural | This paper designs a methodology to explicitly integrate notions (associated with empathy) to expand and promote the understanding of diversity, equity, and inclusion in an engineering classroom. However, this paper does not provide a methodology designed to explicitly promote empathy in contexts of design thinking or human-centred designing, in an engineering classroom; but it is still worth noting. |

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| | | diversity within engineering". Students were given the option to "(1) watching a relevant video; (2) reading and annotating a provided article; (3) responding in a written reflection to a set of specific prompts relevant to the module; and (4) conducting an interview with a peer or community member using a list of suggested questions about the module's contents", as a mean to interact with such topics, and were thereafter requested to explain what they've learnt through submitting a deliverable to be graded and evaluated. Feedback from the students was collected to be later fed into the process of the development and further promotions of such notions in engineering education. | |
| Work In Progress: Implementation of a Skills Based Approach to Diversity, | (Lego, 2023) | Arguing that "lecture-based approaches are | This paper remains a work in |

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| Equity, and Inclusion in Senior Undergraduate Aerospace Capstones | | the least effective pedagogical method for ensuring concept retention, changes in empathetic thinking, and recognition of personal implicit biases", Lego (2023) overcomes this issue by implementing "a skills-based approach to its DEI learning modules within all capstone courses". This was done via implementing "a variety of pedagogical techniques including interactive video-based bystander training; self reflections on microaggressions and implicit bias; and in-class team exercises and discussions on the intersection of power dynamics, team interactions, and discrimination, as well as strengthening empathy though a recognition of societal privilege and economics factors"; ensuring that students develop "concrete action that will promote | progress, however it addresses an intervention designed to explicitly promote empathy in contexts of diversity, equity, and inclusivity; however, said intervention was not designed to explicitly promote empathy in contexts of human-centred designing or design thinking; however, it remains as relevant to the present section, as in explicitly promotes empathy) in an engineering classroom. |

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| | | and ambiance of "an inclusive, collaborative, and psychologically safe environment for all members" when working in teams. Although this remains still as a "work in progress" intervention, the present paper has promising positive impacts. | |
| Increasing Contextualized Social Awareness through Multidisciplinary Teams in Global Service-Learning Projects | (Ely, Hill, & Sparks, 2023) | This work-in-progress paper reviews a methodology to promote "unique collaborations between engineering and non-engineering students in a user-centered design course and humanitarian engineering project work". It assesses "the professional formation of engineers by examining how engineers apply social attributes (namely those identified by the Social and Emotional Learning (SEL) framework) to user-centered design in a multidisciplinary project", asking "What | Although this paper is a work-in-progress, it reviews an intervention designed to explicitly promote user-centred designing (i.e., can be argued to be relevant to human-centred designing); and is therefore, relevant to the present literature review section. It does not presently present solid results; however it displays an array of positive potential influence. |

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| | | key social attributes do undergraduate students identify as significant factors within service-learning engineering projects?” and “How does participating in a user-centered design curriculum impact students’ identification of key social attributes associated with service-learning projects?”. As this is an ongoing project, this paper only reviews the implementation process, however, discusses promising positive socially consideration influence on students. | |
| Creating and Implementing a Custom Chatbot in Engineering Education | (Abdulla, Al Hamidi, & Khraisheh, 2023) | This publication assess the “development and use of a chatbot in an engineering curriculum”; targeted to aid with students’ “keeping track of deadlines, scheduling meetings, and finding resources”, and to promote students’ self-learning. | This paper does not address an intervention designed to explicitly promote empathy, design-thinking or human-centred designing in engineering students and is therefore |

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| | | | irrelevant to the present literature review section. |
| Character Development in the Engineering Classroom: An Exploratory, Mixed-Methods Investigation of Student Perspectives on Cultivating Character | (Koehler, Pierrakos, & Yeaman, 2023) | This paper explores students' "perceptions of character learning and growth across the curriculum", by identifying how student characteristics change over time, using a survey. The research questions explored were: "1. Which character strengths / virtues did students perceive to have strengthened across the engineering curriculum and in specific engineering courses? 2. Which classroom experiences (i.e., activities, pedagogies, or practices) did students attribute to their perceived character growth?"; whilst the characteristics assessed are the following: reativity, curiosity, critical thinking, service, empathy, courage, resilience, honesty, justice, | Although this study observed strengthening student characters, it does not address an intervention designed to explicitly promote empathy, design thinking or human-centred designing in engineering students. |

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| | | purpose, teamwork, intellectual humility, practical wisdom. Results of this study show that “students perceived the most growth in performance and intellectual virtues (using the Jubilee Virtue Framework) such as teamwork, resilience (performance virtues) and critical thinking, creativity, curiosity, and intellectual humility (intellectual virtues). Further, students attributed character development not only to courses with pre-planned character activities, but to courses where no formal character-based learning outcomes existed”, and proceeded to review prevalent activities, recommended to strengthen these characteristics further. | |
| Facilitation for Diversity, Equity, and Inclusion through Design Thinking | (Buzzanell, Eddington, & | This paper’s objective is to “understand better how facilitators work with DT participants in | This study addresses how design facilitators can promote |

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| | Zoltowski, 2023) | particular spaces and engineering cultures regarding sensitive ethical issues like DEI, and to provide guidelines for developing facilitation expertise for DEI in DT sessions”. This paper then drew findings on how facilitators extract “participants’ understandings and explanations of marginalization and inclusion”; this was done by the facilitators’ “attending to design session participants’ own expressions of causality and hopes for the future”. | further design thinking in engineering education, and is therefore relevant to the present literature review section. |
| Board 146: Work in Progress: Incorporating Learning Strategies and Theory into a Multidisciplinary Design Capstone Course | (Rhoads & Schrock, 2023) | This work in progress reviews the modifications made to the Multidisciplinary Design Capstone (MDC) course at The Ohio State University. This involved the enhancement of four major learning strategies and theories (sense of belonging, stereotype threat, calibration and | This paper addresses a change made to a curriculum that resulted in cultivating empathic design thinking in a Multidisciplinary Design Capstone course, by attending to the enhancement of the listed skills |

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| | | retrieval) in the course, in addition to the instructors integrating empathic decision making into the design process. Triangulation feedback (i.e., between students, MCD instructors, faculty advisors, and capstone project sponsors) was analysed to evaluate the changes. The methods implemented in the current development of the course show promising positive influence on students, where students showed skills of working in diverse teams, developed team value, inclusivity and efficiency and empathic decision making in the design process, skills of calibration between their ‘perceived’ and ‘actual’ performance and knowledge of cognitive level, and lastly, trained students to “to reflect and modify their problem identification as they gain knowledge | like sense of belonging, stereotype threat, calibration and retrieval, in the course. This paper is therefore relevant to the present literature review section. |

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| | | progressing through the design process” and avoid ‘jumping to conclusions’. | |
| A Longitudinal Engineering Education Study of a Holistic Engineering Pedagogy and Holistic Design Thinking Methodology on Postsecondary Student Academic Success and Retention | (Povinelli, 2023) | This paper explores the efficiency of an “innovative Holistic Engineering pedagogy for secondary and postsecondary engineering students that includes a novel Holistic Design Thinking methodology”. It integrates knowledge on “love, empathy, and ethics, and with a focus on engaging students’ emotions in the learning process to develop interpersonal and technical skills”. Using surveys, interviews and feedback from students, this research provides knowledge on “the effectiveness of these holistic and transdisciplinary pedagogies in promoting students’ comprehension of engineering principals and interpersonal | This study does not address an intervention designed to explicitly promote empathy, design thinking or human-centred designing in university engineering students, and is therefore irrelevant to the present literature review section. |

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| | | skills”. Results of this study show that “rigorous homework practices, critical reading, time management, and engagement in the HDT [Holistic Design Thinking] methodology are important skills for high school students to develop” (before entering engineering college/higher education), as well as “team dynamics/teamwork; reflective and analytical writing; empathy; ethics; communication; and visual and critical thinking”. | |
| “We’re Learning like Everyone Else”: Best Practices from Men Allies | (Lewis, 2023) | This interesting paper explores “the motivations, perceptions, and experiences of men faculty who identify as allies for undergraduate women in engineering”, arguing that “as men represent the majority in engineering, efforts to create socially just, equitable cultures for women will not be | This paper does not address an intervention directly designed to explicitly promote empathy, design thinking, and human-centred designing in undergraduate engineering classrooms and is therefore irrelevant to the |

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| | | successful if men are not included”. This study aims to answer the following: “How and in what ways do the efforts of men faculty allies towards gender equity manifest in their daily work within their disciplines?”. Findings identified which characteristics should be further developed for “allyship efforts”, and gender equity work, for the purpose of cultivating “more equitable engineering environments for women undergraduate students”. | present literature review section. |
| Integrating Companies and Higher Education in the Teaching-Learning Process of Lean Thinking Using Challenge-Based Learning | (Zavala, Cuevas-Ortuño, Angulo Cedeño, Perez Araos, & de Luna, 2023) | This paper explores the integration of “Lean Thinking in higher education within an organization’s facility using Challenge-Based Learning (CBL)”; this is to improve a Key Performance Indicator (KPI), reduce waste and improve productivity. This paper conducted a model (the ‘MUSIC(R) model of | This paper does not address an intervention specifically designed to explicitly promote empathy, human-centred designing or design thinking in an undergraduate engineering classroom and is therefore |

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| | | motivation') to examine the students' motivation during CBL. Results show that "using CBL maintains students' interest in Lean concepts", and that the model can be replicated easily. | irrelevant to the present literature review section. |
| "It's very important to my professors…at least most of them": How messages from engineering faculty and staff influence student beliefs around seeking help for their mental health | (Ban, et al., 2023) | This study qualitatively examines the "the factors that influence mental health related help seeking in undergraduate engineering students", using the integrated behavioral model (IBM). This is to identify the implicit, as well as explicit, messages engineering faculty or staff dispense, which can possibly influence students' help-seeking – one of them was found out to be that "students perceive lack of flexibility and empathy from faculty as not being supportive of student mental health". The results of the present study show guidance to engineering | This study does not address an intervention designed to explicitly promote empathy, human-centred designing and/or design thinking in an undergraduate engineering classroom, and is therefore irrelevant to the present literature review section. |

