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SEPTEMBER  
2013

# THE ICT STEERING GROUP'S REPORT TO THE WELSH GOVERNMENT

Co-Chairs: **Stuart Arthur**  
**Dr Tom Crick**  
**Janet Hayward**

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# 01

# HEADLINE RECOMMENDATIONS

- A new subject named Computing should be created to replace Information and Communications Technology (ICT) from Foundation Phase onwards. This new subject will disaggregate into two main areas: Computer Science (CS); and Information Technology (IT).
- Computing should be integrated into the curriculum as the fourth science, served by a mandatory Programme of Study, and receive the same status as the other three sciences.
- A Statutory Digital Literacy (DL) Framework should be implemented to work alongside the Literacy and Numeracy Framework from Foundation Phase through to post-16 education.
- Perceptions of Computing education pathways should be changed to recognise the key societal roles of computing and technology, as well as promote the importance and diversity of IT careers.
- The revised Computing curriculum should encourage creativity, allow thematic working and develop real world problem-solving. It should be flexible enough to continually evolve to remain current, adopting an Agile ideology and approach to ensure this.
- A range of engaging and academically rigorous pathways and bilingual qualifications for Computing and Digital Literacy should be devised, encouraging interest and opportunities for deeper learning.
- Engagement and collaboration between education and industry should be an integral part of the curriculum to embed current practices and skills.
- Pathways for Initial Teacher Training (ITT) in Computing should be created to encourage the best talent into the profession. All entrants to the teaching profession should have the skills to deliver the Digital Literacy Framework (DLF).
- A programme of training and professional development to enable the new Computing curriculum should be accessible to new and existing teachers.
- A National Technology Framework should be devised to create an effective technology infrastructure for education. Welsh Government, local authorities, industry and learning providers should be responsible for its effective implementation and strategic development.

# 01

- Effective monitoring arrangements should be created for Computing and the Digital Literacy Framework. Estyn should consider relevant changes to the Common Inspection Framework in light of all of these recommendations.
- An appropriate body or properly constituted group should oversee the implementation of these recommendations. Its remit would need to be broad enough to encompass this crucial governance role, utilising appropriate expertise and representing key stakeholders.





## 2.1. BACKGROUND

In November 2012, in light of significant focus on ICT education in the UK, the Welsh Government's Minister for Education and Skills called for a review<sup>1</sup> of the current ICT curriculum in Wales. A seminar was held at the National Assembly for Wales, attended by representatives from a range of key stakeholder organisations including schools, further and higher education institutions, awarding organisations, industry bodies, and the media. In January 2013, an ICT Steering Group was formed<sup>2</sup> to consider the future of ICT and Computer Science for schools in Wales.

In particular, the group was asked to consider the following points:

- 'ICT' in education needs to be re-branded, re-engineered and made relevant to now and the future
- Digital Literacy is the start and not the end point - learners need to be taught to create as well as to consume
- Computer science should be introduced at primary school and developed over the course of the curriculum so that learners can progress into a career pathway in the sector
- Skills, such as creative problem-solving, should be reflected in the curriculum
- Revised qualifications need to be developed in partnership with schools, higher education and industry

The group was also asked to consider gender inclusion issues in education and industry, and to consider how the recommendations in this report could be implemented.

This report outlines what we believe the Welsh Government and key stakeholders should do to ensure that Computing and technology education in Wales is truly world-class and provides the opportunities to nurture a future generation of digital pioneers and innovators.

We should equip children with the skills and empower them with the knowledge and confidence to become innovative digital creators, effective digital citizens and successful entrepreneurs, so they can take advantage of the global growth opportunities that exist in the digital economy and beyond.

 <http://wales.gov.uk/about/cabinet/cabinetstatements/2012/ictreview/?lang=en>

 <http://wales.gov.uk/about/cabinet/cabinetstatements/2013/ictsteering-group/?lang=en>



## 2.2. ABOUT THE GROUP

The wider group is composed of experts and key stakeholders from across education, industry and government. It is co-chaired by Stuart Arthur (Box UK), Dr Tom Crick (Cardiff Metropolitan University) and Janet Hayward (Cadoxton Primary School), who represent industry, higher/further education, and schools respectively.

The group is composed of an interesting and diverse variety of individuals who have worked tirelessly to ensure that the wide range of viewpoints are all brought together through a unified vision and shared goals. A full list of the group's membership is available in the appendix.

## 2.3. APPROACH

Through a series of stakeholder workshops, building on the work of the 2012 Digital Classroom Teaching Task and Finish Group<sup>3</sup>, the ICT Steering Group started in January 2013, working through to August 2013. It considered existing research and policy reports, views from external stakeholders and invited presenters, a wide consultation survey, interviews with learners and their parents, as well as group discussions involving experts from industry and education to inform the final report and recommendations.

The group consisted of a large number of contributors; to facilitate smooth communication we followed an Agile process. The wider group was segmented into three stakeholder sub-groups covering schools, higher/further education, and industry, with each represented by one of the three co-chairs. Stakeholder groups met with regularity and larger milestone meetings were held to provide feedback. An online collaboration tool was used to centralise communication and facilitate remote collaboration.

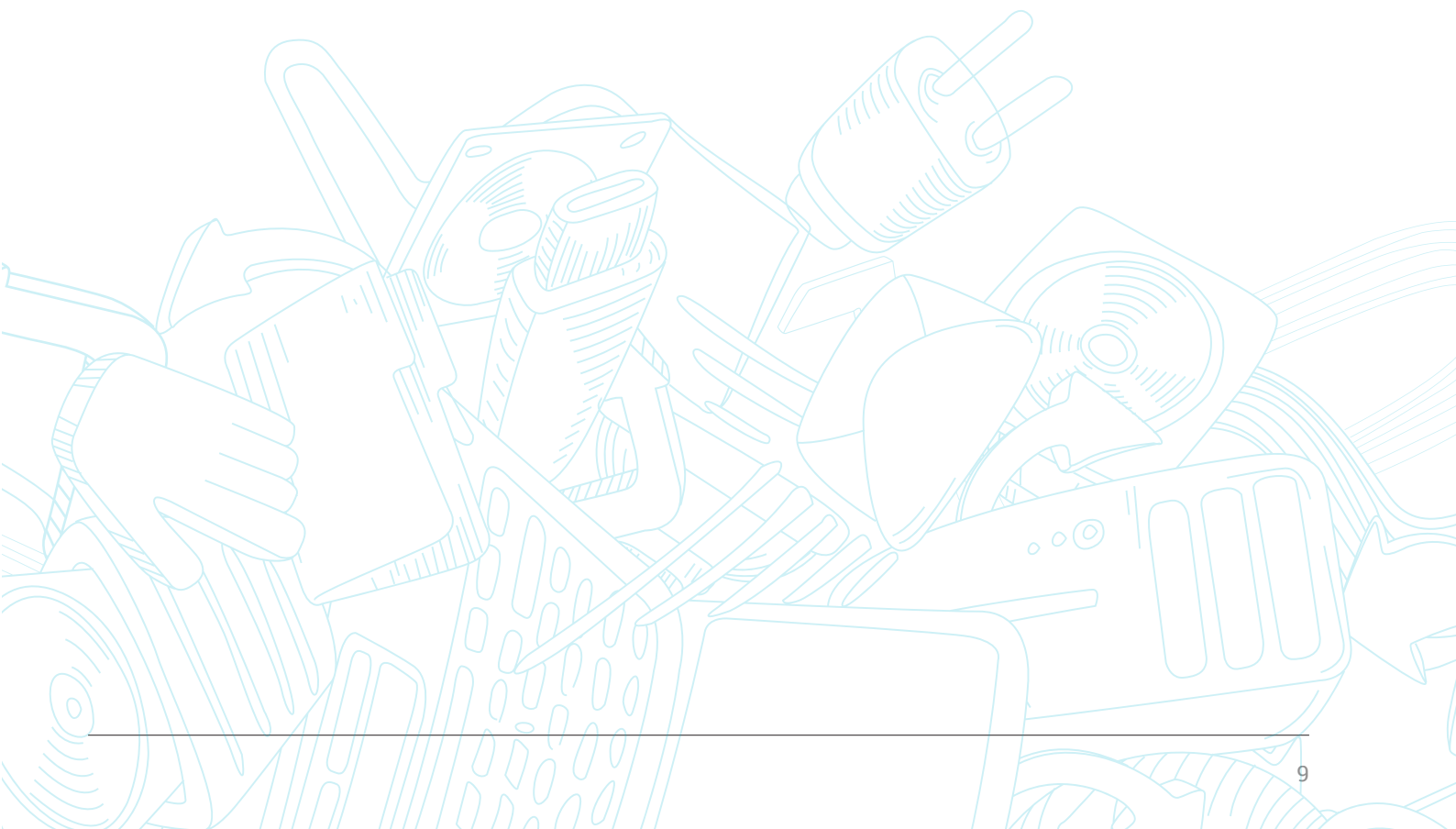
Alongside the formal review process, the group also trialed new ideas and initiatives; through this an industry and education model was created that resulted in various interactions between different stakeholders in the group. For example, Box UK's Coding Masterclasses for Education were conceived out of Stuart Arthur's eagerness to learn more about education and to work directly with the various education providers and stakeholders in the group with the aim of creating a model of engagement to take forward.

 <http://wales.gov.uk/topics/educationandskills/publications/wagreviews/digital/?lang=en>

# 02

Various coding sessions and other related practical activities were held in collaboration with Cadoxton Primary School and the Barry cluster of schools, St David's Catholic College, Cardiff Metropolitan University, Computing At School (CAS), Technocamps, the LIFE Programme, Ysgol Gyfun Gwyr, and many others during the course of the group's activities. Some of these, including a Box UK Masterclass and Cardiff Met-backed Lego Mind-storm initiative with Cadoxton, Barry Island and Romilly Primary Schools, were filmed as part of the research that informed the content of this report.

The group actively engaged in further activities involving learners from a number of different education platforms. This included industry focused careers advice and technical mentoring. This ethos of collaboration and co-working should be embedded into the proposed new curriculum, to showcase what can be achieved when the right people work together with a shared goal; creating clearly defined paths for learners to become immersed in technology.



## 2.4. TERMINOLOGY

Terminology was raised as an issue several times, in particular conflating the term 'ICT' with Computing, Computer Science, and IT, which is more widely used in industry. We agreed not to revisit terminology and to use the terminology defined by the Royal Society<sup>4</sup>.

**COMPUTING** The broad subject area; roughly equivalent to what is called ICT in schools and IT in industry, as the term is generally used.

