Post-16 Further Mathematics blended learning: learner self-regulation, mathematical resilience and technology

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This paper reports on a study set in Wales where the Further Mathematics Support Programme Wales supports the provision of an advanced qualification in mathematics for 16- to 18-year-old students with courses delivered in reduced teaching time. The study aimed to understand how the students experienced the Further Mathematics (FM) courses which are delivered either face-to-face or online and, more generally, to negotiate a place of alternative forms of delivery in post-16 mathematics curriculum. Sixteen students, eight of whom studied through the online course, were interviewed; overall, although they found the course challenging both in terms of the content and relatively limited teaching time, they enjoyed it and appeared to perceive benefits from taking the course. Most volunteered 'tips' about coping with the challenges of the course and the tips can be seen as strategies of self-regulation. Self-regulation strategies were reported more strongly by the students taking the course online than those attending face-to-face classes. In view of the evidence of technology creating new learning environments perceived as advantageous by students, it is hypothesized that introducing blended learning as part of post-16 mathematics curriculum could be beneficial. Improving learner self-regulation is discussed as means of improving access to FM. Other findings included the importance of support from peers, parents and schools and gender differences.

1. Introduction

Although distance, online, blended, open or e-learning originated in higher and adult education, school students also increasingly study from places other than a traditional classroom (Boulton, 2008). Alternative forms of education are mainly introduced because of three, perhaps connected, reasons. Firstly, they are seen as allowing learners who otherwise may have found it difficult to participate in education and to get access to knowledge and skills at full scale, thus contributing to a widening participation and the vision of social justice in education (MacKeogh & Fox, 2009; Jones & Lau, 2010). It is perhaps for this reason that the terms open and distance/computer-based education are sometimes

used interchangeably; although, the former emphasizes social policies and a political vision while the latter refers to methodology to teach and learn at 'distance', which is often interpreted freely as referring to time/space as well as to the media that cover long distances (Bozkurt, 2019). In 2020, a very large increase in solutions to providing remote access to education was seen in response to closing schools and universities in many regions globally, in response to the COVID-19 pandemic in 2020 (Kanwar & Daniel, 2020).

At school level in particular, the studies of alternative forms of delivery often cite effective sharing of resources as a motivator when funding is short, brick and mortar facilities are overcrowded, teacher expertise is limited and geographical locality is a challenge (Gong, 2018; Walden, 2019). Lastly, technology is simply available and is getting increasingly affordable, thus encouraging exploration of alternative forms of education (Collins, 2001; Herring, 2004).

Whatever the initial driving motivation of introducing non-traditional forms of delivery, arguably it is the actual learner benefits that are most important (see, e.g., Ginns & Ellis, 2007). Studies internationally and across various subjects cite student disengagement, low completion rates in environments that lack opportunities for social interaction and increase feeling of isolation while being associated with higher workload, as common areas of concern when introducing students to open, online or distance learning (Boulton, 2008; Kizilcec *et al.*, 2013; Lee *et al.*, 2013; Imlawi *et al.*, 2015; Murphy & Stewart, 2017). Here, certain tension becomes apparent: while aiming to improve access to education, alternative forms of education may instead contribute to narrowing it. The present study dwells on this and aims to contribute to understanding what factors could help to negotiate the place of alternative forms of education in post-16 mathematics curriculum. We approach this through investigating students' perceptions of learning mathematics in a new unfamiliar environment in the context of one post-16 mathematics course set in Wales. In the case considered, predominantly school-based students studied towards a Further Mathematics (FM) qualification with the Further Mathematics Support Programme Wales (FMSPW) where they attended classes online and face-to-face.

2. Wales context: post-16 mathematics and FMSPW tuition courses

In the UK, at the age of 16 years (Year 11), all students have completed compulsory schooling, which is terminated by a formal examination known as the General Certificate of Secondary Education (GCSE). In Years 12 and 13, many choose to study three or four subjects at advanced level (A-level). Two of the subjects available are Mathematics and FM. FM students are usually highly achieving in mathematics as acceptance on the course would be dependent on excellent results at GCSE. While only a small proportion of students (about 17%) who take A-level Mathematics take FM A-level (JCQ, 2018), the qualification is associated with the entrance requirements for some prestigious mathematics degree courses in the UK.

Not only because of the small numbers of students studying the subject, and in some cases there may be only one such student in a school or college, but also due to various reasons, such as lack of suitably qualified teachers, timetabling and funding constraints, not all schools are able to offer FM on their timetable and FMSPW was set up to fill this gap in Wales. In some cases, the FMSPW runs classes in schools (the face-to-face or traditional model) and, where this is not possible, it offers an online course with live online sessions (the online model) with both options supported by online learning materials. While such courses may have been envisaged as a temporary option, in view of recent reforms in England and Wales, access to post-16 distance learning mathematics courses may become essential (Smith, 2017). Indeed, FMSPW has been supporting schools in Wales since 2010 while similar support programmes have been available in England since 2003 and this support is envisaged to continue.