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| | | faculty/staff on how to cultivate an environment that is "supportive of mental health and professional help seeking". | |
| Nuestro Impacto: An Insider Look into the Connections between Our Past Experiences and Current Teaching and Mentoring Practices | (Villanueva Alarcón, et al., 2023) | This paper discusses "the experiences of five Latiné/x faculty in engineering and what motivated them towards developing equity-minded educational practices for their undergraduate students". Using a social constructionism paradigm and a narrative inquiry methodology, reflections of the participants were analysed. Four themes merged: !(a) Counter-storytelling, (b) Structural Determinism (c) Language Origins, and (d) Four Capitals of Community Cultural-Navigational, Aspirational, Social, Familial Capital!. From this, the paper concludes and recommends that future faculty development | This paper does not address an intervention designed to explicitly promote empathy, design thinking and/or human-centred designing in undergraduate engineering classrooms. It therefore not relevant to the present literature review section. |

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| | | programs should be considerate of the prevalent non-Monolithic backgrounds, cultures, languages, and experiences in engineering education; hoping to trigger more consciousness of such factors' impact on engineering education. | |
| Game Over: Reframing Ethical Decision-Making through Failure for Engineering Education | (Fox & Beiter, 2023) | This paper integrates ethics into engineering education through "play" – where "game over does not necessarily mean that the player has lost". Using video games, such as Hades and Dark souls, "the player gains ground each time that they fail. Eventually, the player learns how to overcome any obstacle in the proper way once they have understood what does not work". This is said to teach students on "how failing to account for various ethical dimensions of | Although this study informs on a methodology to promote ethics (which, by extension to the literature, is tied to empathy and societal consideration) in engineering education, it does not address an intervention designed to explicitly promote empathy, design thinking and/or human-centred designing in an undergraduate engineering |

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| | | engineering can have serious social and technological consequences", whilst also teaches them on how to "cope with failure, learn strategies for improvement, and cultivate moral empathy for others". Such an interesting learning experience is said to put students in an "immersive ethical environment to cultivate a deeply-rooted understanding of how failure looks across a variety of moral landscapes and how to navigate failing effectively". | classroom. It is therefore irrelevant to the present literature review section. |
| Sense of Belonging of Women in Construction: Insights from Focus Groups | (Quezada-Espinoza, Silva, & Alvarado, 2023) | This study analyses how women perceive their 'sense of belonging' in a male-dominant construction engineering profession. After qualitatively analysing the experiences of women (as "students, alumni working in the field, and faculty") in a construction engineering degree | This paper does not address an intervention designed to explicitly promote empathy, design thinking and/or human-centred designing in undergraduate engineering classrooms. It therefore not relevant to the |

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| | | program, this paper concludes that all women “believe that self-confidence, recognition from peers and leaders, social interactions, and knowledge and skills are critical factors that improve their sense of belonging”. | present literature review section. |
| Work in Progress: Impact on Students Dropout rates of Introducing a First-Year Hands-on Civil Engineering Course | (CERVANTES & Guerra, 2023) | This paper analyses the factors (both personal and institutional) that drive students to dropout from the engineering major, analysing how academia can be developed with new pedagogical approaches, to reduce the number of dropout civil engineering students. | This paper does not address an intervention designed to explicitly promote empathy, design thinking and/or human-centred designing in undergraduate engineering classrooms. It therefore not relevant to the present literature review section. |

*Table 96 - Reviewing how others conducted priming interventions to promote human-centred designing or sustainable consideration or goals.*

| Publication Title | Publisher | Publication citation | Publication Synopsis | Publication Nudging/Priming Format and Results (with my occasional remarks) |
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| The challenge and opportunity of behaviour change methods and frameworks to reduce demand for illegal wildlife | Nature Conservation | (Wallen & Daut, 2018) | This paper reviews methods to trigger behaviour change, and mitigation of illegal trades of flora and fauna. Nudging and priming, as a methods for behaviour change, are therefore addressed and reviewed for their usefulness in such contexts. | Publication Result:<br><br>This review paper concludes that nudging and priming are efficient methods for behaviour change and mitigation for such issues. The authors therefore suggest that "nudges relevant to IWT and consumer demand may involve the development of text message programmes or smart-phone applications that provide information about known IWT retailers and alert consumers to alternative choices. The principles of behavioural insights can also be used to nudge institutions and governments", and that "with a constituency of stakeholders shifting their behaviour and support for demand reduction policies, a government's default option can be nudged from the bottom-up".<br><br>My Remarks: |

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| | | | | This publication does not explore an intervention in which priming or nudging have been exploited in human-centred or sustainability-related interventions, and is therefore not relevant to the present literature review section.. |
| Designing for two: How enhancing human-centered design with behavioral nudges unlocked breakthroughs to promote young women's psychological safety and access to reproductive care in Tanzania | Elsevier: Social Science & Medicine | (Liu, et al., 2023) | This study tests methods of nudging adolescent girls and young women in contexts of accessing preventive sexual and reproductive health (SRH) services, in sub-Saharan Africa.<br><br>Nudging was used as an ‘encouraging’ manipulative tool, in an empathic intervention, to motivate the girls and women to pursue contraception and HIV self-test kits. | Publication Nudging Format:<br><br>Adolescent girls and young women were set on a default membership gift of an HIV self-test kit (with an opt out option), as a method for encouraging HIV self-testing and consideration of contraceptives.<br><br>Publication Results:<br><br>Positive outcomes of the nudging were shown, as hypothesised. The authors then suggest that “integrating human-centered design and behavioral economics [i.e., nudging] was effective for developing an innovative and effective intervention that simultaneously met the different needs of economic actors in support of public health priorities”. |

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| Designing drug shops for young women in Tanzania: applying human-centred design to facilitate access to HIV self-testing and contraception | Oxford Academic: Health Policy and Planning | (Hunter, et al., 2021) | This study explores the use of human-centred designing to create drug shops where young women could access contraceptives and HIV self-testing, in Tanzania. The authors also use nudges to enhance and encourage such a procedure. | Publication Nudging Format:<br><br>Nudging was in the form of a gifting free HIV self-test kits (with the option to opt out) to girls and women, upon their signing up to a loyalty membership of the 'Malkia Klabu' (see more below).<br><br>Publication Results:<br><br>As a result of applying the human-centred designing framework to the case, the authors designed a "'Malkia Klabu' ('Queen Club') loyalty programme through which young women could earn mystery prizes by shopping at drug shops and discreetly request free SRH products, including HIV self-test kits, by pointing at symbols on loyalty cards".<br>With the nudging strategy incorporated within the human-centred designing framework proposed, the authors conclude that "[their] HCD approach increases the likelihood that the intervention will address the specific needs and preferences |

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| | | | | of both drug shopkeepers and young women". |
| Theory-driven or theory-informed? A review of behavioural economics in design | Taylor & Francis: The Design Journal | (Mejia, 2021) | This paper reviews behavioural economics (i.e., nudges) as form to trigger behaviour change. It reviews how such nudges can be applicable in design processes and critiques how such application may be limited. | Publication Results:<br><br>This paper critiques such behavioural change initiatives to be limited by its (yet) ununderstood long-term consequences, and by its exclusive applicability to discrete problems and narrowly defined interventions.<br>The author also identifies where such triggers may take place – which is, in the *ideation* phase of the design process.<br>The author also contribute with the statement: "a critical step forward is to disseminate the understanding of influence among designers. Cognitive abilities—and thinking systems—of people are complex and designers should care about human traits other than sensorial perception and understanding. But designing only for optimization of cognitive information processing may be inefficient and sometimes even negative" – calling for further understanding personal traits (and other personal factors) |

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| | | | | that might be associated with the engagement with or influence of the nudges.<br><br>My Remarks:<br>This publication does not explore an intervention in which priming or nudging have been exploited in human-centred or sustainability-related interventions, and is therefore not relevant to the present literature review section. |
| Using behavioural economics for effective policy design to improve individual and population well-being | Masters Thesis. Masaryk University, Faculty of Arts, Department of Psychology. | (Kacha, 2016) | This publication addresses how behavioural policy is normally driven by cost-efficiency and effectivity; therefore, tests to analyse how intervening with autonomy supportive framing and normative framing (both are forms of nudging) could influence motivation towards sustainable behaviours. | Publication Nudging Format:<br>Experiments took place online, where participants were requested to respond to weekly assignments whilst undergoing two forms of nudging (separately).<br><br>Assignments were set to “encouraged participants to engage in one of four sustainable behaviours (supporting local producers, saving electricity, supporting less fortunate individuals, and waste recycling, in the stated order)”. Surveys were set to track participants’ change in responses over time (i.e., before and after engaging with assignments). |

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| | | | | Assignments were composed of three parts regarding the assigned task:<br>(1) A title – (e.g. "Your challenge on the following week is: Saving electrical energy");<br>(2) A description; this was also where the the nudging took place; and<br>(3) Four examples of the endorsed sustainable behaviour (e.g. "Prefer using stairs instead of an elevator").<br>The two types of nudges tested were:<br>(i) Autonomy supportive framing – where the description of the task provided a justification for engaging in the sustainable behaviour, accredited participants' perception, and used a "non-controlling language".<br><br>(ii) Normative framing – where the description |

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| | | | | consisted of 'norms' deduced from previous responses made by the participants. Such descriptions were informative of the statistics of the 'norms' deduced from earlier responses – for example, "8 of every 10 asked participants of this study try to save electricity and water on a regular basis. For the following seven days, limit your electricity consumption at your home, employment and other places that you regularly visit."<br><br>Publication Results:<br><br>It was found that normative framing, in encouraging motivation towards sustainable behaviour, maybe hindering individuals' "conscious valuing of a promoted behaviour" (i.e., their intrinsic drive behind the motive), and rather making |

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| | | | | them "pursue the promoted behaviour for adaptive reasons (going with the crowd yields social benefits)" – i.e., the latter hinting towards encouraging extrinsic drive to such motives and sustainable behaviours.<br>The findings therefore suggest that<br>"individuals who internally value sustainable behaviours more engage in these"; and, to a smaller extent, are happier in their life.<br><br>The autonomy supportive framing, on the other hand, was found encouraging of the intrinsic drive (i.e., the "development of internal valuation of promoted sustainable behaviours") for sustainable behaviour and motivation. |
| Designing for society: Products and services for a better world | London: Bloomsbury Visual Arts. | (Tromp & Hekkert, 2019) | This publication discussion notions of globalisation and socio-technical systems supporting the current way of living. It discusses the impact produced by designers on the society and peoples' standards of living as a result of the designing practice and execution. Encouraging the | Publication Results:<br><br>In sum, this book offers a "significant analysis of the social implications of design and the range of products and services that stimulate human behavior", suggesting that "this is a valuable addition to the literature on design of all |