**ICT** The school subject defined in the current National Curriculum.

**COMPUTER SCIENCE** The rigorous academic discipline, encompassing programming languages, data structures, algorithms, etc.

**INFORMATION TECHNOLOGY** The use of computers, in industry, commerce, the arts and elsewhere, including aspects of IT systems architecture, human factors, project management, etc. (Note that this is narrower than the use in industry, which generally encompasses Computer Science as well.)

**DIGITAL LITERACY** The general ability to use computers. This will be written in lower case to emphasize that it is a set of skills rather than a subject in its own right.

 [http://royalsociety.org/uploadedFiles/Royal\\_Society\\_Content/education/policy/computing-in-schools/2012-01-12-Computing-in-Schools.pdf](http://royalsociety.org/uploadedFiles/Royal_Society_Content/education/policy/computing-in-schools/2012-01-12-Computing-in-Schools.pdf)

# 03

## OUR VISION

### 3.1. VISION STATEMENT

By billing Wales as “a small, clever, creative and inventive country” at the heart of global industry, future generations will be inspired.



“ *If our forefathers - our ancestors - were part of this story through their inventiveness, then young people today will also say ‘if they can do it, we can do it’ and we can create a 21st century version of what Wales was then.* ”

**The Rt. Hon. Rhodri Morgan (speaking in 2005)  
First Minister for Wales (2000-2009)**

As co-chairs, this statement captures our vision for the future of ICT and Computer Science in Wales. It is our aim that the proposed Computing curriculum creates economic and social advantages for all children educated in Wales. We see this as an opportunity for the Welsh Government to declare Wales as an Agile-Digital Nation, renowned for producing talented technology innovators, leading software engineers, successful entrepreneurs and other related roles capable of becoming world leaders and contributing to the success of a thriving digital industry in Wales. However, this vision is predicated on a solid science and technology educational base.

### 3.2. AIMS AND ASPIRATIONS

Due to our highly successful devolution, Wales has the potential to become an Agile-Digital Nation and realise the benefits of a transformed education system in a relatively short timeframe. We have a unique opportunity to learn from the challenges identified in this report and aspire to become truly world-class, not just by delivering a Digital Wales, but by becoming a world leader in Computing and digital skills.

Broader Information Technology and Digital Literacy skills are now viewed as a baseline attribute to be an effective citizen in modern society. It is essential to empower our children by giving them the skills required to contribute to the rapidly growing digital economy.

# 03

## 3.3. OBJECTIVES

To underpin these aspirations, we are aiming to:

- Transform the industrialised static system into an empowering learning environment through the adoption of Agile principles and practices
- Increase the number of learners taking Computing and technology focused Level 2 and Level 3 qualifications
- Create clear and progressive education and career pathways
- Ensure teachers are receiving adequate continuing professional development
- Create a larger talent pool to contribute effectively to a thriving IT sector
- Create confident and effective digital citizens
- Change the perception of the IT industry, and increase awareness of the wide range of IT careers
- Ensure industry, education and other key stakeholders work together
- Improve the uptake of females into Computer Science education and future IT career pathways

Once the recommendations are due to be implemented we should revisit these objectives to ensure they are specific, measurable, achievable, realistic, and timely (SMART), in order to determine the ultimate success and impact of any changes made within the education system.

Implementation and delivery of the recommendations outlined therefore need to be governed and overseen by an appropriately constituted body (see Recommendation 12).

# 04

## RECOMMENDATIONS

### 4.1. RECOMMENDATION 1: A NEW SUBJECT

*“A new subject named Computing should be created to replace Information and Communications Technology (ICT) from Foundation Phase onwards. This new subject will disaggregate into two main areas: Computer Science (CS); and Information Technology (IT)”*

#### 4.1.1. Overhauling ICT

There are fundamental issues within the framework of the current subject of ICT; a career in IT typically involves some degree of logic, creativity, communication and collaboration, managing uncertainty, and problem solving. This is at odds with the current ICT curriculum that is prescriptive, outdated and documentation heavy, focusing on the consumption rather than creation of software and digital content.

In addition, it is not progressive or designed to be future-proof and there is a dependency on specific and transient technologies. This is at odds with industry needs for flexible, technology agnostic individuals capable of working effectively in teams and collaborating with third parties.

It is therefore key that the subject currently known as ICT is redeveloped and rebranded to change current perceptions and reflect its wider importance within the National Curriculum in Wales. This redevelopment and rebranding is both a declaration of intent as well as a clear message that this subject has been transformed rather than just improved.

We feel strongly that ICT has lost its meaning and become synonymous with word processing and spreadsheets; by renaming and rebranding it as Computing as part of a new curriculum we will have an opportunity to improve these perceptions.

# 04

## Recommendations:

- A new subject named Computing should be created
- Computing should replace ICT from Foundation Phase onwards
- Computing should become a core facilitating discipline that is seen as having wider educational value
- The new curriculum should be designed and implemented with industry stakeholder input
- Recognise extra-curricular activities through initiatives such as open badges; should build an online assessment tool

## 4.1.2. Disaggregating ICT

As per the 2012 Royal Society report<sup>5</sup>, we note the disaggregation of ICT into three main areas: Computer Science, Information Technology and Digital Literacy. The new subject Computing will address the Computer Science and Information Technology aspects, while the Digital Literacy aspects will be addressed separately (see Recommendation 3).

## Recommendations:

- Computing to be broken down into Computer Science and IT
- Create a new Digital Literacy Framework

## 4.1.3. Technology Enhanced Learning

We note the importance and clear disaggregation of Technology Enhanced Learning (TEL) and embedded technology. We fully support the use of technology for promoting excellence in learning and teaching in Wales, but this is not seen as part of the proposed Computing curriculum. TEL should be recognised as an important component of every subject and therefore it is the responsibility of every teacher to use effectively, as per the 2012 Digital Classroom Teaching Report<sup>6</sup>.

While the scope of this review does not cover the development and implementation of a new Computing curriculum or Programme of Study, we recommend its development as part of the wider National Curriculum review in Wales.

<http://royalsociety.org/education/policy/computing-in-schools/report/>

<http://wales.gov.uk/topics/educationandskills/publications/wagreviews/digital/?lang=en>

**Recommendations:**

- Create a new Computing curriculum and Programme of Study
- Provide support to teachers to take advantage of TEL
- Identify ways to embed TEL across every subject

## 4.2. RECOMMENDATION 2: THE FOURTH SCIENCE

*“Computing should be integrated into the curriculum as the fourth science, served by a mandatory Programme of Study, and receive the same status as the other three sciences”*

The world is changing and no one can deny that technology is a key factor driving this change. Our learners need to be equipped with the skills and knowledge to enable them to engage as future drivers of this on-going evolution. The three Sciences have been core subjects since the launch of the National Curriculum in 1990.

We recommend that Computing be served by a mandatory Programme of Study and should be adopted as the fourth science, and in turn be given the same status in terms of time allocation, assessment and inspection as the other three Sciences. This will help ensure perceptions of the educational value and rigor of the subject will be improved in the eyes of learners, parents and schools.

Computing should be seen as a quintessential Science, Technology, Engineering and Mathematics (STEM) discipline, as it shares a number of attributes with these subjects:

- It has its own theoretical foundations and mathematical underpinnings, and involves the application of logic and reasoning
- It embraces a scientific approach to measurement and experiment
- It involves the design, construction, and testing of purposeful artifacts
- It requires understanding, appreciation, and application of a wide range of technologies

It also provides pupils with insights into other STEM disciplines, in addition to skills and knowledge that can be applied to the solution of problems in those disciplines.



# 04

We also recognise the value and wider utility of computational thinking<sup>7</sup> and problem-solving skills; in particular the ways in which these crosscut and support other disciplines, especially the sciences and mathematics. Computational thinking skills should therefore be developed from primary schools onwards.

In addition, we recommend emphasising the wider value of computational thinking and problem-solving skills that cuts across the curriculum; the process of abstracting and deconstructing problems, defining the problem space, and tracking progress applies to any high-performance work environment.

<http://rsta.royalsocietypublishing.org/content/366/1881/3717.short>

## 4.3. RECOMMENDATION 3: A DIGITAL LITERACY FRAMEWORK

*“A Statutory Digital Literacy Framework should be implemented to work alongside the Literacy and Numeracy Framework from Foundation Phase through to post-16 education”*

As part of a reformed Computing curriculum, it is vital that the profile and importance of Digital Literacy is highlighted and embedded in education. We need to develop confident and capable digital citizens and as such Digital Literacy should be regarded as a core skill that crosscuts every subject.

We therefore recommend the development and implementation of a statutory Digital Literacy Framework from Foundation Phase through to post-16 education. This new DLF would complement and sit alongside the current Literacy and Numeracy Frameworks.

In the same way in which all teachers should be teachers of Literacy and Numeracy, this should now include Digital Literacy; progressively developing key skills and having expectations for all learners at the end of each level.

The acquisition of Digital Literacy skills and digital competencies should not primarily be predicated on rapidly changing technologies, but should focus on pedagogy, deeper skill development, transferability, and understanding, as well as potential application of these competencies.

This should integrate fully with the proposed changes to Essential Skills Wales and the Welsh Baccalaureate.

We recognise that this will require training and support, for both new and existing teachers, but this falls under the remit of the Welsh Government's National Digital Learning Council along with changes to Initial Teacher Training (see Recommendation 8).

## 4.4. RECOMMENDATION 4: PROMOTING CAREER PATHWAYS

*“Perceptions of computing education pathways should change to recognise the key roles of computing and technology. The importance and diversity of IT careers should be promoted”*

### 4.4.1. Computing Education Pathways

For many learners (as well as the wider public), Computing pathways in education have been perceived to be boring, mundane, and lacking in importance. There has been too much emphasis on the consumption of digital technology, with the more creative and challenging facets of the discipline being neglected.

These perception issues were identified through research undertaken within our group, comprising parents and the wider public. Some parents assumed computing and IT to be a low value sector, and in one case a parent encouraged their child to study fine arts because of the perceived lack of earning potential in the IT industry. This could not be further from the truth.

For this reason we should support organisations, such as Careers Wales, and education providers to promote the latent potential that currently exists within the sector and that will only continue to increase as our dependency on digital technology grows.

#### **Recommendations:**

- Ensure early impressions of Computing are excellent from primary school onwards
- Promote careers advice through Careers Wales to highlight the opportunities available
- Highlight technical apprenticeships and expand the Careers Wales apprenticeship-matching service to encourage uptake
- Showcase female role models in IT and related disciplines to address the gender inclusion issues

# 04

- Identify and promote role models who have made a positive impact on society through the use of Computing or related technologies
- Highlight the many uses of technology in popular society, such as sport and film

## 4.4.2. Diversity of IT-Related Careers

There is a lack of awareness from parents and learners about the diversity of possible careers within the IT industry and other related industries. The different types of people and the multitude of roles involved in delivering IT projects are not highlighted, and many people are unaware of the opportunities that exist for technical apprenticeships as an alternative to a purely academic route into industry.