Blended learning is defined as a combination of several delivery methods such as, for example, face-to-face, computer-based learning, live online learning and self-paced learning (Rogers, 2009); this applies to the FMSPW model. FMSPW online and face-to-face courses are all accompanied by resources that contain information and details of activities and tasks, including online and computer-based, for learners to carry out in their own time, channels for asynchronous communication with tutors who are based remotely, as well as short 1- or 2-h sessions spread evenly over 6 months with students typically meeting their tutors once a week. Students that study through online courses attend live online lessons in the evening or late afternoon from home (or elsewhere). All live online sessions are recorded, and recordings are made available to the online students. Face-to-face students attend lessons in school with a tutor or tutors who visit the school to teach the FM course. Both online and face-to-face students receive the same amount of teaching time and are taught the same syllabus. The FMSPW course has fewer hours of tuition than most A-level courses and, in response, for all students, the programme runs face-to-face sessions on Saturdays in FMSPW centres across Wales. FMSPW students do not choose if they attend courses online or face-to-face. The decision is made by the FMSPW and is based on practical considerations such as tutor availability, the combination of modules and a school's A-level Mathematics provision. Approximately half of one typical FMSPW year's cohort would study online. Typically, only 20% of FMSPW students are girls, which is less than the average of 30% in the UK (JCQ, 2018).

The learner benefits of FM support programmes in terms of improved access to the FM qualification (Lee *et al.*, 2016; Tanner *et al.*, 2016), and, by implication, to mathematics degree courses (Darlington and Bowyer, 2016; Lyakhova & Neate, 2019, 2021) have been acknowledged recently. However, studying FM appeared to be associated with higher workload than in other subjects (Tanner *et al.*, 2016; Lyakhova & Neate, 2019); additionally, students viewed their participation as an experience outside of school or even the school syllabus (Smith, 2011). Therefore, it was hypothesized that these factors may work as restricting student choice of FM as a subject requiring students to take more responsibility for their own learning and study by themselves.

3. Coping with non-traditional delivery: inside and outside help

Learning to take responsibility and to engage in self-study is, for most students at this level, new and difficult and, it could be argued, requires students to adopt self-regulated behaviours. The theory of self-regulation is based on social cognitive theory and proposes that human behaviour is regulated by exercising self-influence which includes monitoring one's own behaviour, its determinants and its effects (Bandura, 1991). This requires judgement of, and subsequent adjustment of, one's behaviour in relation to personal aspirations and environmental circumstances. It has been suggested (Lynch & Dembo, 2004; Anderton, 2006) that self-regulated learning theory, such as the one that emerged through the studies of Zimmerman and co-authors (see, e.g., Zimmerman & Schunk, 2001; Schunk & Zimmerman, 2012a), offers a framework for studying educational phenomena from the perspective of the ability of individuals to direct and manage their learning processes. Zimmerman and Pons (1986) argued that learning is more effective when students are able to adopt self-regulation strategies which include self-evaluation; organizing and transforming instructional materials to improve learning; goal setting and planning; seeking information from non-social sources; keeping records and monitoring; environmental structuring of physical setting; self-consequences; rehearsing and memorizing; seeking social assistance from peers, teachers and adults; and reviewing records such as tests, notes or textbooks. In their model, special attention is paid to seeking social assistance. While relying on help from adults is perhaps unavoidable, seeking help from peers in preference to teachers or parents is associated with growing self-efficacy in older learners. Although these described practices could be initiated and maintained by teachers as part

of their usual classroom practice, self-regulation occurs when learners apply these on their own initiative especially when confronted with difficulties in their learning environment.

The concept of personal agency to exercise control over one's thought, motivation and action (Bandura, 1989) is also central to the construct of mathematical resilience which acknowledges that studying mathematics is, in itself, difficult. Mathematical resilience is defined as a positive adaptive stance to mathematics which allows students to continue learning mathematics despite adversity (Johnston-Wilder & Lee, 2010). The study of Kooken *et al.* (2013) favoured a three-factor model of mathematical resilience encompassing a belief that mathematics is valuable and is worth studying (the value factor), recognition that struggle with mathematics is universal for everyone learning mathematics (the struggle factor; cf. with an argument in Lyakhova *et al.*, 2019) and confidence that all people can develop mathematical skill (the growth factor).

While managing one's self can be an important element of coping with the difficulties of non-traditional learning environments, students perhaps need further external support, as Smith (2010) hypothesizes. For example, we know from previous research (Lyakhova & Neate, 2019) not only that FMSPW students are more likely to report feeling supported by parents than students studying FM in their school but also that students who studied FM felt more encouraged by their teachers in pursuing the subject. The studies, however, did not uncover what exactly parent and teacher support incorporated.

4. Methods

Sixteen students (26% of that year's cohort), comprising eight boys and eight girls, were selected to take part in the research. Stratified random sampling was used to select two groups: students that studied all modules face-to-face ('face-to-face' students) and those who studied online ('online' students). Equal numbers of boys and girls were included in the sample with the aim of getting a better insight into girls' perception of the courses and how, if at all, it differs from boys' perception. The geographical spread of the students included schools in suburban and rural areas, but not large city schools or colleges that are resourceful enough to offer FM on the timetable, which was the reason for subscribing for an FMSP course in the first place. The schools were from the areas ranked as 1 (two schools), 2 (five schools), 3 (six schools) and 4 (three schools) according to the Welsh Index of Multiple Deprivation (WIMD, 2019), where 1 stands for the most deprived and 5 (not included in the sample) stands for the least deprived. All students in the sample were high achievers and had at least grade A at GCSE Mathematics. Participation in the study was voluntary and the participants were free to withdraw at any time during the study. Informed consent was sought from, and given by, the participants. The research was conducted in accordance with BERA's Ethical Guidelines (BERA, 2011).