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| | | | incorporation of design thinking as problem-solving tool, the authors highlight how design practices incorporating consideration for social welfare, can be an effective mitigative tool for the enhancement of public welfare and sustainability. This book also provides examples of case studies where such mitigative strategies have been successful. In sum, this book offers a "significant analysis of the social implications of design and the range of products and services that stimulate human behavior", suggesting that "this is a valuable addition to the literature on design of all varieties". Nudges as behavioural economy has been addressed and reviewed in such a context. | varieties". Nudges, as a mitigative approach to behavioural change, has been addressed and reviewed in such a context.<br><br>My Remarks:<br>This publication does not explore an intervention in which priming or nudging have been explicitly exploited in human-centred or sustainability-related interventions, and is therefore not relevant to the present literature review section. |
| Transparency in Persuasive Technology, Immersive Technology and Online Marketing: A Narrative Review. | EROGamb 2 Narrative Review. Technical Report. Poole, England: Bournemout | (Wang, et al., 2020) | This report discusses the importance of transparency and strong ethical conduct in online marketing, critiquing the lack of clear guidelines for designers and marketeers to achieve such transparency and ethical conduct. This report therefore reviews | Publication Results:<br><br>The report summarises that "transparency in persuasive technology involves transparency of persuasive design and techniques, transparency of potential risks and user autonomy, and |

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| | h University. | | how such transparency is interpreted in current practices, across three fields – namely, persuasive technology, immersive technology and online marketing. | informed decision making and dark patterns of design”.<br><br>Linking this to priming and nudging, the report reviews that “subliminal priming can be used as a “dark design pattern” to attempt to manipulate users (Caraban A. , Karapanos, Campos, & Gonçalves, 2018; Brignull, 2011; Greenberg, Boring, Vermeulen, & Dostal, 2014). For example, designers might use subliminal priming to make it easier for users to prefer a particular product over others without their consent (Pinder, 2017)”. The authors then reemphasize the necessity of designers’ exercise of ethical conduct in such user experience (UX) and human-computer interaction (HCI) design cases.<br>Similar to the remarks made on exercising priming in UX and HCI designing scenarios, the authors address the ethical demand on designers when exercising nudges in such designing initiatives. Citing Caraban et al (2019), the authors, the authors comment that nudging seems to be a |

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| | | | | powerful tool to 'manipulate behaviour', critiquing that "such nudges raise ethical concerns as users may not be able to recognise their intentions and effects. For example, users may be automatically enrolled in a procedure while unaware of the enrolment process and opt-out policies".<br><br>My Remarks:<br>This publication does not explore an intervention in which priming or nudging have been exploited in human-centred or sustainability-related interventions, and is therefore not relevant to the present literature review section. |
| Data Science in Public Policy– The New Revolution? Do Hoang Van Khanh | Civil Service College Singapore. Report | (ETHOS, Civil Service College Singapore, 2017) | This report reviews why and how behavioural insights, or nudges, have been adopted in Singaporean policy making strategies, in pursuit of more human-centric, and sustainable public-services and outcomes. Multiple authors contribute to this reports, each with a different perspective on how nudging (or priming) can be integrated in Singaporean public service and policy- | Publication Results:<br>An author (Soon, 2017) addresses why and how nudging have been integrated in policy making, and suggesting that, as a plan for the development of Singapore, the author suggests that: "there are three things we can do for BI [behavioural insights, i.e., nudges] to become even more useful and |

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| | | | making plans aimed for enhanced sustainability and human-centricity. | relevant in Singapore and elsewhere. One is to find new and innovative ways to integrate BI with other disciplines and tools towards a more human-centred approach in public policymaking" (p.13).<br><br>Another author (Chen, 2017) addresses how behavioural insights can be used to improve public service delivery in strategies involving co-designing and design thinking. The author (citing Ministry of Manpower, Applying Behavioural Insights in MOM: 2013-2014 Year in Review, 2014) reviewed how to 'redesign the jobseeker experience' at one of the addresses community development centers, via the "use of social norms and priming to motivate jobseekers". The priming was done via the display of stars on the walls of the consultation rooms of the community development centre, with each star representing the number of people who had found work through the centre; further |

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| | | | | adding that “information about top job vacancies and their average salary ranges were also displayed to influence jobseekers to adopt more realistic job expectations” (p.21; citing Ministry of Manpower, Applying Behavioural Insights in MOM: 2013-2014 Year in Review, 2014)<br><br>A third author (Boh, 2017) states that “nudges fill the gaps where traditional policy interventions have been found wanting” (p.27), as “nudges directly address the social, cognitive and physical barriers — usually unaccounted for by traditional policy tools — that hinder such choices from being made in the first place” (p.28) – signifying that nudging can provide that extra prompt to achieve the desirable result(s), in contexts where the desirable is a “cleaner and greener” Singapore.<br>The author then remarks that the “efforts to nudge people towards more environmentally friendly behaviours have generally involved (a) making the |

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| | | | | practical benefits of environmentally friendly options more salient, (b) leveraging social norms, and (c) making changes to the physical environment to reduce barriers” (p. 28).<br><br>Lastly, an author (Hua, 2017) suggested that in developing countries where “aging, [social] integration, and [environmental] sustainability, are permanent”, policy makers could produce substantial results by focussing on BI [behavioural insights] integration in such areas of concern. For example, it was suggested for:<br>*(i)Retirement planning*: “Many people are not well prepared for retirement. Using BI, we could educate people to adopt a long-term perspective for savings, perhaps as soon as an individual starts his or her working life” (p.66).<br><br>(ii) *Active ageing*: “Ageing is a global phenomenon. To delay premature ageing, we could use BI to promote |

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| | | | | healthy eating and more exercise to stay fit" (p.66).<br><br>(iii) *Social integration*: "Many large cities have diverse populations. BI could be used to educate people to be more tolerant of one another, so that there will be less conflict and greater inclusiveness in the society we live in" (p.66).<br><br>(iv) *Environmental sustainability:* "Climate change will be a central challenge in the century ahead. We could frame key messages using BI-based principles, educating people to be more environmentally responsible by consuming less energy and by adopting behaviours that protect the environment".<br><br>My Remarks:<br>This publication does not explore an intervention in which priming or nudging have been exploited in human-centred or sustainability-related interventions, and is therefore |

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| | | | | not relevant to the present literature review section. |
| The neoliberal subject: Resilience, adaptation and vulnerability | London: Rowman & Littlefield International. | (Chandler & Reid, 2016) | This book raises a philosophical notion on the subjective political callings for the development of a capacity for 'resilience' as means for social security, adaptability, agency and competency. Mocking the society's status, *we*, the authors state, therefore, "must accept and adapt to the 'realities' of an endemic condition of global insecurity and to the practice of so-called sustainable development", the authors question whether the "the discourse of resilience undermine our ability to make our own decisions as to how we wish to live?". | Addressing how nudging has been introduced in politics, social resilience, and agency in making 'better choices' that align with sustainable agendas, the authors critique how nudging therefore leaves little room for society to express its independently and individually driven agency and competency in decision-making, or in other words, "making [their] own decision as to how [they] wish to live".<br><br>Publication Results:<br>As a conclusion, the authors then suggest: "in place of resilience, the book argues that we need to revalorize an idea of the human subject as capable of acting on and transforming the world, rather than being cast in a permanent condition of enslavement to it.<br><br>My Remarks:<br>This publication does not explore an intervention in which priming or nudging have been exploited in human-centred or |

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| | | | | sustainability-related interventions, and is therefore not relevant to the present literature review section. |
| Design for transformative learning: A practical approach to memory-making and perspective-shifting | Oxon: Routledge. | (Grocott, 2022) | This book addresses nudging as a supportive form to continuous learning, and “learning from and adapting to a rapidly changing world”. The book offers practical design approaches to elevate reflective, critical and globalised problem-solving skills, inviting the designers to ‘revise the stories they tell themselves, unlearn old habits and embrace new practices’. The author therefore claims that this book is “an essential read for design and social innovation researchers, facilitators of community engagement and co-design workshops, design and arts educators and professional learning designers”.<br><br>The book also questions “how the cognitive, constructed, relational, personal, experiential and imaginative nature of design might amplify our engagement in the unsettling | Publication Results:<br><br>To yield positive impact through design that align with sustainability agendas, the book discusses and recommends adopting creative design thinking, nudge design and human-centred designing as frameworks for transformative learning. |

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| | | | of long-held meaning structures and the remaking of new constellations of knowing and being". | |
| Gesundheitsverhaltenswirksame Gestaltung [Translate to English from German: Health Behavioural Design]; in Gesunde Gestaltung: Priming- und Placebo-Effekte als gesundheitsverhaltenswirksame empiriegestützte Gestaltungsmethodik [English: Healthy Design: Priming and Placebo Effects as Health-Behavior-Effective Empiricism-Based Design Methodology]. | Wiesbaden: Springer. | (Rehn, 2019) | This book section addresses how clinical patients can be encouraged to make better, 'healthier' decisions using 'health-promoting designs'. The section reviews how priming and the placebo affect can contribute to said health-promoting designs. | Publication Results: Reviewing the health-promoting designs are aimed to influence health related behaviour without triggering a change in the corresponding consciousness, the author addresses how nudges are used in such contexts, which are suggestive to lead to a long-term habitual change, that can be maintained independently to the triggering intervention for change.<br><br>My Remarks:<br>This publication does not explore an intervention in which priming or nudging have been exploited in human-centred or sustainability-related interventions, and is therefore not relevant to the present literature review section. |

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| Savings for Irrational Humans: A design meets psychology approach | Masters Thesis. Auckland University of Technology | (Harvey, 2015) | This thesis addresses the issue of irrational thinking and irrational thinkers' (in)ability to make decision assisting steady financial savings or managing money. This thesis combined practices of behaviour science (i.e., nudging and priming) with human-centred designing strategies to create a device application (app) to trigger for a long-term economic sustainability. | Publication Nudging Format:<br><br>Using an app focussing on the automatic process of thinking, and due to the "always-with-you nature" of the apps on the mobile phone, the phone would therefore allow "behavioural self-helpers such as nudges, reminders, and personal incentive" to be more readily effective (p.29).<br><br>An app, 'Digit' was suggested to be "building skills" that would "employ behavioural techniques that change 'mindsets' along the way". The nudging technique of Automation was addresses. Under "Automation: manage money well day-to-day and prepare for life ahead with automated saving", the app Digit then does the work (of saving money) for the user. The app's "algorithms calculate money available to save based on users account history, current balance and salary and upcoming bills", and then the app "proactively saves that money, by transferring an amount a user |