### Recommendations:

- Embed project and team working in the curriculum across subjects
- Ensure industry leaders promote IT careers to learners through the education system
- Create collaborative projects with industry input
- Provide case studies that showcase the use of IT across industries and in academia

## 4.4.3. Wider Public Perception of Computing

Alongside the curriculum and qualifications reform, it is also hugely important to change the wider public perception of both Computing's role as an economic driver and its wider education benefit to all students; not only to create more computer scientists or to feed the growing IT industry.

### Recommendations:

- Ensure that current advice about IT and related careers information is accurate and represents the latest industry viewpoints
- Promote and invest in the Careers Wales online service, as they showcase the diversity of IT careers on their career planning website

# 04

- Build upon successful extra-curricular activities to enthuse and engage young people e.g. Technocamps, Raspberry Jams, Box UK Coding Masterclasses for Education, and other similar initiatives
- Careers advice should come from education providers as highlighted by the Estyn report “Informed decisions: The implementation of the Careers and the World of Work framework”<sup>8</sup> (please note that responsibility for this will need to be ascertained as part of a subsequent review)

## 4.4.4. Gender Inclusion

Gender inclusion and female uptake of computer science and other STEM disciplines remains an issue. To some extent teaching Computing from Foundation Phase will be a significant step forward. Evidence suggests that girls in primary school enjoy mathematics and science, but it has been said, “Year 8 is too late”<sup>9</sup>. By the time girls get to secondary school and selecting GCSE subjects, a poor perception of the discipline has already developed. Working alongside teaching from an early age, we also need to counter this reputation by overhauling the branding and marketing of Computing.

### Recommendations:

- Place a stronger emphasis on creative and multimedia disciplines and the communication and commercial skills required in modern industry
- Create a targeted marketing plan to promote more role models within the industry who do not fit the stereotypical blueprint of a coder

<http://www.estyn.gov.uk/english/docViewer/258012.3/informed-decisions-the-implementation-of-the-careers-and-the-world-of-work-framework-october-2012/>

<http://mulqueeny.wordpress.com/2011/08/10/year-8-is-too-late/>

# 04

## 4.5. RECOMMENDATION 5: PROGRESSIVE LEARNING

*“The revised Computing curriculum should encourage creativity, allow thematic working and develop real world problem solving. It should be flexible enough to continually evolve to remain current, adopting an agile approach”*

### 4.5.1. Agile Education Model

Most learners studying ICT are taught to develop software using a waterfall methodology. This involves a linear process consisting of several distinct stages: requirements gathering, system design, implementation, testing, and support. This is the sort of approach that has become synonymous with failed public sector IT projects within industry<sup>10</sup>.

There is, however, an alternative methodology fast emerging as the de facto approach to delivering software: Agile. It is based on the principles of the Agile Manifesto<sup>11</sup>, which advises that focusing on people, communication, collaboration, working software and responsiveness to change will yield optimum results.

The ideals of Agile and learning can be seen to align and as Miles Berry asks in the 2012 article “The Case for Agile Pedagogy”<sup>12</sup>: “Aren’t some of our best lessons those where the learning journey takes an unexpected turn, because of pupils’ contributions or, indeed, the unanticipated problems they encounter?”

This highlights the potential benefits of Agile in education; responsiveness to change and a more learning-centric approach can significantly improve the education system. We need to change the burden of assessment and move away from checking boxes as a means of measuring progress and results as this linear and non-creative approach has created a system that encourages the wrong behaviours in learning providers.

<http://www.computerweekly.com/blogs/public-sector/2011/05/nhs-it-system-condemned.html>

<http://agilemanifesto.org/>

<http://www.theguardian.com/teacher-network/teacher-blog/2012/may/16/agile-pedagogy-computer-programming-learning>

# 04

Many of the issues being tackled by the Agile Manifesto have a large degree of crossover with those being faced in education and the bad behaviours the existing system has created:

- Heavyweight processes and over investment in software tools
- Over emphasis on curriculum materials and linear testing cycles
- Contract negotiation and politics driving activity
- A culture heavily embedded in upfront planning and design
- Resistance to change and lack of feedback loops

One of the fundamental problems holding back the education sector, in Wales and also globally, is that the current model was created in the industrial age and is inherently static, which is unsuitable in the dynamic, ever changing digital world in which we now live. A system that has such long cycle times will invariably become outdated due to a lack of regular feedback and an inability to respond quickly to change. This is similar to the top-down rigid waterfall approach still blighting software delivery in many larger enterprise organisations.

If Agile was able to improve the delivery of IT projects and transform organisations to better adapt to the changing needs of their customers and the marketplace, then it's not absurd to think that such an adoption could have a profound impact upon the failing education system, which shares many of the characteristics that led to the creation of the Agile concept.

The Agile ideology is focused on the things we value in education such as collaboration, responsiveness, and continual feedback loops with the learner central to our efforts. Agile practices also consist of learning cycles that help teams to learn fast, and by constantly reviewing progress Agile teams accelerate learning. With some tweaks this could easily be turned into a model or paradigm to transform learning. There are some examples of this type of thought leadership and there are also Agile principles and practices being piloted, such as the 2011 Article Agile Schools<sup>13</sup>.

## **Recommendations:**

- Use Agile principles as the blueprint for a new dynamic and responsive education, which can be piloted as part of the proposed new Computing subject
- Define the principles for the new education system based on those detailed in the Agile Manifesto; that emphasis should be on communication and collaboration over documentation and contracts
- Carry out research into the use of Agile to overhaul the education system
- Review assessment procedures to enable creativity

 <http://www.infoq.com/articles/agile-schools-education>

# 04

## 4.5.2. Culture and Values

Agile encompasses more than just a set of processes; it is an idea supported by a set of beliefs, a target culture to promote successful software delivery<sup>14</sup>. Changing the culture and values of an entire system can have a profoundly positive or negative impact, such as the joint venture between GM Motors and Toyota illustrated back in 1984 when Toyota shared the secrets of its production system and culture with a GM car factory in California, which transformed it into a Japanese style factory. Remarkably, with the same personnel, the factory turned around its fortunes<sup>15</sup>.

If a significant revision is made to the learning model and paradigm, it is vital that the underlying culture and values empower people, from teachers to parents, to collaborate, think, and act in ways different to those they may be accustomed to. Ken Robinson emphasises the need for people and learning to become more central to the education system and process model:

*“The fact is that given the challenges we face, education doesn’t need to be reformed -- it needs to be transformed. The key to this transformation is not to standardize education, but to personalize it, to build achievement on discovering the individual talents of each child, to put students in an environment where they want to learn and where they can naturally discover their true passions.”*

**Ken Robinson**

The Element: How Finding Your Passion Changes Everything

### Recommendations:

- Create a people focused strategy for the education system
- Review the leadership approach
- Equip teachers with the skills to manage a progressive and dynamic curriculum
- Provide on-going support through training and mentoring

<http://www.forbes.com/sites/stevedenning/2012/09/25/what-exactly-is-agile-is-kanban-agile/>

<http://www.thoughtsofaleanguy.com/2013/07/can-you-copy-culture-nummi-story.html>

### 4.5.3. Coaching and Mentoring

In industry, the positive results from adopting an Agile organisational model are plentiful and well documented; however, changing to such an approach will require expert skills and support. Teachers working in Computing-related fields of study need on-going guidance and resources due to the ever-changing technologies used within the domain and should also make efforts to stay up-to-date with the latest thought leadership and insight in the community.

#### Recommendations:

- Run workshops and create a training plan for teachers
- Develop a support community whereby teachers can seek guidance and advice
- Appoint expert coaches and mentors to support education providers
- Review working examples of Agile in other education systems

### 4.5.4. Trial Agile Methodologies in Computing

Using Agile methodologies in Computing courses to promote how modern software solutions are constructed is not only more current, but allows the concept of Agile education to be piloted as part of a controlled and progressive implementation approach. If successful, this should be considered as part of a wider review into the culture, values, and learning model in education, and how Agile can be leveraged to transform the system through continuous improvement.

#### Recommendations:

- Teach learners about Agile methodologies, including the historical context
- Embed Agile thinking and best practices in the curriculum
- Define success criteria from which we can measure the impact of adopting Agile



## 4.5.5. Thematic Working and Problem-Solving

The current curriculum and implementation is largely prescriptive and static by design; ICT is taught in silos, which is restrictive and does not encourage essential problem solving and computational thinking skills to develop. This is partly due to the way in which the curriculum is created. It currently involves a lot of upfront design and remaining static for a long period of time; this is at odds with the fluidity of the IT industry and the emphasis on being able to creatively solve problems in a number of a different ways using an array of different technologies and tools. Using Agile encourages solutions to problems to emerge iteratively, with designs and plans adjusted accordingly.

### **Recommendations:**

- Design the curriculum with an emphasis on outcomes and deliverables
- Utilise Computing elements across a range of subjects
- Encourage cross-subject collaboration on project work and assignments
- Provide opportunities for STEM and Arts subjects to be integrated in the curriculum

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## 4.6. RECOMMENDATION 6: QUALIFICATIONS

*“A range of engaging and academically rigorous pathways and bilingual qualifications for Computing and Digital Literacy should be devised, encouraging interest and opportunities for deeper learning”*

The curriculum and infrastructure reforms previously proposed aim to create a deeper and more stable pipeline in which to encourage knowledge, understanding and enthusiasm for this cognate area. Furthermore, it is important to ensure that a range of engaging and academically rigorous qualifications exist which cater for all learners.

We should encourage and increase the uptake of Level 2 qualifications in this area, especially the newly developed GCSEs in Computing/Computer Science. This will also support the uptake of Level 3 qualifications, especially A-Level Computing, which has seen extremely poor national uptake over the past few. However, we would also encourage the development and uptake of broader (but academically rigorous) Level 2 and Level 3 qualifications to address the wider focus of Computing area.

Alongside the reform of Essential Skills Wales and the Welsh Baccalaureate, it is imperative to ensure that the burden of assessment is considered; firstly, that the modes of assessment are relevant and fit-for-purpose, but also that there is no unnecessary duplication of assessment for learners in Wales, as currently happens for students working towards both Essential Skills ICT Level 2 and a GCSE (or equivalent) qualification in ICT.