The students were interviewed on the telephone at the end of the academic year. The interviewer had a set of open-ended questions (see Appendix) prepared in advance: students were asked about how they felt about their overall experience of the FMSPW course and their most and least enjoyable experiences, what they thought of the workload associated with the course and what advice they would give to students considering FMSPW courses; this, it was thought, had a potential to reveal how students embraced new learning situations (perhaps different for online and face-to-face students) which were thought to have created opportunities for them working unsupervised, engaging with new format learning materials and, more generally, exercising their initiative, which, in turn, could have affected students' perceptions of doing mathematics.

For the analysis of responses related to students coping strategies, which appeared among the students' answers, the classification of self-regulation strategies introduced by Zimmerman and Pons (1986), see above, was used with minor adjustments. Reviewing session recordings was introduced

in addition to reviewing tests, notes and textbooks but the rehearsing and memorizing category was omitted as it was only referred to twice in the interviews but in the context of other strategies. In total, the following strategies were considered: (1) *self-evaluation*; (2) *organizing and transforming of instructional materials to improve learning*; (3) *goal setting and planning*; (4) *seeking information from non-social sources*; (5) *keeping records and monitoring*; (6) *environmental structuring of physical setting*; (7) *self-consequences*; (8) *seeking social assistance from peers, teachers and adults*; and (9) *reviewing records such as tests, notes, textbooks or recordings*.

In the next section, student identifiers are used to clarify the mode of study and gender in the student quotes, such as 'FB1' indicating a boy studying face-to-face or 'OG2' indicating a girl studying online.

5. Findings

5.1. Attitudes to FM

Whereas there were no questions asked specifically about mathematics, students commented on mathematics throughout the interviews. Studying more mathematics was named the most enjoyable aspect of FM and was given as one of the main reasons for recommending FMSPW courses to other students. As one student put it, 'the best thing was learning new stuff' (FB3). Students also strongly suggested that studying mathematics in FM was more enjoyable than A-level Mathematics with some stressing that studying FM and/or studying it alongside A-level Mathematics changed their attitude to mathematics in general. The following quotes provide examples:

> 'I am so glad I did it. At times it was really difficult but now having done it shows it is so much more immersive than normal [A-level] Maths. It made me love maths. I am really glad I did it.' (OG1)

> 'It made me realize how much I really like maths. Maths is so much prettier than normal A-level Maths because I was doing both at the same time, I was doing lots of maths, it was really immersive. When I talked to my friends that would be the main thing I talked about. I loved it!' (FG2)

Students' comments implied that not only what mathematics they learn and how they learnt it but also how this new mathematics related to their 'normal' A-level Mathematics all contributed to their attitude. For example, the very first module that the students studied in FM was considered by all the students as difficult. The module contained several totally new mathematics concepts and assumed knowledge of topics from A-level Mathematics that students had not encountered yet in their A-level classes. However, as a result of having to work harder to fill these gaps, students appeared to feel that it helped them learn mathematics, as illustrated by some of their comments:

> 'Especially [the first unit] throws you into the deep end of things so you can kind of feel more ready for the next year.' (FB1)

> '[The first unit] was definitely a hard module for me. I am now beginning to see how it will help with the A-level Maths modules next year.' (OB3)

> 'The best thing was the help it gave with A-level Maths, it made the mathematics easier with the integration and differentiation.' (FG3)

Furthermore, the questions in FM were seen as 'not as structural as A-level Maths' and students suggested that they were left to decide on intermediate steps and, sometimes, on the whole strategy—explaining, for example, that in FM there was more variability in the types of questions, meaning that they needed to learn to think independently.

Student comments further implied that while spending more time thinking on their own and learning from different sources as well as different people, both adults and peers allowed them to do mathematics and think about mathematics in a new way. One of the students summarized how he viewed the essence of the approach:

'Students themselves needed to do the work and practise questions. They needed to get it explained to themselves not just what to do, but why.' (OB1)

Students reported that they became open to different strategies, became not scared to try new and different approaches and developed awareness of interconnections between topics which resulted in them learning several ways of finding answers.