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| | | | | will not miss into a saving account”.<br><br>Publication Results:<br><br>In discussing the successful research findings, the author remarks that “an automated process such as this [the nudge in the app] could mean students forget money is leaving the account and it takes them by surprise”. The author then elaborates with that it is thus “important that the ‘app’ is communicative and open about what is happening to the users’ money ahead of time. The theory at this point was to make communication via text message, not through app notifications as texts is more salient and also more personal and when dealing with money it is important the message gets through”. |
| The observing self as a catalyst for behaviour change and wellbeing: Effective personal informatics | Masters Thesis. University of Cape Town. | (De Villiers, 2017) | This study addresses “how wellness-related personal informatics (PI) systems can be effectively designed to better promote lasting behaviour change and sustained wellbeing”. With the current unsupportive health care that does not | Publication Nudging Format:<br><br>“Strategies applied in design play an important role in ensuring that feedback is delivered in a style likely to promote meaningful, lasting change”. Therefore, this |

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| system design to promote behaviour change in the changing health paradigm | | | support and address “the complex challenges modern lifestyle diseases and behavioural disorders”, a new model (the System Medicine Model) has therefore emerged. The new system incorporates PI systems that acknowledges and triggers shifts towards pre-clinical, patient-centric, behavioural focus in healthcare. Moreover, it was argued that “PI systems can therefore incorporate a balance of persuasive and reflective strategies to cultivate a necessary balance of mindful attitudes which include elements of curiosity, present-centred awareness, attentiveness and recognition of patterns and correlations in a constantly changing internal and external environment” (p.50-51).<br><br>This study therefore argues that efficient design and incorporation of PI can encourage behaviour change and sustain health outcomes strategies like “persuasive | research studies 2 categories of strategies opposing in style of promoting such a lifestyle change: persuasive and mindful.<br>It was said that “both approaches are effective in encouraging change; however, each presents concerns and barriers”.<br><br>Semi-structured interviews on the different ways in which the PI systems are experienced by users were qualitatively analysed. This was to feed the PI design process, and influence behaviour change tactics, to “support more lasting shifts and sustainable states of wellbeing”. Additionally, an online survey was distributed to establish a PI tracking method (i.e., via the user’s usage of personal tracking methods and apps), and allow for the persuasion (i.e., the nudge or priming) to take place; the survey was to “gain insight into effective persuasive and reflective UX design elements”.<br><br>Publication Results: |

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| | | | and mindful experience (UX)”.<br>This research provides a prototype design of a ”PI system design that balances persuasive and mindful strategies and aims to promote lasting behaviour change and enduring states of wellbeing more effectively”; nudges were also tested as means for triggering behavioural change. | Results revealed that the use of an influence of the PI tracking activity on wellbeing was promising. It was also shown that the wording of the survey content and the introduction of the face-to-face interviews, may have primed responders into responding according to a desirable outcome. The wordings and subsequent responded were discussed to may have also influenced the users’ views on tracking activity in the period between the survey and interviews.<br><br>Overall, it was found that the persuasion specifically, the authoritarian and coercive nature of the persuasion) integrated in the PI system was shown to have a negative effect on the users: “the relationship is often strained and experienced as punitive and often unfair or inaccurate. This leads to low levels of trust and display of characteristics such as rebellion, cheating and undermining behaviours. Focus is on external validation through incentives |

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| | | | | such as physical rewards, competitive measures and numerical goals while little attention is paid to the connection with personal wellbeing and effects of resulting activities on wellness and how to improve. Self-reflection and intrinsic motivation is therefore seen to be low. As such, the system experience can be interpreted as dictatorial, policing and partial, adding volatility and complexity to the pursuit for sustained wellbeing" (p.72). |
| Curtailing smartphone use: a field experiment evaluating two interventions | Taylor & Francis: Behaviour & Information Technology | (Ochs & Sauer, 2022) | This study addresses problematic smartphone usage (PSU). Nudging was tested to overcome this issue. 97 students took part in this study. | Publication Nudging Format:<br><br>Two methods were tested to overcome such issues: (1) moving problematic applications to a different page of the phone; and (2) changing the phone into greyscale.<br><br>Publication Results:<br><br>It was found that the nudging significantly reduced their 'objective smartphone usage', but subjects' self-reported PSU has increased. This was discussed to be possibly due |

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| | | | | to the subjects heightened awareness of the usage of the phone.<br><br>My Remarks:<br>Although this publication specifically addresses nudging to prompt a decrease in smartphone usage, it does not necessarily do so in contexts of human-centred designing or sustainability-related interventions. This publication is therefore irrelevant to the present literature review section. |

*Table 97 - Reviewing how others conducted interventions with the use of cues (whether referred to as primes, or not) in contexts of engineering, characterising sustainably-considerate or human-centred designing practices.*

| **Publication Title** | **Publisher** | **Publication Citation** | **Publication Synopsis** | **Publication Methodology and Results (with my occasional remarks)** |
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| Cognitive differences among first-year and senior engineering students when generating design solutions with and without additional dimensions of sustainability | Cambridge University Press | (Hi, Shealy, & Milovanovic, 2021) | Designs were produced by first- and senior year engineering students. Half of the designs were informed with sustainability-related concepts or ‘dimensions’ as forms of prompts. Students’ designs and neurocognitive activation were recorded. | Publication Results:<br><br>It was found that first-year students generated significantly more solutions compared to the senior year students – without the additional sustainability requirements. First-year students were shown to have had higher activation in the cortical region of the brain, which is associated with cognitive flexibility, and divergent and convergent thinking.<br>Senior year students were shown to have higher activation in the region mostly associated with uncertainty processing and self-reflection.<br>When additional sustainability dimensions were requested, first-year students then produced fewer solutions, whereas senior students produced a similar number of solutions as before. This was thought to be associated with the senior students’ “less cortical activation to generate a similar number of solutions”.<br>These changing patterns of cortical activation determines |

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| | | | | how engineering students grasp and manage information during the design process. From these findings, the authors suggest that "this paper offers potential opportunities for interventions to help improve sustainable design outcomes. For example, future research could explore whether priming the recruitment of activation in the dlPFC [i.e., the dorsolateral prefrontal cortex] or through transcranial direct current stimulation (tDCS) to the dlPFC, can improve senior engineering students' ability to generate more novel design solutions".<br><br>The authors then suggest that "future studies can begin to test the effectiveness of novel design methods and tools, for example, concept mapping or priming, to overcome fixation and enhance engineering students' ability to develop engineering design solutions".<br><br>My Remarks:<br><br>These findings are interesting as they address a notion that requires further research: analysis of cognitive responding to sustainability and sustainability-related designing. |

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| Priming Designers Leads to Prime Designs | Cham: Springer | (She, Seepersad, Holtta-Otto, & MacDonald, 2018) | This chapter addresses two design methods that "actively prime designers to exhibit or accentuate certain skills during the conceptual design process". This study tests two forms of priming to "help designers generate design features that communicate sustainability to customers". The authors use the five human senses (i.e., sight, sound, touch, smell, and taste) in combination to the sustainability concepts for priming. 2 studies were tested in this chapter/paper – one with the use of implicit (i.e., low-immersion) priming, and the other using an explicit (i.e., high-immersion) form of the priming.<br><br>The first was to test the feasibility of priming to influence | Publication Methodology:<br><br>"Both low-immersion and high-immersion priming activities were hypothesized to enhance designer performance in a later conceptual design task in terms of the number of concepts generated by the designer and the extent to which the concepts' features are beneficial in communicating a product's sustainability".<br><br>Study 1; Implicit Priming: "Designers were primed implicitly with the mindset of sensory perceptions and sustainability by answering two simple questions or finishing a collage activity". This was the low-immersion priming activity.<br><br>Subjects were primed via their responding to a questionnaire in which subjects were asked to give answers to describe: (1) "three examples of things that they have done to reduce their environmental impact" and (2) "the sponge or cloth they use at home [i.e., the focal design] to clean dishes using some or all of the five senses [i.e., sight, sound, touch, taste, and smell]".<br><br>Study 2; Explicit Priming: |

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| | | | the generation of more concepts and solve problems more efficiently, whilst the second was to induce sustainability semantics in the designer, and enhance the communication on products' sustainability with the user ; as it was stated that "both low-immersion and high-immersion priming activities were hypothesized to enhance designer performance in a later conceptual design task in terms of the number of concepts generated by the designer and the extent to which the concepts' features are beneficial in communicating a product's sustainability". | The priming in this study was intended to "help designers generate more unique, user-centered concepts".<br><br>In the second study, subjects were primed by their working on a collage activity. This activity was designed to develop "sustainable product semantics" and establish "a set of design recommendations for sustainable designers with collage activities".<br>Subjects were requested to position images of sponges [i.e., the focal product] and sensory words on a "white background with two axes: one tracked preference, from "dislike" to "like", and the other tracked environmental impact, from "high impact" to "low impact"".<br>There were eight images in total to be arranged, and 28 sensory descriptors like "dim, smooth, soft, musty, disgusting" (etc.) to be matched with. This, the authors stated, would subsequently influence the design produced by the designers as "when subjects are working on a collage activity, not only specific cognitive orientations but also relevant cognitive procedures become activated. Effects on subsequent design tasks may then |

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| | | | | be driven by both the orientations and procedures".<br><br>Publication Results:<br>Study 1:<br>Findings of study 1 showed results aiding designers in generate more ideas and concepts; however, it did not show "significant effect on the quantity of concepts generated in total". The high-immersion prime (i.e., Study 2) was found to have led subjects to better "communication of sustainability through the design". Subjects in Study 2 were found to "generate design concepts with higher levels of originality and more innovative features targeting product-user interactions, without loss in feasibility". High-immersive priming was also found and were found to aid in generating more concepts in general, compared to the low-immersive priming.<br><br>Building upon these findings, the authors conclude that both forms of priming are "promising techniques that can be used to enhance design skills".<br><br>My Remarks:<br>It is interesting to observe that such a priming methodology |