While there is a statutory provision for the Welsh Joint Education Committee (WJEC) to provide qualifications through the medium of Welsh, we would encourage the Welsh Government to incentivise the other examination boards to offer their qualifications through this medium to provide diversity and a range of appropriate qualifications for learners in Wales.

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## 4.7. RECOMMENDATION 7: INDUSTRY AND EDUCATION ENGAGEMENT

*“Engagement and collaboration between education and industry should be an integral part of the curriculum to embed current practices and skills”*

### 4.7.1. Mechanism of Engagement

A disconnect has been evident between industry and education for a long time with regards to education and training and how best to develop the skills for the workforce. For the new curriculum to succeed we believe it is vital for true collaboration and regular feedback loops between these key stakeholders to be facilitated; current industry best practices and modern approaches are essential to develop future talent, and to achieve our aims we need an effective mechanism and model of engagement.

There is a huge opportunity for industry to better support the Computing education agenda within Wales, offering more effective input and on-going support to not only assist with the implementation of the proposed curriculum, but to also offer support with technical infrastructure, software solutions, and importantly careers advice to help correct some of the preconceptions that exist about IT career pathways.

Industry can also play a key role in identifying and nurturing talent in Wales by providing individuals with support throughout their learning pathway and offering routes into industry through academies and technical apprenticeships. Initiatives such as Young Rewired State (YRS)<sup>16</sup> and hack days involving industry and young learners are a great example of best practice to support young coders, and we should explore similar models nationally.

#### **Recommendations:**

- Incentivise industry to co-work with education and build formal links
- Support teachers by providing skilled resources for coding sessions
- Create a self-sustaining business model of industry-led teaching support
- Teachers should become facilitators of learning rather than prescribers
- Explore the creation of coding academies and expand technical apprenticeships

 <http://rewiredstate.org/young-rewired-state>

## 4.7.2. Embedded Best Practice

In industry, the way in which software is created and shipped has changed significantly through the acceleration of development frameworks, automation, and Agile methodologies. This is in direct contrast to the approaches we teach in computing and IT-related disciplines and should be modernised to be brought up to current standards.

### Recommendations:

- Ensure project work is created, with input from industry, that is focused on real-world problem solving, desired outcomes, and covers the full software lifecycle
- Implement computational thinking, problem solving, and analytical skills across the wider curriculum through the adoption of cross-subject Computing projects
- Introduce collaborative working, communication skills, and project-based scenarios across the curriculum to promote practical learning and skills required by industry
- Consider the use of social coding initiatives, such as the use of GitHub<sup>17</sup>, to encourage collaboration, engagement, and cross-functional team working

## 4.7.3. Extracurricular Activities

Education providers do not currently have access to industry experts who can provide extracurricular activities, such as coding sessions, on an on-going basis. These initiatives should be rolled out across Wales as they help provide invaluable support to teachers and would enable learners to develop industry skills from passionate and engaged IT experts on activities from user experience design through to development and automation.

### Recommendations:

- Support and enhance initiatives such as Technocamps, Box UK Coding Masterclasses for Education, Code Clubs, and others that can support education
- Promote the need for industry to work with education providers in order to produce a future workforce with suitable skills and behaviours
- Create project scenarios that can be delivered between industry and education

- Utilise existing schemes such as STEM Ambassadors
- Build an assessment tool that supports integration with open badges to ensure learners extra-curricular activities are incentivised and formally recognised

## 4.8. RECOMMENDATION 8: INITIAL TEACHER TRAINING

*“Pathways for initial teacher training in Computing should be created to encourage the best talent into the profession. All entrants to the profession should have the skills to deliver the Digital Literacy Framework”*

We are aware of the concurrent review of Initial Teacher Training in Wales, but it is clear that, alongside the proposed curriculum and qualification reforms, it is imperative that teachers are supported and invested in to ensure they achieve the skills and knowledge necessary to deliver the proposed new curriculum.

We accept that significant changes to the ICT curriculum in Wales will present both challenges and opportunities, but a key part of these proposed changes is in support for the teaching profession. There should be a clear focus on developing new PGCE (or similar) routes for Computing and/or Computer Science, as well as funding mechanisms to attract high-quality and suitably qualified graduates.

We note excellent examples of universities encouraging computer science undergraduates to consider teaching; for example, the implementation of the Undergraduate Ambassadors Scheme<sup>18</sup> at Swansea University, as well as cross-school collaboration and initiatives between the education and computing departments at Cardiff Metropolitan University. These models can be easily replicated at other universities across Wales.

We also note the importance of all entrants to the teaching professional being capable of delivering the statutory Digital Literacy Framework, which may require a re-evaluation of the NQT skills framework.

 <http://www.uas.ac.uk/>

**Recommendations:**

- Create new PGCEs in Computing/Computer Science
- Provide bursaries at the highest level to encourage first-class Computer Science graduates into the profession
- Build links with universities in Wales to promote and support teaching to Computer Science undergraduates
- Ensure all newly qualified teachers are able to deliver the statutory DLF

## 4.9. RECOMMENDATION 9: TRAINING AND PROFESSIONAL DEVELOPMENT

*“A programme of training and professional development to enable the new Computing curriculum should be accessible to new and existing teachers”*

To support the previous recommendations, there should be clear and long-term investment in professional development and training for new and existing ICT/Computing teachers in Wales. We support the creation of a “network of excellence” model of training and professional development to identify, embed and cascade best practice for the teaching of Computing across Wales.

We note the success and impact of the Department for Education-funded CAS/BCS Network of Computer Science Teaching Excellence<sup>19</sup> in England, with its regional cascade model of Computing at School (CAS) Hubs, Master Teachers, and universities working in partnership. We feel that this model would be particularly effective in Wales, addressing regional variance and need, as well as geography and density of schools. There are also significant opportunities for the use of online training, such as Massive Online Open Courses (MOOCs), to develop capability for teaching Computing in Wales.

 <http://www.computingatschool.org.uk/index.php?id=noe>

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## Recommendations:

- Fund a network of excellence model to build capacity and cascade best practice of teaching Computing in Wales
- Ensure all teachers have the training to provide them with the skills, knowledge and understanding to deliver the Digital Literacy Framework
- Ensure, in the primary phases, that all teachers are able to deliver the Mandatory Programme of Study for Computer Science while staff at KS3, 4 & 5 have the necessary training to support their teaching of the new fourth Science
- Have education providers working together to develop new networks and also extend existing networks, such as CAS in Wales.
- Online learning and the development of training content by teachers for teachers should be accentuated and will be key
- Have training supported and funded by Welsh Government through the prioritisation of Digital Literacy and the teaching of Computing in SEG and PDG guidance, as well as being supported by the Regional Educational Consortia
- Take advantage of the significant opportunity that exists to utilise existing infrastructure to deliver training and add value to extant resources and initiatives

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## 4.10. RECOMMENDATION 10: NATIONAL TECHNOLOGY FRAMEWORK

*“A National Technology Framework should be devised to create an effective technology infrastructure for education. Welsh Government, Local Authorities and Learning Providers should be responsible for its effective implementation and strategic development”*

### 4.10.1. Block and Lock

For many education providers, there is an environment of ‘block and lock’ whereby existing IT providers are enforcing the adoption and use of certain platforms and operating systems. This leads to learners failing to see the possibilities and benefits of a technology-agnostic approach; creating unhealthy dependencies on certain vendors.

There is also a degree of waste and cost overhead involved in supporting the current IT infrastructure and software solutions within the education system; this presents an opportunity to create more fit-for-purpose solutions that save money and improve productivity. A review is needed to establish the investment currently in place and estimate its replacement cycle.

The report “Cost Savings in Education: Saving money with ICT”<sup>20</sup> produced back in 2010 provides some insight as to the scale of the problem and is a good reference point to gauge the potential cost savings that could be made.

In this report, Stephen Peverett, Network Manager at Lodge Park Technology College, says: *“I used to work on a four year life-cycle for servers alone. With 20 servers, we were replacing 6 servers a year at approximately £2,000 per server. If I can reduce those 20 servers with 6 virtual machines I’m cutting my costs by more than half.”*

Based on the assumption that there is not much difference between schools in Wales and England, if the projected costing savings highlighted in the report can be validated, the potential for reducing costs is huge, representing millions of pounds. Although this covers more than just infrastructure, it is all IT-related expenditure. Savings made can be put back into the classroom where they will have the greatest impact upon learners, and could even be used to finance some of the recommendations in this report.

 <http://www.slideshare.net/Microsofteduk/cost-savings-in-education-saving-money-with-ict>



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To test this theory Ysgol Gyfun Gwyr implemented a virtualisation strategy and managed to reduce their hardware from 9 servers down to 2 and are migrating their services. They realised the cost benefits of this change and are also experiencing additional value through the ability to spin up virtualised environments for their learners more quickly with additional capacity being provided.

## Recommendations:

- Review the IT infrastructure costs in the education system and implement potential cost savings to return money into the classroom or to support these recommendations
- Establish a common goal focused on providing learners with the optimal support and resources to become proficient across a range of platforms and technologies
- Ensure clear guidelines and best practices are communicated to education providers
- Coach and mentor IT support services to equip them with the skills to support cloud-based technologies, and multiple platforms and operating systems
- Allow choices to be made as to the most appropriate tools to solve problems
- Explore browser-based coding environments, such as Try Ruby<sup>21</sup>, where education providers are unable to provision hardware or cloud hosting. This could work well for younger learners and would help them to understand coding logic and syntax.

 <http://tryruby.org>

## 4.10.2. Effective Infrastructure

As with the rollout of Hwb, Welsh Government and Local Authorities should ensure the infrastructure, systems, and technology used to support education is effective. As the proposed new Computing curriculum and Digital Literacy Frameworks will promote the effective use and creation of software in education, it is vital to provide guidance information for education providers, as well as a strategic plan for development.

We should get to a place where we “build software once for Wales” and avoid duplication of effort and resources whereby one local authority builds an expensive learning platform only for another to emerge from Welsh Government, as was the case with Hwb. An effective and high-performance

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infrastructure supported by appropriate software solutions will enable us to be more innovative with teaching methods and leverage IT to deliver the greatest benefit to all stakeholders, including teachers and, most importantly, learners.

## Recommendations:

- Create a national technology framework to advise education providers on all hardware, software, and other technology decisions and implementation
- Ensure infrastructure, particularly internet connections, are fit-for-purpose
- Allow support for multiple and diverse platforms and operating systems
- Utilise cloud hosting services to enable rapid creation of development environments that support the coding needs of learners throughout Wales
- Develop more software as a service (SaaS) browser based software solutions for education providers to reduce hardware and software costs
- Develop a platform as service (PaaS) solution to make the creation of development environments faster and easier to provision; should be hosted in Wales

### 4.10.3. Open Source and Open Data

We have been exploring the open data initiatives and Digital Roadmap<sup>22</sup> creation being implemented by New York City's Rachel Haot, who said that open data played a part in helping to save lives when Hurricane Sandy hit New York<sup>23</sup>.