Interestingly, the hard work required for succeeding with the course was reflected in a number of student comments that their ability was less relevant than hard work. For example, one said that although FM is regarded as an 'elitist subject', if students were prepared to work hard then most people doing A-level mathematics would be able to cope with FM. Another one mentioned that if students can do mathematics, and were committed to FM, they would manage. Some respondents even questioned why only students who achieve the top GCSE grades take FM, with one saying, for example:

'Only A grade students study Further Mathematics, but that's not necessarily good. I think even with a C in [GSCE] Maths, you could improve it with Further Maths because you get a different way of looking at it. Maybe they will see Further Maths as being more enjoyable.' (FG1)

5.2. Student coping strategies and self-regulatory behaviours

Despite finding the FM course difficult, all the students in our sample carried on with the course for 1 year. Eleven students (68% of the sample) achieved grades A or B which was approximately in-line with the FMSP results that year. All the students added tips about how they coped with the studies. These appeared throughout the interviews and, notably, when describing the whole course, the least and the most enjoyable experience, when talking about other A-levels they study and the workload. The tips were sometimes reinforced when talking about advice to other students considering the FMSP. The analysis of these showed that students displayed the characteristics of self-regulated learners and, in total, self-regulation strategies were mentioned 112 times in the interviews, see Fig. 1, with the three most popular categories being *reviewing records*, *goal setting and planning* and *seeking social assistance*. Out of different types of records, reviewing notes was the most popular category followed by reviewing recordings. When asking for help, peers were mentioned most often followed by teachers and, then, by adults.

The number of self-regulation strategies mentioned by the students was not uniform across the whole sample. For example, we noticed girls overall being more vocal about their coping strategies than boys. In total, 70 strategies were mentioned by the 8 girls against 42 mentioned by the 8 boys. But even more pronounced differences (31 against 81) were noticed between students who studied face-to-face and those who studied online where the differences were most marked in *reviewing records*, *seeking social assistance* and *goal planning and setting* categories; see Fig. 1.

The central theme of the responses of the face-to-face students related to those elements that students perceived the course lacked in comparison with other A-level subjects they studied in school and which made it challenging for them to cope with the course. In these students' views, the course offered only one point of contact (the tutor), too little contact time and too much time between contacts as, for example, the following quotes demonstrate:
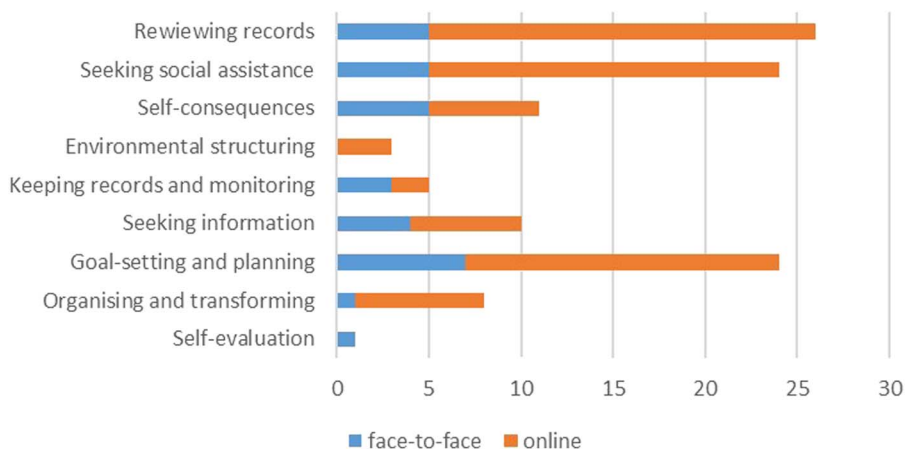
Fig. 1 Popularity of self-regulation strategies.

'The lessons were of good quality. The only problem I would say was that if I missed a lesson, I found it quite hard to catch up. Obviously, there were online resources but if I did not understand part of the work then sometimes it would overlap into the two weeks so then with the homework, I found it quite difficult at times.' (FB2)

'It was not hard going to attend the session. The problem was just one point of contact. I would understand the work at the beginning of the week and forget it by the end. For me, I think, only seeing the tutor once a week and not being able to ask a question was a big thing.' (FB3)

'The number of hours we had did not seem like enough. I would have liked more time to look at examples with someone.' (FG2)

Additionally, students from this group made a strong point about having difficulties in finding extra learning resources relevant to their course. One of the students summarized his experience (FB1): 'If I was stuck in other subjects, I could go to a teacher if I wanted or there was a lot more resources available.' Like the other students in the sample, he said he felt that neither option was available in FM. While students recognized that there was extra help available in terms of Saturday sessions or access to the tutors, it seems that for some, there was still not enough contact time. For example, one student said that about his experience of Saturday sessions (FG3): 'It was still just a few extra hours of contact. It's not necessarily going to be enough to cover everything even then.'

Unlike the face-to-face group, the responses of the online group about what they found challenging were not uniform. For example, only one student studying online mentioned that the number of teaching hours was not enough. Although some comments of the online students echoed those issues indicated by students in the other group, for many, it was rather a combination of different factors. One of the students explained,

'The first module was hard at first. I struggled with online. I questioned whether it was right for me. But then it fell into place. I did work hard, and it finally clicked.' (OB1)