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| | | | | influences the quality and not necessarily the quantity of creative ideas generated. This therefore calls for further research, to specifically address this in contexts of the 'rapidly-changing' world and the updated (more creativity-requiring) demands of engineers. |
| Mind the Face | Proceedings of the 2007 International Conference on Designing Pleasurable Products and Interfaces. Helsinki, Finland. | (Sleeswijk Visser & Strappers, 2007) | This paper examines the use of visual representations of a person's face in designing processes, as "images of real people trigger designers to empathise with users".<br>The authors argue that the representation of the user is vital, however, the way in which the users are represented is tricky – and is therefore a "a design problem in itself". They found that "images of the users have impact on the way designers interpret the result and are inspired by them". | Publication Methodology:<br><br>Different studies exposed designers and designer students to images of the users in different formats, quantities and sizes. The images were placed on cards for designers to read when building user need information to inform the designs with.<br><br>Publication Results:<br><br>The authors find that, indeed, "images of users are a powerful means to represent results of user studies to design teams". One study showed that the combination of a photo and user's name was most informative to the designers, when presented with cards of the users . Additionally, when sketches of users as opposed to photos of fictional characters were exposed on cards to the designer, it was found that |

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| | | | | the fictive photos were more effective than sketches, indicating an empathic enhancement in the designers. Similarly, a combination of sketches and photos gave the designers a ‘feeling of satisfaction’ due to the “richness of the presented materials”; however, sketches alone were found unsatisfactory as they lack detail, and were less convincing, and therefore result in “a lesser emphasis on real people”. Moreover, designers preferred additional information to accompany the images, and the combination of sketches and photos (i.e., ‘abstract representations’) helped designers to “quickly step into the shoes of the user”.<br>Lastly, the size of the visual representation played a role, as it was found that a size smaller than a ‘letter size’ would be most preferred by designers exposed to visual representations of the end-user; and so were the quantities of the images – it was found that showing designers multiple but smaller images were more preferred than presenting them with one but bigger image of the user(s). |

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| Enhancing the Teaching of Research Ethics Through Emotional Priming with Encounters with Patients and Reflection | ASEE Virtual Conference | (Earle, Nishimura, Smith, & Small, 2021) | This study examines the influence of emotional priming and meeting with cancer patients (i.e., those who are impacted by biomedical engineers' or engineering students' designs and research) on the enhancement and the receptivity of biomedical engineers' ethics and ethics education. This study hypothesises that "having a personal and emotional interaction with people impacted by research decision would impact interest in ethics or influence decision making toward more ethical or inclusive behaviours". Another strand of the study examines "whether the timing of the emotional intervention in relation to the ethical education would impact the student | Publication Methodology:<br><br>The control group attended a research ethics seminar then met with cancer patients (i.e., those influenced by the research or the design of biomedical engineers/engineering students), whilst the "treatment group" were "primed with the emotional experience [i.e., meeting and engaging with the cancer patients] then received the research ethics seminar".<br><br>In Phase I, all students received "formalized instructions on research ethics in a didactic seminar", but the "treatment group" (i.e., the primed group) were set to meet the patients before the research ethics seminar. Students were given the choice to meet with the patients.<br><br>In Phase II, all students were obliged to meet with the patients, but half of them were set to meet with the patients before the seminar (i.e., emotionally primed before the seminar), whilst the other half met with the patients after the seminar. |

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| | | | outcomes". Students' reflections on a time when students "may have acted unethically", and survey data on ethical tendencies and moral expansiveness were analysed in relation to the interventions. | Publication Results:<br><br>In phase I of the study (where students were given the choice to meet with the cancer patients), it was found the there were no "statistically significant changes in situational ethics response, moral disengagement, perspective taking, or moral expansiveness". Students' ethical leanings remained the same despite the interventions. The authors suggested that "it is possible that the brevity of these interventions was insufficient to lead to a significant change in response to the [bioethics] survey questions". Moreover, it was interesting to observe that "the group that self-selected to see the cancer patients scored statistically lower on the situational ethics and moral disengagement elements of the survey instrument". Primed students, however, were found to have engaged in "deeper reflective practices".<br><br>In Phase II, it was found that the students who met with the patients before the seminar (i.e., the primed) compared to those who engaged with the patients after the seminar, showed "no |

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| | | | | change in the ability of our students to clearly describe and analyze an example of ethical/unethical behavior from their own lives".<br><br>Overall, it was found that those primed with the engagement with the patients before the seminar were found "nearly twice as likely to mention the downstream consequences of their actions, an emotional response to the actions they took, or to take responsibility for their actions" . These results, the authors suggest, imply that those who chose to engage with the patients (i.e., primed) possibly encouraged "deeper self-reflection and possible deeper integration of the ethics instruction". |
| Fostering Entrepreneurship in Project-based Software Engineering Courses | ASEE Conferences | (Buffardi & Rahn, 2020) | This paper reviews an adopted 'Tech Startup" intended to cultivate entrepreneurship and intrapreneurship in software engineering education. This was to encourage collaboration on novel software ideas (between engineering and entrepreneurship students), and | Publication Methodology:<br><br>Students were primed by exposing them to a ten-minute presentation on innovative technologies – specifically, VR (virtual reality), AR (augmented reality) and Iot (internet of things). The hypothesis was: "after priming students with a presentation on emergent technologies, software engineers would be more likely to propose entrepreneurial project ideas". |

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| | | | leveraging of entrepreneurship students to provide feedback, and change requirements whilst learning *Lean Startup methods*, and understanding students' motivation for generating innovative, entrepreneurial ideas in software engineering.<br>The study hypothesized (H1): "after priming students with a presentation on emergent technologies, software engineers would be more likely to propose entrepreneurial project ideas". | Publication Results:<br>After priming students with a presentation on emergent technologies,<br>it was found that "only 3% of software engineering students took the initiative to propose their creative ideas among their peers and business students". However, when compared to entrepreneurship students, it was found that "software engineers' pitches increased more than sevenfold in semesters when the emergent technology intervention was applied" - therefore supporting the study's first hypothesis (H1).<br>Additionally, it was found that "engineering students identified that a desire to learn a new programming language, framework, or technology was the most common motivation for project selection. Students also reported motivation from how interesting they find the problem and whether they would personally use it".<br>My Remarks:<br>The latter finding is interesting, as it highlights the agentic nature of motivation in engineering students and/or innovation. |

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| Measuring Students' Interdisciplinary Competence and Entrepreneurial Mindset based upon Exposure to a Holocaust Narrative | ASEE Conferences | (Ritz, Bodnar, & Montalbo-Lomboy, 2022) | This study researches the association between narrative-based interdisciplinary case study and engineering students' entrepreneurial mindset. | Publication Methodology:<br><br>Engineering students were exposed to "narratives that included testimony, biography, photos, and data related to the Holocaust in a story-like format", and were engaged with the narrative through "reflections, discussions, and other activities used to promote students' curiosity and critical thinking".<br><br>Publication Results:<br>Amongst this study's findings was that "the interdisciplinary narrative case study increased students' perception of their altruism, ideation skills, interdisciplinary skills, and recognizing disciplinary perspectives to the point of statistical significance". Exposure to such narrative therefore is concluded to enhance social consciousness and consideration in engineering education settings.<br><br>My Remarks:<br><br>Although this study does not explicitly prime engineering students, it does use imagery in a process to influence students' consciousness (i.e., extension of empathy (Thompson, 2001)) |

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| | | | | which makes it relevant to the present PhD project. |
| STS Postures: Changing How Undergraduate Engineering Students Move Through the World | ASEE Conferences | (Tomblin & Mogul, 2022) | This paper developed a new framework for students to encounter intellectual problems with emotions. This was done by conducting a so-called *techno-ableism* intervention. | Publication Methodology:<br><br>In this techno-ableism intervention, engineering students were instructed to wear bracelets for 24 hours to remind them to "imagine they are hosting a friend from high school that day, and the friend is using a knee scooter to get around because of a sports injury". This was essentially to trigger empathy towards that imaginary individual, and acknowledgement of how surrounding areas might be problematic for that person. Acknowledging that students and professors "need continual practice to embody any habit or skill", this method was argued to be the "most successful".<br><br>Publication Results:<br><br>The techno-ableism module, the authors discuss, "has helped reveal to [them] challenges around teaching students not simply how to have empathy, but to practice cultivating situations in which they will gain empathy". Arguing that "empathy itself is not the destination", the authors |

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| | | | | reiterate on them wanting students "to be able to design their own experiments to change perspective and cultivate empathy".<br><br>My Remarks:<br>Although this study does not explicitly prime students to express empathy, it does employ a mechanism that acts as inducers and 'reminders of empathy'; this therefore makes it loosely relevant to the present project, as the priming pictures are argued to also induce empathy and act as reminders of the students' social impact via design (and subsequent responsibility). |
| The Theatre of Humanitarian Engineering | ASEE Conferences | (DiBiasio, et al., 2017) | This study implements role-playing in an interdisciplinary design course choreographed by faculty from engineering and humanities departments. The course attempted to target and engage students' empathy when designing a waste management solution for residents in the 19th century. | Publication Methodology:<br><br>In the study, all student teams were informed on the case to be designed for, with the same information, photo, and brief scenario when considering a solution. Students were then instructed to "determine what they could about the conditions of this family [the family they are designing for] in order to recommend interventions that would improve their lives". Roleplaying was also part of this intervention, as this was a method for students to immerse |

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| | | | In characterizing empathy, this paper states that "by digging deeply into their roles and thinking of the course content through the persistent lens of their character role, students learn what it means to identify with another person, even a person at some considerable historical remove. But they must identify not only with their own roles; to do well in this game they must also learn to listen well". | themselves in the case study (or scenario) they are solving for.<br><br>The intervention was purposely left open-ended to encourage students' creativity. It could also be deduced by the exposure of students to photos and information, this was also an attempt to induce a 'deeper understanding', which in essence relates to empathy.<br><br>Publication Results:<br>As a result of the role playing game, the findings revealed "a strong grounding in collaboration for all teams and individuals; strong evidence of empathy among some (but not all) teams and individuals; and varying degrees of learning that integrates the humanities and engineering". The findings indicated that the role playing game yielded an induction of empathy and interpersonal skills in (some) engineering students.<br><br>My Remarks:<br><br>Although this study does not explicitly specify the use of the photo as a prime, it does use imagery (and other documents) with the intention to induce |

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| | | | | empathy and deeper understanding. This makes it worthy of note in this project, as it loosely ties with the motivation or intention of using photos to induce empathy, and other characteristics that relate to human-centred designing or design thinking. |
| Design: Cultural Probes | Interactions | (Gaver, Dunne, & Pacenti, 1999) | This paper addresses the use of Cultural Probes in the process of context mapping (i.e., addressing the context to be designed for) as a method to work with the users – i.e., codesign with those to be influence by the design (which happen to be elderly people in diverse communities).<br><br>Cultural probes, in this study, were information packages that included postcards, maps, camera, photo album and media diary, which were set up to be prepared by user-end, and used by the | Publication Methodology:<br><br>Probe boxes were given to volunteering members of the elder groups in a series of meetings, and were requested to be filled and returned later to the designers.<br><br>Publication Results:<br><br>The authors (designers) stated that "the probes were not designed to be analyzed, nor did we summarize what they revealed about the sites as an explicit stage in the process. Rather, the design proposals we produced reflected what we learned from the materials".<br><br>The designers therefore emphasizes that although the probes were vital to their understandings of the sites, they "didn't directly lead to our [their] designs"; indicating that the |