Furthermore, New York is utilising an open education system as a mechanism to creating more open government initiatives, which is something we should explore in Wales:

<http://www.nyc.gov/html/digital/html/roadmap/roadmap.shtml>

<http://blog.opengovpartnership.org/2013/01/hurricane-sandy-open-data-social-media-nyc-rachel-haot/>

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*“It is generally agreed that open government requires three major components: an open media, accountable politicians and an open education system catering for all levels of society. Open education bolsters open governance in two key ways: it provides an example of an open institution for students, parents and teachers to learn from; and produces informed individuals who are more likely to hold their governments to account.”*

**Ysanne Choksey**

Open Education Paves the way for Open Governments<sup>24</sup>

In stark contrast, the current management of the education system in Wales is thought of in terms of years rather than months, weeks, and days, while data is scarcely made available or analysed to manage performance and inform intervention to support the learning journey of individuals. Such slow cycle times and lack of near real-time data results in ineffective decision making processes.

Open source technology and the community that drives it are focused on learning, developing, and support each other, and the education system should take note and join in, as this will encourage learning and interaction with industry. Open source tools such as GitHub would allow this to happen in a controlled manner.

In industry, many companies and large successful products (such as Facebook) use and rely on open source technologies extensively and there's a growing need in industry for people who understand these technologies and have a wide array of experience. We should aim to mirror this need in the classroom and allow people to experiment and express themselves by making as many operating systems, programming languages, and database formats available as possible. We need to promote technology agnostic skills.

## **Recommendations:**

- Review the current systems that support education with a view to creating a roadmap to create more efficient and fit-for-purpose software solutions
- Build a single Wales Learner Record (WLR) from which we can track a learner's progress throughout the system via a single identifier
- Utilise Software as a Service (SaaS) based solutions that can be 'built once for Wales' and shared across the entire education system via a web browser
- Encourage social coding initiatives such as GitHub, which provide access to a plethora of open source code projects that can be used to bootstrap learning

 <http://blog.opengovpartnership.org/author/ysanne-choksey/>

## 4.10.4. Enterprise Architecture

The fragmentation of education across local education authorities has become a complex web of multiple systems, which duplicates effort and attempts to solve the same problems. This results in financial waste, precision errors, and various inconsistencies. Education needs to be thought of as a single product with a clear vision throughout Wales and a strategic plan to guide its progress.

Additionally, current running costs and overheads of supporting tired legacy back office systems to deliver useful and meaningful data analysis is costly and not fit-for-purpose, which makes getting a joined up view as to the health of the system very difficult to ascertain. A reporting middleware service, data warehouse, and learning tool could be explored to solve this problem, and the provision of data to guide some of the improvements in this report would become easier to manage

### **Recommendations:**

- Appoint an enterprise architecture team responsible for education
- Create a strategic plan to solve the problems inherent in the current architecture
- Create a governance framework to govern changes made to the system
- Focus future efforts around emerging technologies such as cloud hosting
- Explore building a comprehensive learning tool and data solution to simplify the reporting of essential data to key stakeholders

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## 4.11. RECOMMENDATION 11: MONITORING

*“Effective monitoring arrangements should be created for Computing and the Digital Literacy Framework. Estyn should consider relevant changes to the Common Inspection Framework in light of all of these recommendations”*

Estyn inspects quality and standards in education and training providers in Wales. In its latest report “The impact of ICT on pupils’ learning in primary schools” published in July 2013<sup>25</sup> they state:

*“Since ICT is not a core subject, teachers are not required to assess every pupil in it formally at the end of Key Stage 2. Neither is ICT assessed at the end of the Foundation Phase. There is no official national data on standards of attainment in ICT in primary schools although a minority of schools do undertake informal assessments.”*

Through the introduction of the Digital Literacy Framework and Computing as the fourth Science these standards of attainment will now be assessed and inspected. Importantly, the focus of any monitoring should not just be about the technology provision, e.g. one-to-one iPads, or the use of specific software tools and environments, but on the pedagogy of teaching Computing and attainment against a new curriculum and Programme of Study.

As previously discussed, the effective use of technology to support and enhance the learning experience is a key responsibility of teachers of all subjects and should not be regarded solely as the purview of ICT/Computing teachers.

### **Recommendations:**

- Create success criteria that encourage desired behaviours and effective learning
- Review the application of technology to assess Digital Literacy skills
- Ensure the DLF is aligned with existing frameworks

 [http://www.estyn.gov.uk/english/docViewer/285585.3/the-impact-of-ict-on-pupils-learning-in-primary-schools-july-2013/?navmap=30,163,](http://www.estyn.gov.uk/english/docViewer/285585.3/the-impact-of-ict-on-pupils-learning-in-primary-schools-july-2013/?navmap=30,163)

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## 4.12. RECOMMENDATION 12: IMPLEMENTATION

*“An appropriate body or properly constituted group should oversee the implementation of these recommendations. Its remit would need to be broad enough to encompass this crucial governance role, utilising appropriate expertise and representing key stakeholders”*

After the completion of this review, there will be a number of subsequent actions and recommendations to be finalised before implementation of a new Computing curriculum in September 2014. It is vital that an appropriate body is formed or an existing body's remit is extended to cover responsibility for the implementation of these recommendations. This group will need to have appropriate governance over policy and funding, as well as being composed of key stakeholders with relevant expertise and experience to deliver these strategic changes.

In June 2012<sup>26</sup>, the Minister for Education and Skills said:

*“I am establishing a National Digital Learning Council to provide expert and strategic guidance on the use of digital technology in teaching and learning in Wales. The remit of the Council will be to guide the implementation of the learning in digital Wales programme and to promote and support the use of digital resources and technologies by learners and teachers. The Council will work closely with the School Practitioner Panel which I announced in March 2012.*

*The Council will start work in September 2012. The membership of the Council will be drawn from schools, further education and the skills sector in Wales. In order to ensure that there is a strong learner voice in the Council, I have also agreed that a pool of associate members will be established, comprised of learners from primary schools, secondary schools and further education colleges.*

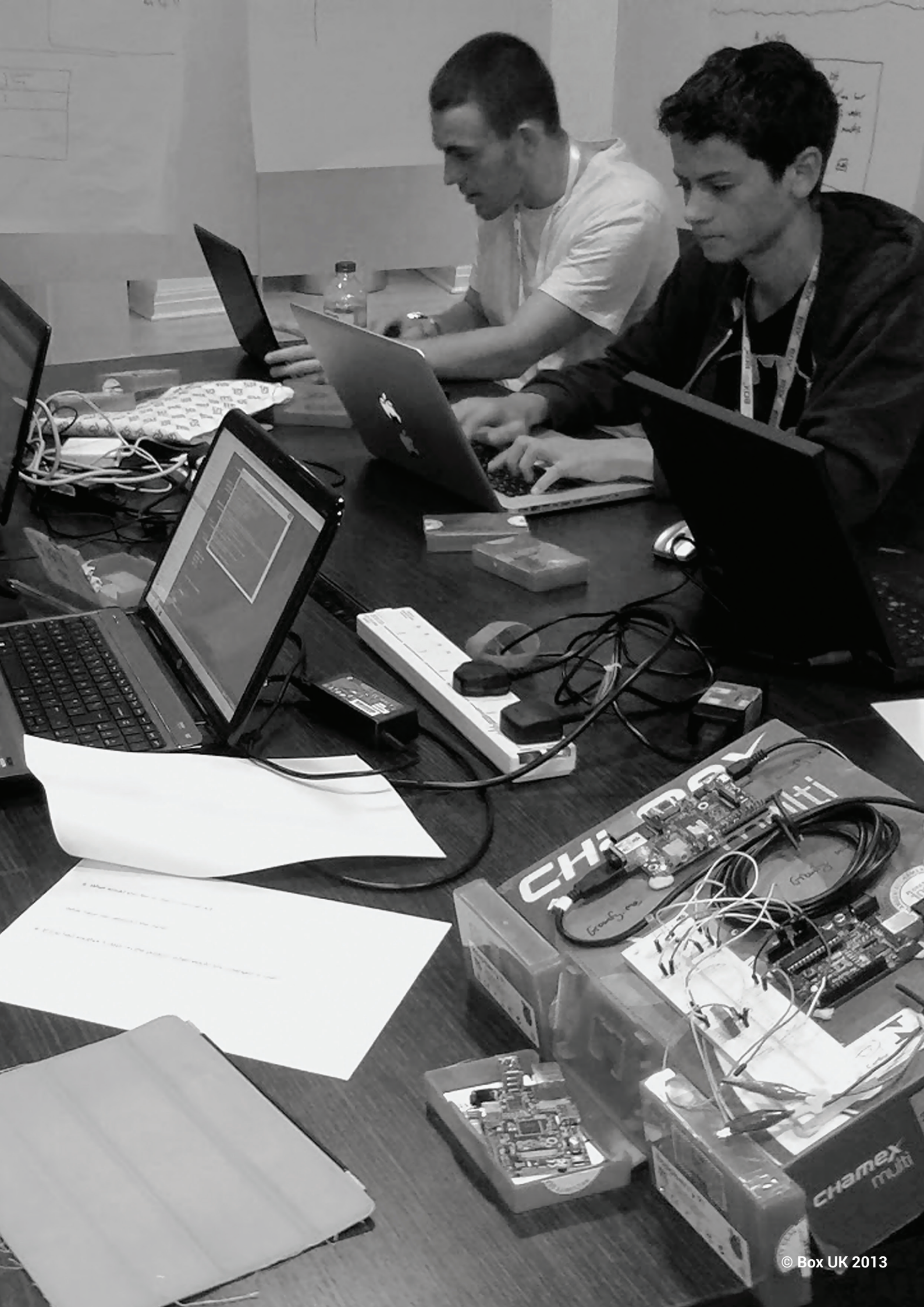
*In addition, the work of the Council will be supported by a number of professional advisors from higher education and industry”*

The Council has successfully operated since September 2012, steering the implementation of recommendations from the Digital Task and Finish Group Report (March 2012). It may be suitable to widen the membership and remit of the National Digital Learning Council to include industry specialists and other subject matter experts, so that these recommendations can be effectively overseen and implemented.