The quote above is somewhat typical for this group. While it explicitly suggests online learning as a challenge, some other students generally gave the novel format of the course as a reason. However, like

the student above, many reported that once they were settled into the course, they could manage it while also referring to effort and commitment on their part as a factor that helped. It seems that the format of the course played a role in students' perception of the whole course and their experience. Students studying online appeared to like the new format, saying, for example, 'I found it quite good', 'worked well for me' and 'I liked it.' Moreover, there were students in the sample who found studying online the most enjoyable part of the course and, in some way, 'slightly better than the school's class'. Several students used the phrase 'no pressure' when describing their experience of studying online which referred to both being in the virtual classroom and subsequently revisiting recordings offline. More specifically, several girls emphasized how the virtual classroom provided them with a more comfortable and safer environment, with one girl, for example, explaining, 'I quite liked it . . . I felt like it wasn't so much pressure because you weren't being picked on for an answer all the time. It was like you could give an answer if you know the answer' (OG4). But there were also downsides of having a live online class. The quality of internet connection sometimes caused problems when 'people kept dropping out of the lessons and coming back'. While these students did not seem to feel it was a major issue as recordings of sessions were available after each lesson, there was another student who thought that the technology was the least enjoyable experience of studying the course. The student had repeated problems getting into the online classroom and adopted an almost entirely asynchronous format of studying the course, accessing the materials online and communicating with her tutors. However, like other students in these groups, she added (OG1), 'But once I got in the rhythm of it, I was fine.'

Despite the challenges, all the students in this group appeared to feel positive about the outcomes of the course as captured in the quotes below:

'I feel like it was pretty good. It was definitely good in providing a structure how to learn [FM]. I could not have done it on my own.' (OG3)

'I think it is a very good programme – it worked effectively for me.' (OB2)

In the opinions of the students, one feature of the course was 'less directed teaching', which perhaps is not inconsistent with the views of the face-to-face students. What made the views of the online students distinct is that these students appeared to think that it required them to approach the course differently.

'I think it requires different ways of organising things but for the work itself, if you are willing to work then it's not really that difficult.' (OB2)

'The most important bit is to be committed to it. If you start not whole-heartedly willing to do it then it's so easy to get lost and not be dedicated to wanting to learn. It is a lot more independent than other subjects in school, so you have to be more committed to be successful.' (OG4)

'If you are not committed to doing online lessons, you are not going to do as well as somebody else.' (OB4)

The students suggested that as an added value the FMSPW courses 'brought on a whole load of new skills'. Alongside other self-regulation strategies, most students in this group emphasized the role of will-power. One student, for example, explained (OG1), 'I just had to be really strict with myself going to the library, going through lessons and extra work and stuff.' The apparent persistence of the students who studied online is interesting and in view of their comments about how they struggled first and questioned whether the course format was right for them, and, importantly, in view of a high numbers of self-regulated strategies they employed, perhaps indicates perseverance in students.

In the next sections, self-regulation strategies and students' tips on how they coped with the course provides the background against which experiences of students will be examined in more detail.

5.3.   Planning and organizing for homework, more work and more independent work

Students appeared to perceive their experience of the course as almost exclusively working in between the lessons. Many, including all but one online student, emphasized not only that they allocated more time for FM work than they did in other subjects but also that they suggested it was different kind of work, e.g., 'more going off and finding out what you need to do and work on'. The comments implied that students could choose to engage in three kinds of work: homework, reviewing notes prior to the next lesson and practicing solving more problems. Engaging in these and working independently was seen as essential for making progress with the course, as the following quotes demonstrate:

> 'During the lesson I always understood the work, but until I tried to do things later on my own, I did not realize what I didn't really understand. Because [mathematics] is sequential, if I did not do the homework, I would struggle with understanding the next lesson. Always do the homework.' (OB3)

> 'I personally found it quite easy to understand straight away [in lessons] and then it was more about going over lots and lots of questions in my own time … even if it's just the questions that the tutor has not gone through and skipped because you can do it later.' (OG4)

Revising between the lessons, as in the case of the homework, was understood as leading to 'knowing what to do in the next lesson' (FG4) with a typical comment being 'Review the lesson before you go to the next one' or, more specifically in the case of online studies, 'Go back and watch the video again then you can see what you have forgotten before the next lesson' (OB2). Students further emphasized how they decided to revise from the start of the course not waiting until they got closer to the examination. One student for example, explained (OG2), 'I guess I knew what was happening and I revised from the beginning. I made revision notes, I made detailed ones.'

Students evidently aimed to utilize as much school time as possible, such as using occasional empty slots in their timetable for FM, synchronizing their timetable with FM peers, finding a way to 'spread' the workload in FM or other subjects throughout the year or finishing early with the subjects they found easy so more time could be used for FM. However, whether students had, or had not, such opportunities depended on how post-16 curriculum provision was organized in their school. For example, in some instances, A-levels were shared between several schools and students needed to travel from one setting to another for different subjects. One such student reported that she felt she had no choice but to use the time spent in travelling between the settings for revision, which she felt added to her workload.

5.4.   Transforming, organizing and using resources for self-study

In view of earlier remarks registered by face-to-face students about the lack of resources for FM and a striking lack of such remarks from online students, we consider what materials were mentioned in the context of self-regulated strategies 2 (*transforming the instructional materials to improve learning*), 4 (*seeking information from non-social sources*) and 9 (*reviewing records*).