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| | | | designers to inform their design.<br><br>The probes were "designed to provoke inspirational responses from elderly people in diverse communities", and were to "pursue experimental design in a responsive way".<br><br>The probes were to "address a common dilemma in developing projects for unfamiliar groups". The authors explain that "understanding the local cultures was necessary so that our designs wouldn't seem irrelevant or arrogant, but we didn't want the groups to constrain our designs unduly by focusing on needs or desires they already understood. We wanted to lead a discussion with the groups toward | designs were also informed with other information anecdotal data. The authors further elaborate that the probes were successful in informing and familiarizing the designers with the sites, allowing them to base their design in the "detailed textures of the local cultures".<br><br>As a conclusion, the authors (designers) address that "the real strength of the method was that we had designed and produced the materials specifically for this project, for those people, and for their environments".<br><br>My Remarks:<br><br>Although this methodology is different to the one in the present PhD project, this popular study was mentioned here as personal pictures (in the form probes) were used to inform the designs with; and although the probes were not explicitly addressed in the sense of inducing empathy in the designers (to further understand the contexts they are designing for), they can be argued to be used as such. This use of probes was also argued to be "a type of empathic design" by Steen (2011). See also Mattelmaki |

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| | | | unexpected ideas, but we didn't want to dominate it". | (2006) on the use of probes to induce empathy in designers and "enrich designs".<br><br>Moreover, the work of Sleeswijk Visser (2009) tests and addresses the use of probes as a method to prepare and help designers to gain 'rich' (i.e., multilayered, complex and emotionally informed) information on the users' needs (through personification, imagination, immersion, curiosity and connection, for example) – this clearly addresses the characterising of empathy in such a design process. In similar contexts, Mattelmaki (2006) shows that the way in which the probes have been designed (i.e., what documents have been requested from the volunteering users/to be returned to the designers), and have been communicated (requested from or addressed to the volunteering users) has the potential to boost sensitivity for the users,<br>and eradicate possible biases that may inform the design. Therefore, it can be deduced that such a framework also characterizes empathy in such design frameworks.<br>Such use of probes is supportive of codesigning and more socially |

| | | | | |
|---|---|---|---|---|
| | | | | considerate designing frameworks. |

## Appendix B – Insignificant Results, and Examples of Communal Designs Produced

Intervention Variation 1 Examples of Communal Designs Produced

*Table 98 - Extracts of Communal Designs Produced by Civil Engineering Undergraduates, May 2019 – Intervention Variation 1*

| Group Number | Priming Status | Extractions from Communal Designs Produced |
|---|---|---|
| Group 2 | Primed (P3) | *"Construction of tower block housing…will provide a social improvement, with a sense of community in the blocks, with economic improvements due to good living conditions, less illness, social improvements".* |
| Group 7 | Middle (P2) | [construct/provide] "*Community Youth Centre to provide free education and support social problems".* |
| Group 4 | Middle (P2) | [construct/provide] *"School in area (New)...● Occupies youth and educated them, so should help with youth violence, ● Could host social events, …● Needs welfare facilities for kids – could be public use."* |
| Group 3 | Middle (P2) | *"1. Security: Setting up local police station; ● Protection: Social-security, safer living space, ...● Protect peoples' right, …*<br>*4. Education: Setting up more educational institutes; … ● Cultural Diversity (Different languages from different place)…*<br>*5. Setting up more recreational places (playground, parks, theatres); ● Work-life balance, ● Provide places for relaxation and social interaction, ● Promote sense of belongings."* |
| Group 20/21 | Non-Primed (P1) | *"Social and leisure places allow[~~s~~] locals to have a sense of fun and enjoying life which can result in producing and enhancing creativity and harmony".* |
| Group 18 | Non-Primed (P1) | [construct/provide] "*Renewable Energies; The use of solar panels and other renewable sources of energy would help to provide power for various facilities including the school and hospitals. In addition increased power supply for residents could be used for social/community engagement projects".* |
| Group 16 | Non-Primed (P1) | [construct/provide] "*Commercial and Residential high rise Buildings; …Shared office place can be included in the building which provide a better work atmosphere and improve social communication between different companies…Gyms and other social facilities can be included so people can have a place to improve their physical and mental health as well."* |

| | | |
|---|---|---|
| Group 14 | Non-Primed (P1) | *"…Job Shortages is the main cause of community division…Our solution to improving Shatila is by upgrading the electricity supply. Firstly, in terms of society a better street system allows for a safer environment through reducing the number of overhead wires as well as providing street lights during the nights. Electricity will improve the lives of residents at home as well as in terms of the economy…with grocery stores being the main source of income, refrigeration as well as the ability to use cleaning equipment will improve the ability to make money…[provide] opportunity for pubs, bars, hotels and restaurants to attract tourists…In terms of education, electricity can improve facilities and give access [to] internet facilities... opportunity to improve lighting, sewerage, and water systems… All the above improve basic human needs such as protection in terms of 'having' and 'interacting'; creation in terms of 'having' and 'doing', and freedom in terms of 'interacting'."* |

Intervention Variation 2 Insignificant Results

*Table 99 - Association of Communal Design Production, Empathy: Empathic Concern, and Higher Order Value Categories*

| | Openness to Change | Self Transcendence | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Empathic Concern* Scores | 5 | 7 | 12 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Empathic Concern* Scores | 6 | 3 | 9 |
| Column Totals | 11 | 10 | Grand Total = 21 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Values and the production of Communal Designs whilst having higher- or lower-than-average *Empathy: Empathic Concern* scores. The relation between these variables was found not significant, $X^2$ (1, N = 21) = 1.289, p = .256. See **Table 99** for more information.

*Table 100 - Association of Communal Design Production, Empathy: Fantasy, and Higher Order Value Categories*

| | Openness to Change | Self Transcendence | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Fantasy* Scores | 5 | 3 | 8 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Fantasy* Scores | 6 | 7 | 13 |
| Column Totals | 11 | 10 | Grand Total = 21 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Values and the production of Communal Designs whilst having higher- or lower-than-average *Empathy: Fantasy* scores. The relation between these variables was found not significant, $X^2$ (1, N = 21) = 0.531, p = .466. See **Table 100** for more information**.**

*Table 101 - Association of Communal Design Production, Empathy: Personal Distress, and Higher Order Value Categories*

| | Openness to Change | Self Transcendence | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Personal Distress* Scores | 3 | 6 | 9 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Personal Distress* Scores | 8 | 4 | 12 |
| Column Totals | 11 | 10 | Grand Total = 21 |

A Pearson chi-square test of independence was performed to examine the relation between Higher Order Values and the production of Communal Designs whilst having higher- or lower-than-average *Empathy: Personal Distress* scores. The relation between these variables was found not significant, $X^2$ (1, N = 21) = 2.291, p = .130. See **Table 101** for more information**.**

*Table 102 - Association of Communal Design Production, Empathy, and Priming – Intervention Variation 2*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy* Scores | 10 | 9 | 19 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy* Scores | 7 | 8 | 15 |
| Column Totals | 17 | 17 | Grand Total = 34 |

A Pearson chi-square test of independence was performed to examine the relationship between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy* scores. The relation between these variables was found not significant, $X^2$ (1, $N$ = 34) = 0.119, p = .730. See **Table 102** for more information**.**

*Table 103 - Association of Communal Design Production, Empathy: Empathic Concern, and Priming – Intervention Variation 2*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Empathic Concern* Scores | 8 | 12 | 20 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Empathic Concern* Scores | 9 | 5 | 14 |
| Column Totals | 17 | 17 | Grand Total = 34 |

A Pearson chi-square test of independence was performed to examine the relationship between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Empathic Concern* scores. The relation between these variables was found not significant, $X^2$ (1, $N$ = 34) = 1.943, p = .163. See **Table 103** for more information**.**

*Table 104 - Association of Communal Design Production, Empathy: Fantasy, and Priming – Intervention Variation 2*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Fantasy* Scores | 7 | 8 | 15 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Fantasy* Scores | 10 | 9 | 19 |
| Column Totals | 17 | 17 | Grand Total = 34 |

A Pearson chi-square test of independence was performed to examine the relationship between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Fantasy* scores. The relation between these variables was found not significant, $X^2$ (1, $N$ = 34) = 0.119, p = .730. See **Table 104** for more information**.**

*Table 105 - Association of Communal Design Production, Empathy: Perspective Taking, and Priming – Intervention Variation 2*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Perspective Taking Scores* | 10 | 9 | 19 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Perspective Taking Scores* | 7 | 8 | 15 |
| Column Totals | 17 | 17 | Grand Total = 34 |

A Pearson chi-square test of independence was performed to examine the relationship between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Perspective Taking* scores. The relation between these variables was found not significant, $X^2$ (1, $N$ = 34) = 0.119, p = .730. See **Table 105** for more information**.**

*Table 106 - Association of Communal Design Production, Empathy: Personal Distress, and Priming – Intervention Variation 2*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Personal Distress* Scores | 8 | 8 | 16 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Personal Distress* Scores | 9 | 9 | 18 |
| Column Totals | 17 | 17 | Grand Total = 34 |

A Pearson chi-square test of independence was performed to examine the relationship between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Personal Distress* scores. The relation between these variables was found not significant, $X^2$ (1, $N$ = 34) = 0, p = 1. See **Table 106** for more information**.**

*Table 107 - Association of Communal Design Production, Self Consciousness, and Priming – Intervention Variation 2*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Self Consciousness* Scores | 11 | 9 | 20 |
| No. of Communal Designs Produced – whilst having lower-than-average *Self Consciousness* Scores | 6 | 8 | 14 |
| Column Totals | 17 | 17 | Grand Total = 34 |

A Pearson chi-square test of independence was performed to examine the relationship between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Self Consciousness* scores. The relation between these variables was found not significant, $X^2$ (1, $N$ = 34) = 0.486, p = .486. See **Table 107** for more information**.**

*Table 108 - Association of Communal Design Production, Social Consciousness, and Priming – Intervention Variation 2*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Social Consciousness* Scores | 8 | 7 | 15 |
| No. of Communal Designs Produced – whilst having lower-than-average *Social Consciousness* Scores | 9 | 10 | 19 |
| Column Totals | 17 | 17 | Grand Total = 34 |