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## **Recommendations:**

- Identify appropriate groups and structure to oversee review recommendations
- Design clear goals and measures of success
- Include key stakeholder representation and relevant specialist expertise in membership of the group
- Create a delivery model
- Create a governance framework
- Devise a structured and progressive rollout plan





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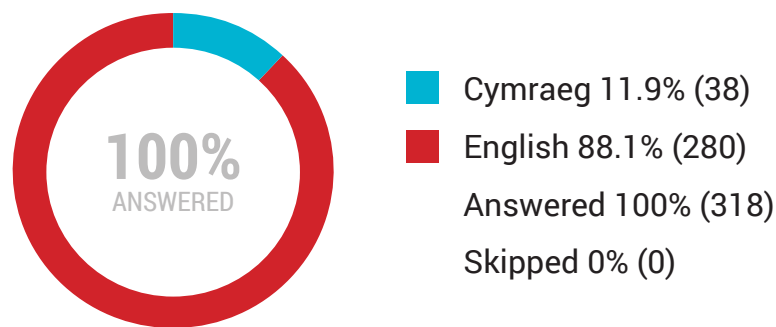


# CONSULTATION DATA

As part of the work of the ICT Steering Group, an open consultation and review process (“Review of ICT and Computer Science Education in Wales”) took place between April and May 2013. More than 300 submissions were received, from across education, industry and the general public. A summary of the data collected is presented in this section.

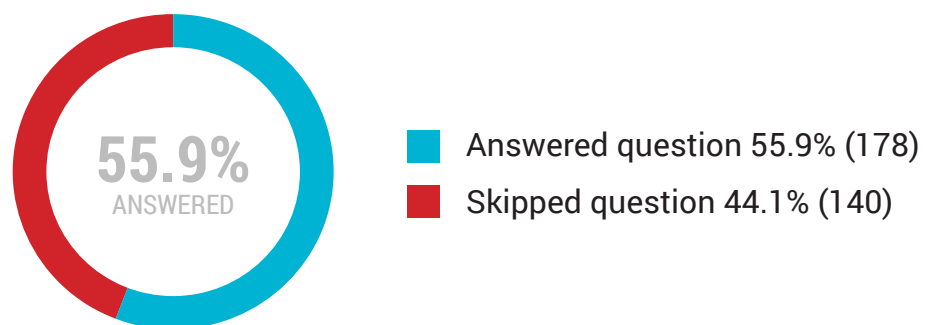
## PAGE: DEWIS IAITH / LANGUAGE PREFERENCE

1. Beth yw eich dewis iaith / What is your language preference



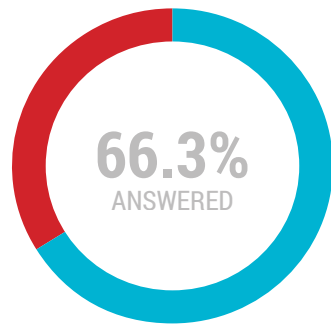
## PAGE: YOUR DETAILS

2. Name



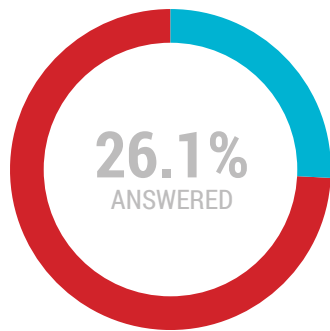
# APPENDIX 03

## 3. Occupation



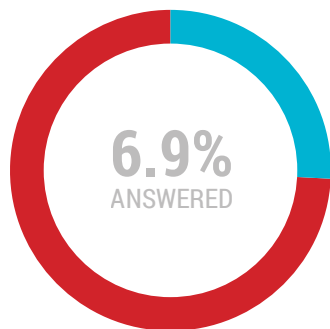
- Answered question 66.3% (211)
- Skipped question 33.7% (107)

## 4. Responses to consultations may be made public – on the internet or in a report. If you would prefer your response to be kept confidential,



- Answered question 26.1% (83)
- Skipped question 73.9% (235)

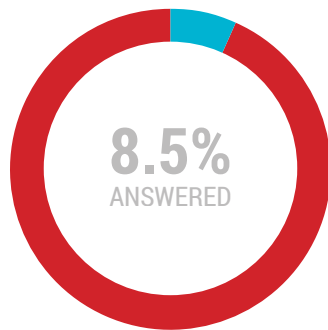
## 5. Enw



- Answered question 6.9% (22)
- Skipped question 93.1% (296)

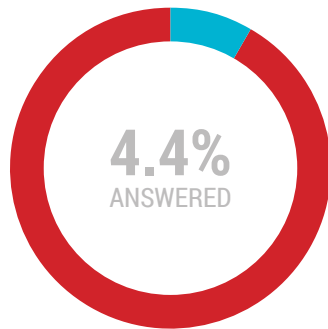
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## 6. Galwedigaeth



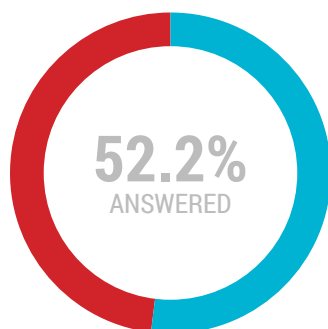
- Answered question 8.5% (27)
- Skipped question 91.5% (291)

7. Mae'n bosibl y bydd ymatebion i ymgynoriadau yn cael eu cyhoeddi – ar y rhyngwyd neu mewn adroddiad. Pe bai'n well gennych i'ch ymateb gael ei gadw'n gyfrinachol,

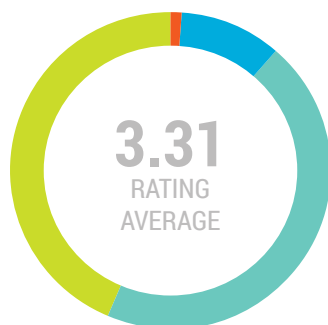


- Answered question 4.4% (14)
- Skipped question 95.6% (304)

8. 1. Should 'ICT' in schools be re-branded and re-engineered to make it more relevant and future-proof?



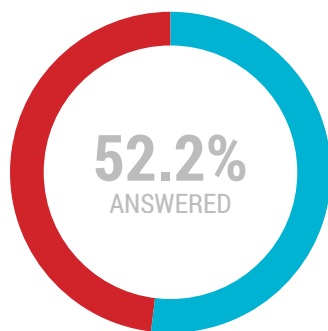
- Answered question 52.2% (166)
- Skipped question 47.8% (152)



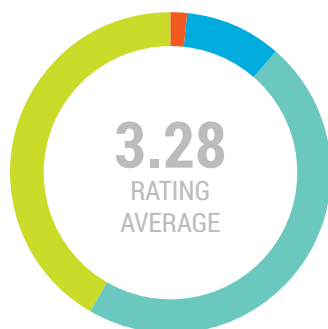
- Strongly Disagree 1.2% (2)
- Disagree 10.2% (17)
- Agree 45.2% (75)
- Strongly Agree 43.4% (72)

# APPENDIX 03

9. 2. Should digital literacy be a baseline on which we can develop a deeper understanding of technology and its possible application across a range of subjects?

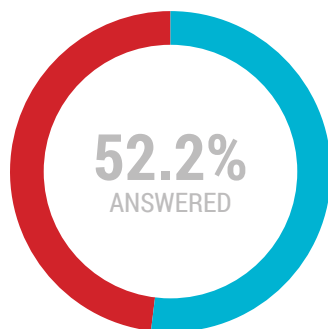


- Answered question 52.2% (166)
- Skipped question 47.8% (152)

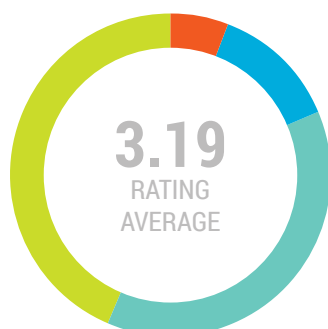


- Strongly Disagree 1.8% (3)
- Disagree 9.6% (16)
- Agree 47.0% (78)
- Strongly Agree 41.6% (69)

10. 3. Should computer science be introduced at primary school and developed progressively over the course of the curriculum?



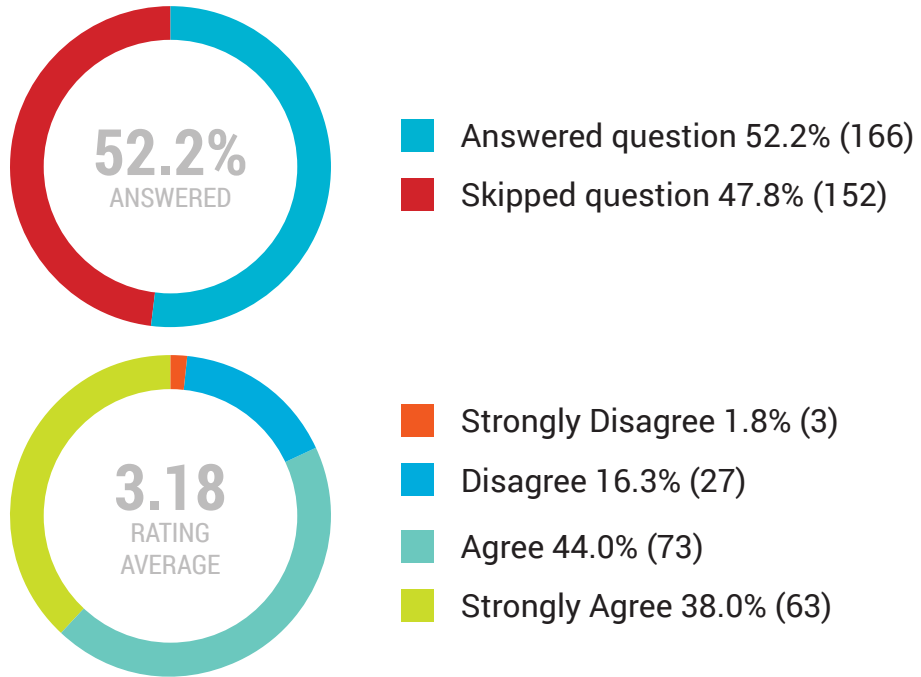
- Answered question 52.2% (166)
- Skipped question 47.8% (152)