When referring to instructional materials, students referred almost exclusively to the materials 'generated' by the live online tutorials rather than the standard resources available to all FMSPW students. Importantly, such resources would not have been available to the students studying the course face-to-face. Three types of such resources were identified as most helpful: a recording after the tutorial,

a teacher PowerPoint and a PDF document which consisted of the screenshots of the recordings. The option of converting screenshots of the recording into a PDF was pointed out by the tutor and seemed to be perceived by students to be helpful even in some difficult situations, such as when they missed a lesson or had problems with internet connection. PDFs were also used as a set of notes for revision before the examination or for reviewing materials before the next lesson. Students reported that they printed and annotated the PDF while re-watching the recording and subsequently used their annotated record for revision before the examination. When working through the recording, students said that they especially appreciated working at their own pace, which allowed them to take time to review what they had done and return to it when they were ready.

When studying outside the lessons, students seemed to value not only resources that, they explained, were clear and self-explanatory but also those that were a good source of more questions as the following quotes demonstrate:

'Always go through the PowerPoints after the lesson when [the tutor] have sent them to you because [...] most of the time [the tutor] did not go through it all but there are questions at the end you can do.' (OG1)

'[The textbook] was very useful for questions, there were different ones from WJEC [the exam board].' (OB4)

'Always take down loads of notes after the lessons, even if it's just questions that the tutor hasn't gone through and skipped because you could do it later.' (OB3)

But the quotes perhaps also indicate that some students were consciously looking for extra practice.

There were numerous comments on arranging the instructional materials and keeping them in order. These were motivated, it seems, by the pressure of the workload. One boy, for example, explained (OB1), 'Get files and put things in sections. Putting work into the right slots so that you know where to find things. If you can't find something you get wound up. Then you are not in the right frame of mind to work. File dividers are good.'

5.5.   *Social environment and seeking social assistance*

As seen in Fig. 1 above, getting others to help with FM seemed to be important for the students. One student summarized his overall advice on how to cope with the FMSPW course as 'know who your support network is – identify people who can help you (OB2)'. As the number of contact hours was limited, the students were mostly concerned about whom to turn to so they could 'ask questions when they come up, do not wait and waste time struggling'. While some students reported that they would email their tutor, others said that they would go to their regular mathematics teachers in school. Some students noted that learning mathematics from different people contributed to their awareness of alternative approaches to solving mathematics tasks. One student stressed (FB1), 'Do not think the way the tutor does it is the only way. My teacher showed me a way which was much better for me.'

Saturday revision sessions were generally reported as helpful and seen as 'big opportunities to ask for help' when preparing for examinations and, as a result, some students reported that they aimed to attend as many as they could. Students who studied online suggested that the Saturday sessions were one of the most helpful aspects of the course, sometimes providing an explanation such as 'there was no delay in response' (as may have been the case with an email to a tutor, for example). When students found it difficult to grasp the materials the first time they encountered them, they appeared to find the

sessions particularly helpful (OG3): 'But once you got to the Saturday sessions everything would click into place.'

The majority of the comments, however, were concerned with peer support. For example, attending the Saturday sessions was apparently seen as an opportunity to meet new friends; one student explained that it provided an opportunity to meet 'people like you' and have a 'conversation about maths with them'. Some students said they had made new friends through online tuition classes and then maintained the relationship with their new friends through social media and occasionally asked for their help with mathematics. Overall, girls more often than boys reported making new friends. Students reported studying together whenever they could, with some explaining that they did homework in school together although they studied online. A girl who studied FM alongside five other students from the same school explained (FG4), 'I think it is easier when there are people you know doing it as well. You have got people to talk to if you do not quite understand maths fully.' The importance of peer support, as mentioned above, was reinforced by numerous comments from the students who did not have other FM peers. For example, one girl being the only FM student in her school stated that she would have preferred 'to have had a couple of other people to just ask questions' (OG2).

Additionally, there were cases of students asking their parents to help with what could be perceived as advanced mathematical tasks and, more generally, many students felt they could ask their parents to help with other subjects. One girl explained her strategy (OG4), 'Just reading through it and saying it to someone else you find your own mistakes.' She added that she did not expect her parents to understand the mathematics and, yet, she felt that by listening to her, 'they helped which was nice'. Parents' help also seemed to be important when schools were reluctant to offer FM. As one student explained (FB1), 'My parents helped to push for it and get FM into our school.' In some cases, it was the parents who found 'the online method' because 'they really wanted me to be able to do the best and get into the university.' Further, parental support was also crucial for getting students to keep their schedule on time, such as when getting back from school ready for an online tutorial or to the Saturday sessions.