A Pearson chi-square test of independence was performed to examine the relationship between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Social Consciousness* scores. The relation between these variables was found not significant, $X^2$ (1, $N$ = 34) = 0.119, p = .730. See **Table 108** for more information**.**

*Table 109 - Association of Communal Design Production, Social Desirability, and Priming – Intervention Variation 2*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Social Desirability* Scores | 8 | 6 | 14 |
| No. of Communal Designs Produced – whilst having lower-than-average *Social Desirability* Scores | 9 | 11 | 20 |
| Column Totals | 17 | 17 | Grand Total = 34 |

A Pearson chi-square test of independence was performed to examine the relationship between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Social Desirability* scores. The relation between these variables was found not significant, $X^2$ (1, $N$ = 34) = 0.486, p = .486. See **Table 109** for more information**.**

Intervention Variation 2 Examples of Communal Designs Produced

*Table 110* **-** *Extracts of Communal Designs Produced by Civil Engineering Undergraduates, May 2020 – Intervention Variation 2*

| **Student Pseudonymised Ref No.** | **Ethnicity/ Nationality** | **Gender** | **Priming Status** | **Identified Higher Order Value Category** | ***Snippets from Communal Design Provided*** |
|---|---|---|---|---|---|
| 6 | British | Female | Non-Primed (Control) | Openness to Change | *"To begin with, residents and engineers can work to develop public spaces, such as schools, shops, temples and outdoor spaces, allowing for growth within the community. This method is both sustainable and economically viable…"* |
| 72 | Malaysian | Male | Primed | Conservation | *"Organize social recreational area to improve both social spacing and living environment of the area…"* |
| 109 | British | Male | Primed | Self Transcendent | *"Communal areas such as parks could be built to increase the communal spirit.."* |
| 93 | British | Male | Non-Primed | Openness to Change | *"I propose that a library should be built close to the centre of Shatila so that it can be used as a social area for learning and used to expand the spaces for class teaching in the week…This addition will add to the Max-Neef number 8 by providing a social environment for people to meet. It also acts as a place of togetherness and can provide the community to learn skills in which they can be employed by..."* |
| 51 | French | Male | Non-Primed | N/A (did not complete a PVQ-RR) | *"I propose a community centre which provides aid and care for women within the camp who feel vulnerable* |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | *or isolated…The community centre I am proposing will offer a sanctuary for women, allowing isolated and vulnerable women to feel part of a community in a safe space. The building will provide room for social activities to enable friendships to form but will also include wash facilities and baby changing stations to provide privacy and encourage the idea of selfcare and self-worth”* |
| 11 | British | Male | Non-Primed | Openness to Change | *“…have youth clubs for socialising and making friends.... sustainable industry within the area would significantly improve the quality of life for people, as they would not have as much financial difficulty and therefore, would have a positive impact on many aspects. For example, their mental health and wellbeing...Another thing I have tried to improve on is the sense of community and encouragement to help each other wherever possible. To do this I would improve social spaces and leisure activities, like making parks, paths for socialising. This would then make them feel safer and secure in their own neighboured with less to worry about. A public transport bus network would also be a good way for people to travel around and interact with other communities, as right now, they are clearly quite divided, this would involve improving the roads within the area...Rebuilding* |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | *demolished churches and temples would be a great way of injecting life and hope back into the community because as we can see from statistics, most people have lost all faith in the government."* |
| 30 | British | Male | Non-Primed | N/A (did not complete a PVQ-RR) | *"…increase the ability to incorporate green space into the society. This would address the 2nd Basic human need 'freedom-spacial plasticity' this would directly improve the life of the children of the community as they would have places to socialize outside and not have to be stuck inside…"* |
| 33 | British | Male | Primed | Openness to Change | *"…need to increase the amount of recreational services available to their inhabitants. While this isn't necessary, it will likely increase the happiness of the camp. This can also be done by investigating in things such as restaurants and bars, nightlife atc which will provide a sense of freedom and fun for the Shatila population.... However, this is a secondary need to the previous needs, so should only be done after the previous improvements are met…"* |
| 39 | British | Male | Non-Primed | Self Transcendent | *"…public services like Health, Education, Social safety-net and Disability programmes are more needed. Although on the Highstreet they do need social services therefore they will be having a market and some cafes as well as bus services which can take them to factories/ other workplaces… need to be a greater* |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | *police presence…creates a better sense of community and Feel like they belong there more. As making people feel like they belong there will create a happier society because they want to be there. The solution also addresses missing needs such as subsistence, protection, affection understanding, precipitation and creation sections in the matrix of human needs.. It also helps with needs like affection because it gives space for intimacy, togetherness. This Highstreet will also give understanding and participation needs like educational purposes , communication purposes....the bus stops will allow for easier transport out of the camp to the local factories which will better the income for residents which also gives them hope for moving out of Shatila to find a better life because they can earn a higher income… giving them opportunities to earn more money also giving them a better social life bettering the quality of life…"* |
| 90 | British | Male | Primed | Openness to Change | *"I propose that a library shoould be built close to the centre of Shatila so that it can be used as a social are for learning and used to expand the spaces for class teaching in the week….This addition will add to the Max-Neef number 8 by providing a social environment for people to meet. It also acts as a place of togetherness and can provide the community to* |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | *learn skills in ehich they can be employed by..... Another way to improve the are is by adding commercial areas in the centre to increase the number of social spaces and areas of work.”* |
| 97 | British | Male | Non-Primed | Conservation | *“For example, opening markets, implementing 2-way cash flows, starting community-based businesses and promoting camp design that facilitates movement between communities… The construction of these superblocks can provide labour jobs for the people. The pedestrianized streets would be able to facilitate shops and other commercial businesses. This would further increase the number of jobs and the strength of the local economy... The project would link the refugee camp to other cities and increase the likelihood of integration; this will give people a sense of belonging and will improve their mental health…”* |

Intervention Variation 3 Insignificant Results

*Table 111 - Association of Communal Design Production, Empathy, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy* Scores | 15 | 21 | 36 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy* Scores | 15 | 14 | 29 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.654, p = .419. See **Table 111** for more information.

*Table 112 - Association of Communal Design Production, Empathy: Empathic Concern, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Empathic Concern* Scores | 11 | 18 | 29 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Empathic Concern* Scores | 19 | 17 | 36 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Empathic Concern* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 1.425, p = .233. See **Table 112** for more information.

*Table 113 - Association of Communal Design Production, Empathy: Fantasy, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Fantasy* Scores | 15 | 20 | 35 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Fantasy* Scores | 15 | 15 | 30 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Fantasy* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.332, p = .565. See **Table 113** for more information.

*Table 114 - Association of Communal Design Production, Empathy: Perspective Taking, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Perspective Taking* Scores | 18 | 21 | 39 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Perspective Taking* Scores | 12 | 14 | 26 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Perspective Taking* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0, p =1. See **Table 114** for more information.

*Table 115 - Association of Communal Design Production, Empathy: Personal Distress, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Empathy: Personal Distress* Scores | 17 | 19 | 36 |
| No. of Communal Designs Produced – whilst having lower-than-average *Empathy: Personal Distress* Scores | 13 | 16 | 29 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Empathy: Personal Distress* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.0371, p = .847. See **Table 115** for more information.

*Table 116 - Association of Communal Design Production, Self Consciousness, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Self Consciousness* Scores | 12 | 18 | 30 |
| No. of Communal Designs Produced – whilst having lower-than-average *Self Consciousness* Scores | 18 | 17 | 35 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Self Consciousness* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.849, p = .357. See **Table 116** for more information.

*Table 117 - Association of Communal Design Production, Social Consciousness, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Social Consciousness* Scores | 16 | 16 | 32 |
| No. of Communal Designs Produced – whilst having lower-than-average *Social Consciousness* Scores | 14 | 19 | 33 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Social Consciousness* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.375, p = .540. See **Table 117** for more information.

*Table 118 - Association of Communal Design Production, Prosocialness, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Prosocialness* Scores | 14 | 17 | 31 |
| No. of Communal Designs Produced – whilst having lower-than-average *Prosocialness* Scores | 16 | 18 | 34 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Prosocialness* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.024, p = .878. See **Table 118** for more information.

*Table 119 - Association of Communal Design Production, Prosocial Behavioral Intention, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Prosocial Behavioural Intention* Scores | 17 | 23 | 40 |
| No. of Communal Designs Produced – whilst having lower-than-average *Prosocial Behavioural Intention* Scores | 13 | 12 | 25 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Prosocial Behavioral Intention* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.559, p = .455. See **Table** 119 for more information.

*Table 120 - Association of Communal Design Production, Social Desirability, and Priming – Intervention Variation 3*

| | Primed | Non-Primed (Control) | Row Totals |
|---|---|---|---|
| No. of Communal Designs Produced – whilst having higher-than-average *Social Desirability* Scores | 17 | 16 | 33 |
| No. of Communal Designs Produced – whilst having lower-than-average *Social Desirability* Scores | 13 | 19 | 32 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between the priming and the production of Communal Designs whilst having higher-than-average or lower-than-average *Social Desirability* scores. The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.775, p = .379. See **Table 120** for more information.

*Table 121 - Association of Self Oriented Perfectionism Categories and Social Desirability in civil engineering undergraduates.*

| | High Social Desirability | Low Social Desirability | Row Totals |
|---|---|---|---|
| No. of students with Self Oriented Perfectionism higher than the 67th percentile. | 38 | 28 | 66 |
| No. of students with Self Oriented Perfectionism lower than the 67th percentile. | 61 | 52 | 113 |
| Column Totals | 99 | 80 | Grand Total = 179 |

A Pearson chi-square test of independence was performed to examine the relation between Self Oriented Perfectionism and Social Desirability in civil engineering undergraduates. The relationship between these variables was found not significant, $X^2$ (1, N = 179) = 0.218, p = .641. See **Table 121** for more information.

*Table 122 - Association of Other-Oriented Perfectionism Categories and Social Desirability in civil engineering undergraduates.*

| | High Social Desirability | Low Social Desirability | Row Totals |
|---|---|---|---|
| No. of students with Other-Oriented Perfectionism higher than the 67th percentile. | 35 | 33 | 68 |
| No. of students with Other-Oriented Perfectionism lower than the 67th percentile. | 64 | 47 | 111 |
| Column Totals | 99 | 80 | Grand Total = 179 |

A Pearson chi-square test of independence was performed to examine the relation between Other-Oriented Perfectionism and Social Desirability in civil engineering undergraduates. The relationship between these variables was found not significant, $X^2$ (1, N = 179) = 0.653, p = .419. See **Table 122** for more information.