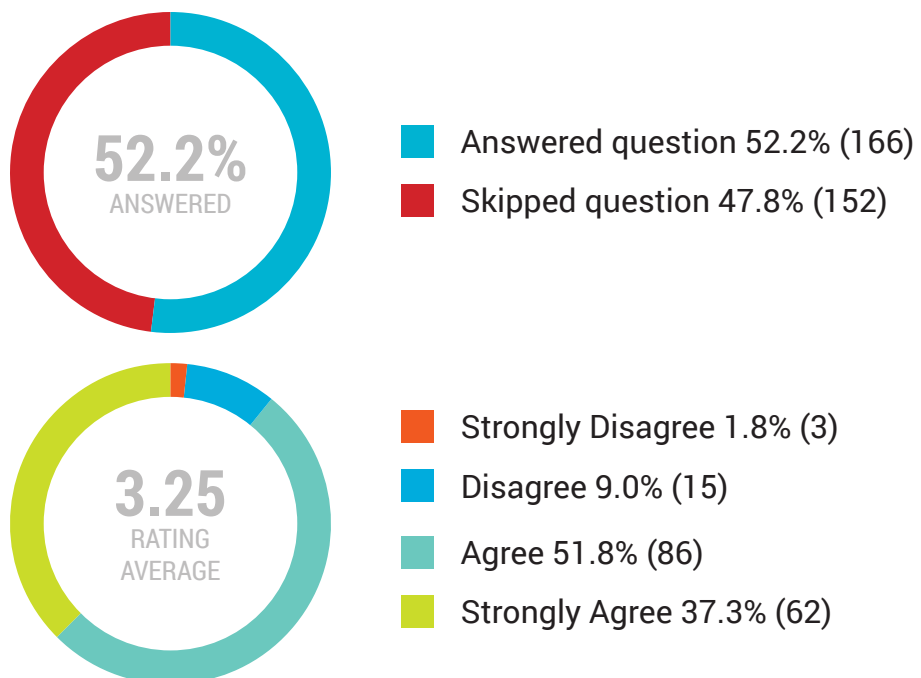
- Strongly Disagree 6.0% (10)
- Disagree 12.7% (21)
- Agree 38.0% (63)
- Strongly Agree 43.4% (72)

# APPENDIX 03

11. 4. Should we prioritise the development of computational thinking and creative problem-solving skills as part of a reformed curriculum?

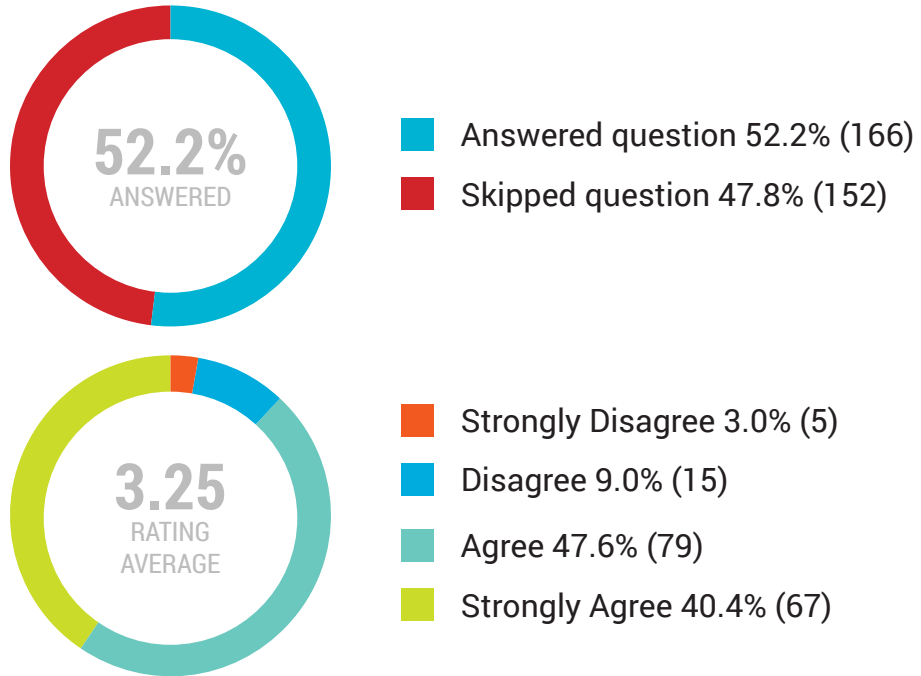


12. 5. Should revised qualifications be developed in partnership with schools, Further Education (FE), Higher Education (HE) and industry?

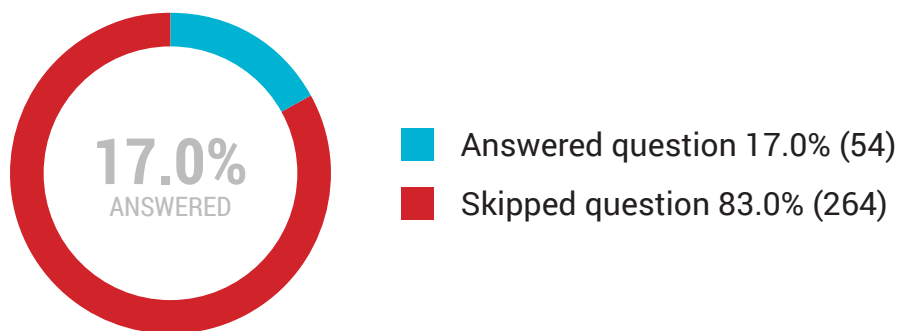


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13. 6. Should schools, FE and HE forge closer links with industry networks to support the implementation and delivery of a reformed curriculum?

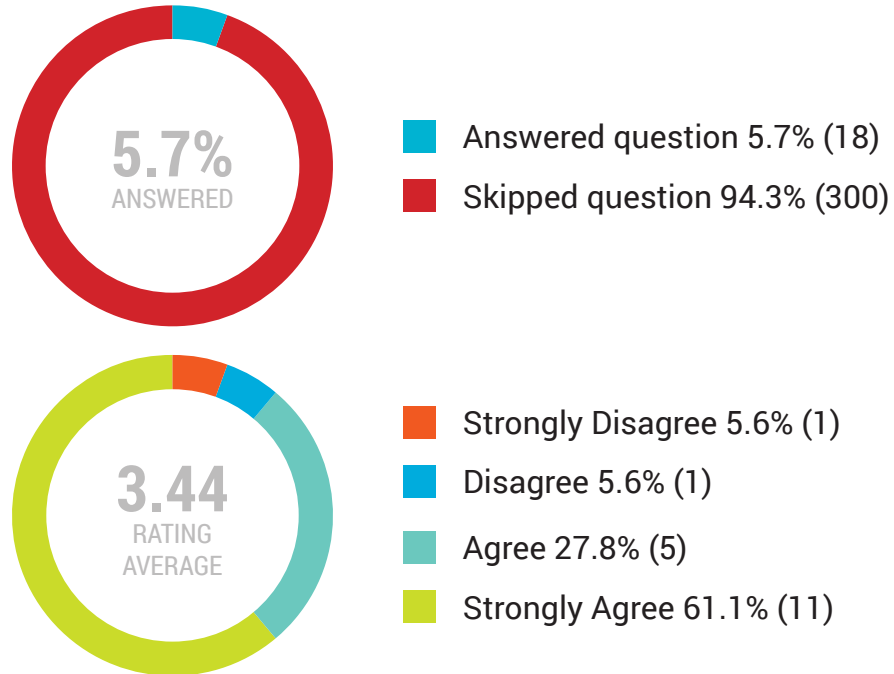


14. We would also welcome any general comments and feedback relevant to this consultation that will help formulate the recommendations for the final report to be published in June 2013.

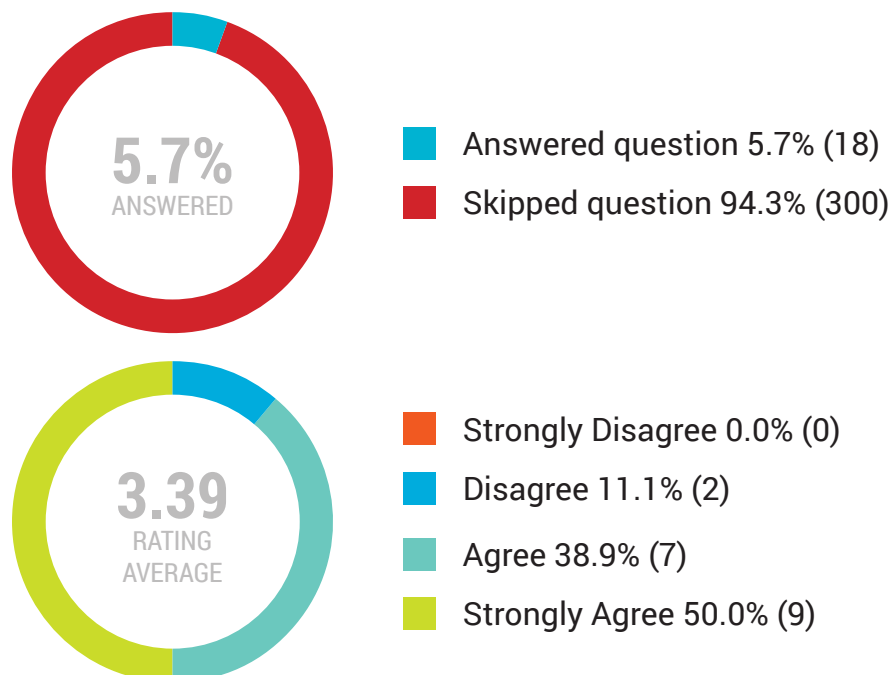


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15. 1. A ddylai 'TGCh' mewn ysgolion gael ei ail-frandio a'i ail-drefnu i'w wneud yn fwy perthnasol ac addas ar gyfer y dyfodol?

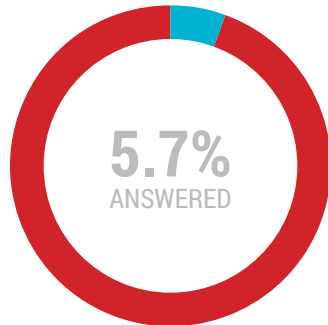


16. 2. A ddylai llythrennedd ddigidol fod yn waelodlin y gallwn ddatblygu deallt-wriaeth ddyfnach o dechnoleg a'r defnydd posibl ohono ar draws ystod o bynciau?

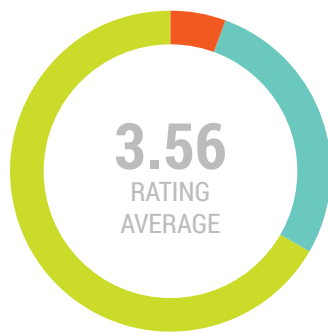


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17. 3. A ddylai cyfrifiadureg gael ei gyflwyno yn yr ysgol gynradd a'i ddatblygu'n raddol dros y cwricwlwm?