The students' reported perceptions of their peers' attitudes to them studying FM were mixed. The boys talked more about their friends being 'impressed', explaining that this was because FM is seen to be difficult. The girls used words 'funny', 'crazy' and 'mental' to describe what others thought about them taking FM. One girl, for example, commented (OG3), 'They [peers] thought I was a bit mental, but I have always been hard-working and not bothered what other students have thought. This is about me.' On the other hand, it seems that at least one of the girls felt unsupported by her peers: 'it was just "Stop it! She is talking about integration again!"' (OG2)

5.6. *Self-consequences and self-evaluation*

Several occasions of using the *self-consequence* strategy were registered in the context of completing the whole course and gaining a FM qualification. It appears that students envisaged securing university or apprenticeship places and securing university places specifically where competition was high as a result of doing the FM course. One quote provides an example:

'If you are going to do mathematics based subject then it would be really useful just to get more mathematical practice really because the core subjects are quite a lot of work but if you want a competitive university then an extra qualification would show that you cope with mathematics.' (FG1)

In such contexts, references were made not only to the extra mathematical contents but also to the format of the course. Students appeared to view that studying online, experiencing less directed teaching and

more independent work or, simply, more work would help to adapt to university studies in future which served as an additional motivator for some students to put the hard work in. One of the students explained,

> 'I suppose the method was similar to university style learning. I had to knuckle down and understand the work before I went to the lecture If you ask a question, then they [tutors] will answer you. It is good practice for university as you have to be more independent.' (OB4)

On the contrary, only one reference was made to self-evaluating own progress (self-regulation strategy 1) and that was in the context of the overall progress with the course. This was from a boy who studied face-to-face and who perceived that due to not enough teaching time, he felt he was not doing well. While acknowledging that with the FM course extra effort on students' part was important, he decided to carry on doing FM 'on the side'. As a reward of continuing with the course the student imagined the knowledge gained benefiting his future degree course in aeronautical engineering, saying (FB4), 'Especially the Further Pure modules will definitely help me with a maths-based course at university.' But he also imagined the consequences of his choice: 'you are not gonna get a brilliant grade if you do it on the side.'

5.7. *The role of the students' home institution*

Students reflected on the overall support and attitude to studying FM in their school. For some, the school's attitude in encouraging students to take FM was seen in their organizing FMSPW to support their students and, perhaps, further in-school support. One of the students, for example, explained that it was the school that prompted the question of FM wanting the student to 'apply to Oxford and be competitive'. A different student explained that their school arranged not only FMSPW tuition but also timetabled a weekly lesson with the student's regular mathematics teacher. Other factors reported by the students that helped them to decide to study FM through FMSPW were also related to their home institutions. These included regularly attending mathematics events at a local university with their school, a long-standing relationship with FMSPW and some continuity, however patchy, of provision for FM in their school. For example, in one school FM was on and off the timetable and the FMSPW was used by the school when they could not timetable it. However, the students seemed to be aware of it and the fact that they knew there was a teacher in school who taught the course the year before appeared to help them to feel comfortable.

Although the students recognized that being able to study independently was important to succeed in FMSPW courses, only one student acknowledged the role of his school in this respect. The boy explained that his school 'does not spoon-feed, purposely, so it encourages self-directed learning' (OB2).

6. Discussion

Students' experience of the course appears to be shaped not only by the format of the course, the school and the family and peer support but also by the students' personal strengths and the subject itself, which is the mathematics they learn in the course.

The students' responses suggest that FM FMSPW courses are valuable for the students as these allow learning and doing more mathematics, enjoying mathematics more and learning and thinking about mathematics in new ways. Moreover, our findings may be interpreted as evidence of mathematical resilience present at least in some of the students in the sample, as references to the value, the struggle and the growth are recognizable in students' talk. A perception of effort being more important than ability

for succeeding with mathematics noted in the study is not generally found among mathematics students. For example, a recent study of STEM undergraduates found that the majority of those who studied FM felt that only gifted students should study the qualification (Lyakhova & Neate, 2021). But the study also found that students studying through FM support programmes in England and Wales (including FMSPW in Wales) were likely to agree that studying FM gave them a broader understanding of mathematics in general than those who did FM in their school or college.

We therefore suggest that the format of the course and, more specifically, the opportunities for asynchronous learning that the course offered impacted on students' approaches to learning mathematics. As we have seen, technology could create new learning situations as well as new learning materials that students perceive as beneficial; although, perhaps an effort from students, as well as external support, is required to successfully adapt to these. The positive views on using technology referred to the asynchronous feature of learning which allowed students not only to compensate for limited teaching time available but also to accommodate for their individual differences in learning. While the format of face-to-face studies is perhaps more familiar to the students, it is the online FMSPW courses in its current format, which includes face-to-face support, about which the students appear to be most positive. This reflects the findings of comparative studies on online and face-to-face courses that generally agree that blended learning that combines elements of both is more beneficial than either entirely online or entirely face-to-face options (see, e.g., Ginns & Ellis, 2007).

However, and importantly, our finding about self-regulatory behaviours being essential to succeed with the FMSPW reinforces the argument of Hartley and Bendixen (2001) that the technology alone does not improve access to education; rather, it is improving learner self-regulation that makes learning in new technology-enhanced learning environments effective, therefore contributing to widening access (cf. Lee *et al.*, 2013). To further understand this, below, we consider self-regulation in relation to some other factors that were found to shape the experience of students in this study.

Gender stereotypes about mathematics are well known and are recognized as contributing to narrowing access to post-compulsory studies of mathematics (Stoet & Geary, 2018). We found evidence that FMSPW girls not only could be aware of such stereotypes but also could be affected by them. The importance of tackling gender imbalances in the context of the uptake of FM follows partially from a recent study of undergraduates that found that among students who studied FM, girls more than boys tend to say that it made the transition to university easier (Lyakhova & Neate, 2019). In view of explanations given by girls studying online, one may be encouraged to ask if introducing more mathematics courses requiring and stimulating asynchronous learning and self-regulatory behaviours may help to tackle gender imbalances in mathematics in general (cf. Smith, 2014).