*Table 123 - Association of Communal Design Production, Priming and Self Oriented Perfectionism*

| | No. of Communal Designs Produced – whilst being *Primed* (Primed Cohort) | No. of Communal Designs Produced – whilst being *Non-Primed* (Control Cohort) | Row Totals |
|---|---|---|---|
| No. of undergraduates with Self Oriented Perfectionism score higher than 67th percentile score | 9 | 9 | 18 |
| No. of undergraduates with Self Oriented Perfectionism score lower than 67th percentile score | 21 | 26 | 47 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between Self Oriented Perfectionism scores and the production of Communal Designs whilst being primed (i.e., primed cohort) or non-primed (i.e., control cohort). The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.148, p = .700. See **Table 123** for more information.

*Table 124 - Association of Communal Design Production, Priming, and Other Oriented Perfectionism*

| | No. of Communal Designs Produced – whilst being *Primed* (Primed Cohort) | No. of Communal Designs Produced – whilst being *Non-Primed* (Control Cohort) | Row Totals |
|---|---|---|---|
| No. of undergraduates with Other Oriented Perfectionism score higher than 67th percentile score | 7 | 13 | 20 |
| No. of undergraduates with Other Oriented Perfectionism score lower than 67th percentile score | 23 | 22 | 45 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between Other-Oriented Perfectionism scores and the production of Communal Designs whilst being primed (i.e., primed cohort) or non-primed (i.e., control cohort). The relation between these variables was found not significant, $X^2$ (1, N = 65) = 1.446, p = .229. See **Table 124** for more information.

*Table 125 - Association of Communal Design Production, Priming, and Socially Prescribed Perfectionism*

| | No. of Communal Designs Produced – whilst being *Primed* (Primed Cohort) | No. of Communal Designs Produced – whilst being *Non-Primed* (Control Cohort) | Row Totals |
|---|---|---|---|
| No. of undergraduates with Socially Prescribed Perfectionism score higher than 67th percentile score | 11 | 11 | 22 |
| No. of undergraduates with Socially Prescribed Perfectionism score lower than 67th percentile score | 19 | 24 | 43 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between Socially Prescribed Perfectionism scores and the production of Communal Designs whilst being primed (i.e., primed cohort) or non-primed (i.e., control cohort). The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.198, p = .656. See **Table 125** for more information.

*Table 126 - Association of Communal Design Production, Priming, and 'Total MPS' Perfectionism*

| | No. of Communal Designs Produced – whilst being *Primed* (Primed Cohort) | No. of Communal Designs Produced – whilst being *Non-Primed* (Control Cohort) | Row Totals |
|---|---|---|---|
| No. of undergraduates with 'Total MPS' Perfectionism score higher than 67th percentile score | 7 | 9 | 16 |
| No. of undergraduates with 'Total MPS' Perfectionism score lower than 67th percentile score | 23 | 26 | 49 |
| Column Totals | 30 | 35 | Grand Total = 65 |

A Pearson chi-square test of independence was performed to examine the relation between 'Total MPS' Perfectionism scores and the production of Communal Designs whilst being primed (i.e., primed cohort) or non-primed (i.e., control cohort). The relation between these variables was found not significant, $X^2$ (1, N = 65) = 0.0494, p = .824. See **Table 126** for more information.

*Table 127 - Association Socially Prescribed Perfectionism Categories and Social Desirability in civil engineering undergraduates.*

| | High Social Desirability | Low Social Desirability | Row Totals |
|---|---|---|---|
| No. of students with Socially Prescribed Perfectionism higher than the 67th percentile. | 38 | 32 | 70 |
| No. of students with Socially Prescribed Perfectionism lower than the 67th percentile. | 61 | 48 | 109 |
| Column Totals | 99 | 80 | Grand Total = 179 |

A Pearson chi-square test of independence was performed to examine the relation between Socially Prescribed Perfectionism and Social Desirability in civil engineering undergraduates. The relationship between these variables was found not significant, $X^2$ (1, N = 179) = 0.049, p = .826. See **Table 127** for more information.

*Table 128 - Association of 'Total MPS' Perfectionism Categories and Social Desirability in civil engineering undergraduates.*

| | High Social Desirability | Low Social Desirability | Row Totals |
|---|---|---|---|
| No. of students with 'Total MPS' Perfectionism higher than the 67th percentile. | 33 | 26 | 59 |
| No. of students with 'Total MPS' Perfectionism lower than the 67th percentile. | 66 | 54 | 120 |
| Column Totals | 99 | 80 | Grand Total = 179 |

A Pearson chi-square test of independence was performed to examine the relation between 'Total MPS' Perfectionism and Social Desirability in civil engineering undergraduates. The relationship between these variables was found not significant, $X^2$ (1, N = 179) = 0.0139, p = .906. See **Table 128** for more information.

Intervention Variation 3 Examples of Communal Designs Produced

*Table 129 - Extracts of Communal Designs Produced by Civil Engineering Undergraduates, May 2021 – Intervention Variation 3*

| Student Pseudonymised Ref No. | Ethnicity/ Nationality | Gender | Priming Status | Identified Perfectionism Category | Snippets from Communal Design Provided |
|---|---|---|---|---|---|
| 18 | British | Male | Primed | Non-Perfectionist | *"…open up a brand new school that could accommodate for poorer students as well as serving as a youth centre after school. With crime being prevalent and youth violence being listed as a main contributor to community divisions in Shatila the youth club would keep kids off the streets and getting involved in those types of activities… The school can also act as a safe refuge from violence if any kids get into trouble as it will be filled with people for most of the day so they can't be targeted whilst there."* |
| 26 | British | Female | Primed | Maladaptive Perfectionist | *"…when designing these buildings, where there could be rooftop gardens, promoting gardening as well as green space that can provide people with a hobby and also contribute positively to their surroundings and environment… the rooftop garden areas can feature plants as well as fruits or vegetables which are more resistant to weather change. Overall, this method would assist Shatila in giving people a better quality of life, where they are* |

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|---|---|---|---|---|---|
| | | | | | *able to reside in liveable standards, as well as have an improvement to their physical and mental health*." |
| 54 | International | Male | Non-Primed | Maladaptive Perfectionist | *"Next, the design and construction of recreational places i.e. bars, pubs and hotels. Unlike in Hamra, in Shatila, the sight of such places is of the utmost rarity. This has a major effect on the mental health and would be a good way for the residents of Shatila to engage with each other socially."* |
| 59 | Home | Male | Non-Primed | Maladaptive Perfectionist | *"A community is crucial for the people of Shantila. It will allow people to regain trust within the government as well as increasing the interactions of various people from different communities…The community centre could be the crux for the people of this area and improving the social fabric in that area. It will also create more peace and harmony which is key to stabilize that area. There should also be zoning areas for commercial and residential areas… This will promote the basic human need of living space, social environment and dwelling as per the matrix of basic human needs. I also highlighted that there weren't enough liv[e]able or cohabiting space for the residents. Therefore more usable living space needs to be created*." |
| 63 | Home | Male | Non-Primed | Adaptive Perfectionist | *"…, by creating a fit to purpose area specifically for buying and* |

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|---|---|---|---|---|---|
| | | | | | *selling such as a market, the surrounding area can improve massively due to people being able to shop in the same place for all types of goods. This reduces the time spent shopping which makes more time for family or work…, it can also become a social hub where different people can meet and interact…"* |
| 72 | Home | Male | Non-Primed | Non-Perfectionist | *"An initial idea is for a new education facility to be built… With better education more purpose and identity could be given to the children. They'd be learning more and with more knowledge they could gain ambitions to do more…Having a better educational scheme in place would cover a fair bot of the matrix of basic human needs and satisfiers. For example, it could help friendships and relationships to be created as well as providing a space of togetherness. It would also improve the coverage of the understanding category in Shalita and provide a place for children to remove themselves from the pressures and stress they may have at home."* |
| 111 | International | Male | Non-Primed | Non-Perfectionist | *"the general lack of entertainment in shatila camp is directly related to the metal heath of people living there due to the low income of each person there proper entertainment won't be accessible for the even if it* |

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|---|---|---|---|---|---|
| | | | | | *there since it would compensate on their living expenses. so restaurants can be built not necessarily a high end restaurant but just a normal restaurant which is accessible to low income, this will help provide a place for families to go to and friends to hang out in, this would improve the social setting over there and provide jobs which would bring more positivity on the mental health of people living there."* |
| 127 | Did not complete | Did not complete | Non-Primed | Did not complete an APS-R (Phase I) | *"As development and standard of living is not just a simply the physical redevelopment and construction of the area, a social consideration must also be taken to encourage the improvement in quality of life. Ideas such as free training/education for all or encouragement of women to begin a career rather than accept to be housewives are key to stimulate the local economy and thus improve the quality for life."* |
| 135 | Home | Female | Non-Primed | Adaptive Perfectionist | *"Rather than multiple individual dwellings that are built anywhere, large communal structures should be built that involve multiple, furnished apartments or different sizes to accommodate different sized families. These buildings should include communal areas, educational facilities and medical centres on site. There should also be onsite cafes and places of work.* |

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|---|---|---|---|---|---|
| | | | | | *Childcare could also be onsite. This will create a sense of community. These structures should be built by residents to give them a sense of belonging and a sense of achievement… Safe spaces to walk along without trespassing others land will be provided to allow for outdoor activities such as walking and running to improve mental health… Having youths off the streets and into education will decrease tension and violence between youths…Educational establishments could include outdoor learning spaces. not necessarily indoor rooms. These could be simple shelters with benches and desks, for youths to gather and feel values and appreciated. These shelters could be used for sexual health clinics, sexual education and for extra curricular activities such as den building, musical classes, singing etc.. The armed presences could use such shelters as bases and to communicate with youths to stop youths being intimidated."* |
| 182 | International | Male | Primed | Non-Perfectionist | *"Since the overall area in the Shatila refugee camp is on a low income providing proper entertainment facilities like shopping malls and stuff like that which costs quite a bit is not a viable option since people wont be* |

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|---|---|---|---|---|---|
| | | | | | *able to afford it, so entertainment options like a basketball field or stuff like that which doesn't require money to enjoy would be generally a better option to go for. Having pubs in the refugee camp would be a bad thing in my opinion since the general mental health in there is bad which could easily result in alcohol addiction resulting in more financial loss resulting in more depression."* |