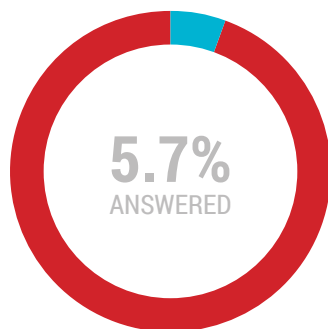


- Answered question 5.7% (18)
- Skipped question 94.3% (300)

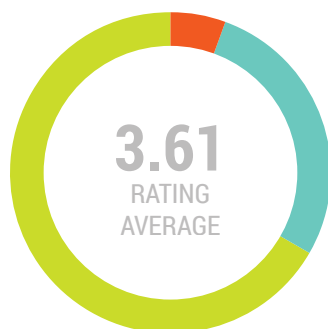


- Strongly Disagree 5.6% (1)
- Disagree 0.0% (0)
- Agree 27.8% (5)
- Strongly Agree 66.7% (12)

18. 4. A ddylem flaenoriaethu datblygu sgiliau cyfrifiadureg a datrys problemau creadigol fel rhan o gwricwlwm ddiwygiedig?



- Answered question 5.7% (18)
- Skipped question 94.3% (300)

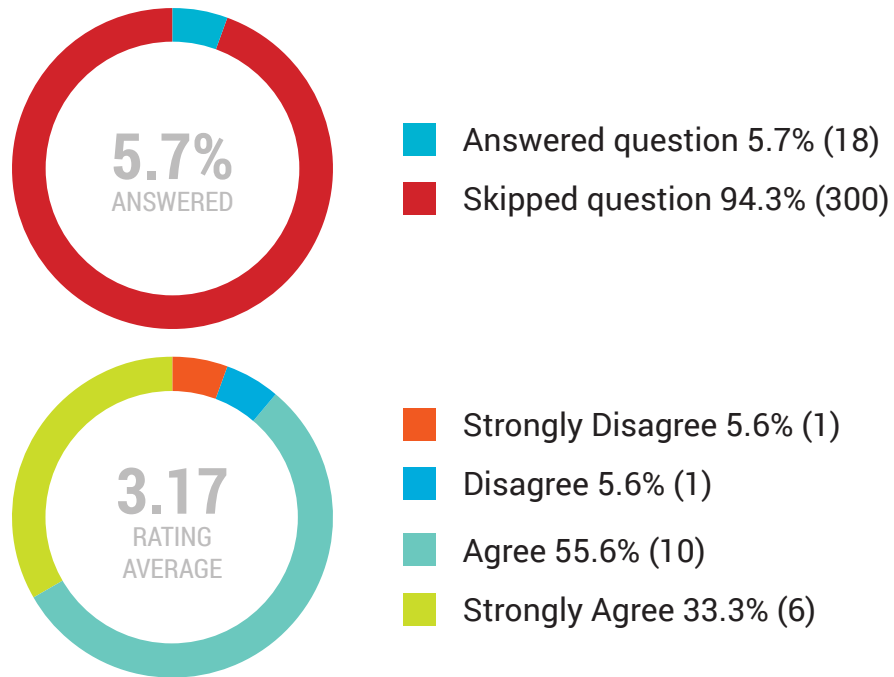


- Strongly Disagree 0.0% (0)
- Disagree 0.0% (0)
- Agree 38.9% (7)
- Strongly Agree 66.1% (11)

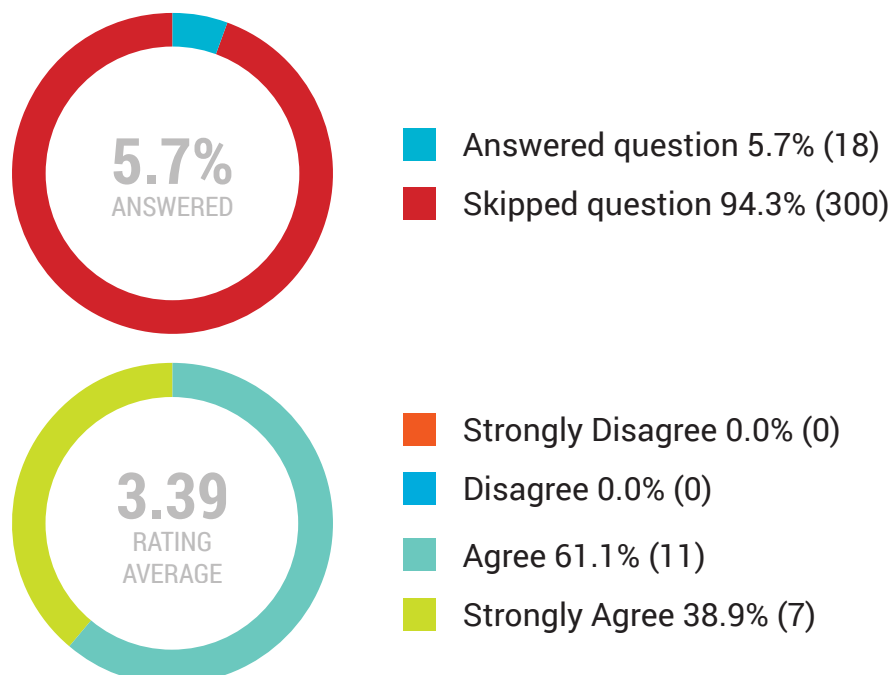


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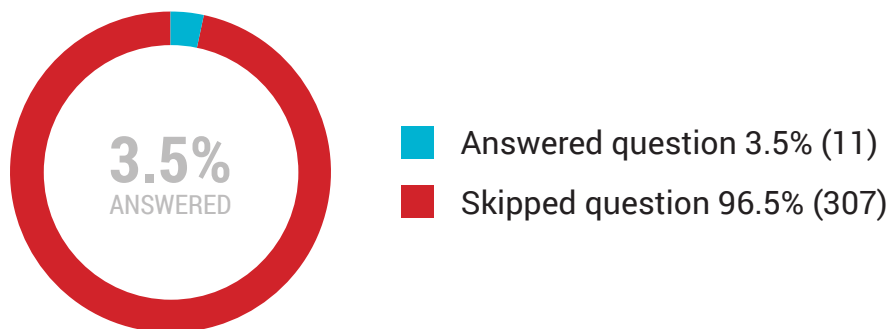
19. 5. A ddylai cymwysterau diwygiedig gael eu datblygu mewn partneriaeth ag ysgolion, AB, AU a'r diwydiant?

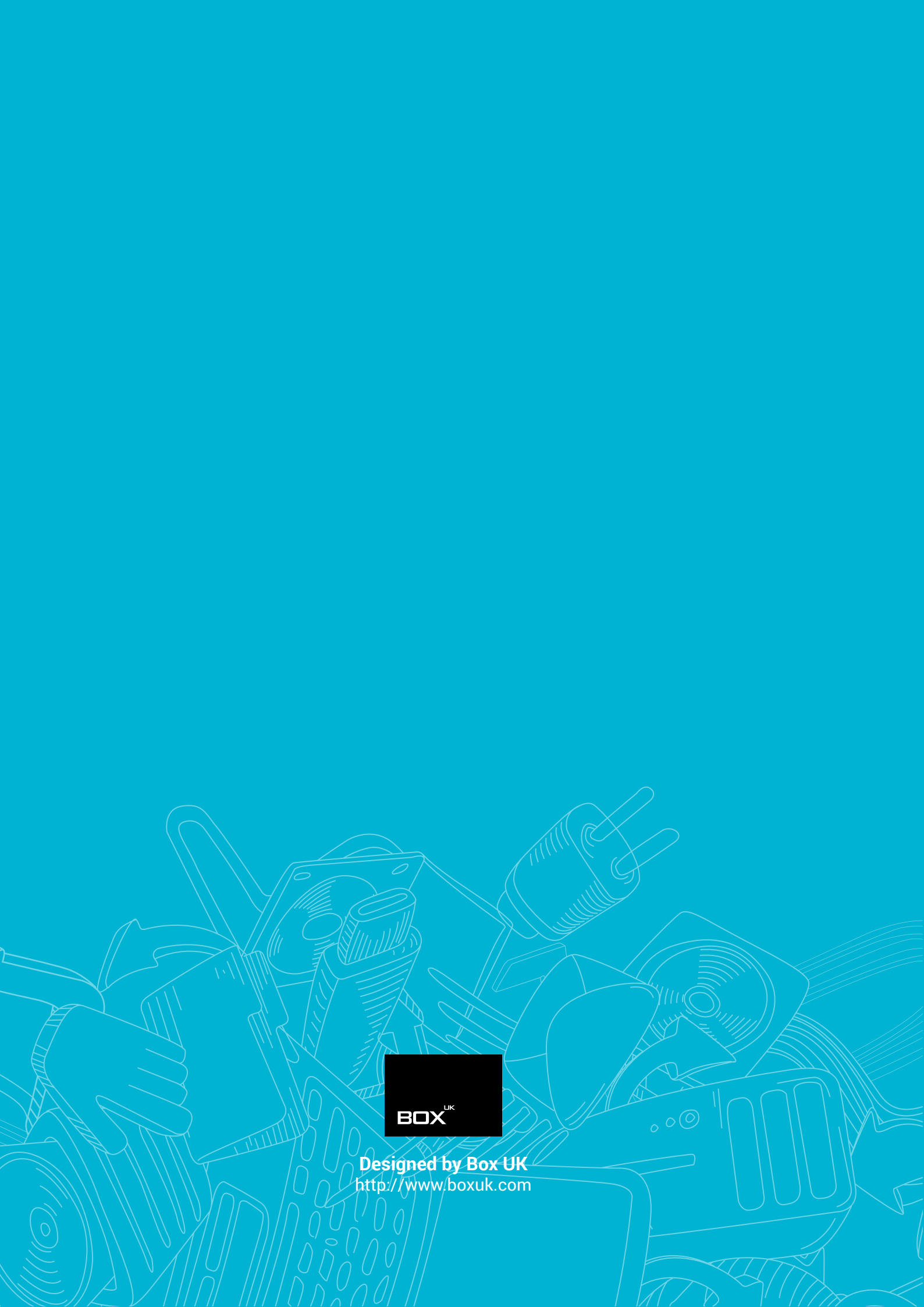


20. 6. A ddylai ysgolion, Addysg Bellach (AB) ac Addysg Uwch (AU) lunio cysylltiadau agosach â rhwydweithiau'r diwydiant i gefnogi'r broses o weithredu a darparu'r cwricwlwm diwygiedig?



21. Hoffem hefyd groesawu unrhyw sylwadau cyffredinol ac adborth sy'n berthnasol i'r ymgynghoriad hwn fydd yn helpu i ffurfio'r argymhellion ar gyfer yr adroddiad terfynol i'w gyhoeddi fis Mehefin 2013.





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