The result that girls mentioned self-regulation strategies more than boys may be because they adopt more of these behaviours or because they are more aware of their own self-regulatory behaviours. It seems, from the literature, as reported by Yukselturk and Bulut (2009), for example, that this is to be expected. The important implication would be that girls are perhaps better equipped than boys to study with the FMSPW.

Studies of school children learning via an online or distance course noted that, in addition to the role of the tutor who is remote from the learner, a second role needs to be fulfilled, which is that of a mentor (Hernández-García *et al.*, 2015; Imlawi *et al.*, 2015). We note that in the course considered in this study, it is sometimes the student's schoolteacher and sometimes the parents who fulfil the mentor role. In our sample, better student–parent interaction may have been related to greater parental academic skill ('good at maths' or 'scientific') but it also assumes parental availability or, perhaps even more importantly, parental interest. In this, our findings agree with the results concerning gifted and high-achieving students who are generally known to take greater advantages of parental support at home (see, e.g., Zimmerman &

Martinez-Pons, 1990). Parental resourcefulness may become an equity issue and the evidence considered in this study suggests that schools themselves have an important role to play in providing support. This could be in terms of advice on studying FM, regular access to the mathematics teacher to look at FM materials together as well as a timetable that allows for these regular slots to be built in. While one may agree with Boulton (2008) that schools may want to consider planned parental involvement for students studying with courses like the FMSPW, it is perhaps even more important to include planned school involvement for the courses delivered by external providers to anticipate narrowing access for students who may struggle to secure parental support. The positive role of the school is noted by Harnisch and Taylor-Murison (2012) in the context of a vocational course delivered by a university to sixth form students.

Drawing on the theories of self-regulation, we find the students' views on the role of social support and, in particular, peer support important. While reliance on adults is expected to decrease as students mature and become more self-efficient, their active seeking of peer-support, in turn, is associated with increase in self-efficacy. Although the term 'self-regulation' may sound like reliance on socially isolated methods of learning, the study of the nature and origins of self-regulation (see, e.g., Zimmerman & Schunk, 2001) showed that social contexts are essential for its development in learners. Moreover, if one is to agree that mathematics is an essentially social activity where meanings are acquired through negotiations fostered by social interactions (Khait, 2005), then our findings on the importance of peer support for studying advanced mathematics is of no surprise.

Theories of learner independence and autonomy are regarded as important for studying distance, blended or open education. In the context of higher education that involves mature learners this is explained by the relationship of pedagogy ('to lead the child'), andragogy ('to lead the adults') and heutagogy ('to lead the self') in relation to learner maturity/autonomy required by the course on one side and instructor control/course structure on the other side (Bozkurt, 2019). 'Leading the self' in learning is associated with situations when greater learner autonomy is required or greater learner maturity is exercised while instructor control and/or course structure is deficient or its influence is diminishing (Canning, 2010). The characteristics of self-directed learning are known to incorporate learner independence and ability to manage their own learning, the potential to learn from novel experiences, the learner deciding on their own path by negotiating the learning through interacting with others and the environment (see, e.g., Blaschke, 2012). These all echo the experience of the students considered in this study. We speculate whether going through a process of maturation at the age of 16–18 years plays a role in students enjoying the course which, as it seems from the evidence considered, fosters greater learner maturity.

The lack of self-evaluation strategies in our study is puzzling in view of previous evidence on FMSP students likely to display high self-efficacy (Lyakhova & Neate, 2019) which is known to be related positively to one's ability to self-evaluate; although, see a discussion in Schunk and Zimmerman (2012b) about the relationship between self-efficacy and self-evaluation in environments that are 'learning goal' (i.e., aiming to learn how to solve problems) or 'performance goal' (i.e., aiming to solve problems) oriented. The results may have been different if self-regulation strategies had been purposely prompted. Perhaps even more importantly for us, the evidence of one student deciding to take FMSP course 'on the side' taken together with the evidence of some other students reflecting how once they realized how demanding FMSPW courses were, they questioned whether it was right for them, indicates that the process of making a choice of FM did not stop once the students enrolled onto the FMSP courses. While there is evidence that students took the decision to enrol on a FMSPW course together with adults or peers, there is no evidence of discussions with adults about ongoing commitment and hard work. We consider that it may be beneficial for students to have such conversations, perhaps with a

particular emphasis on self-regulation and self-evaluation, prompted by FMSPW, their regular teachers or a mentor.

If previous studies of student choice of FM suggested that a return of the subject on the timetable was a preferable option to improve access to FM (Smith, 2010; Smith, 2011; Tanner *et al.*, 2016; Lyakhova & Neate, 2019), the findings of the present study provide a different perspective on this question. While acquiring academic knowledge is usually seen as the aim of studying academic subjects at post-16 and self-regulated learning is generally assumed to take the role of serving this aim, a different view may be taken: that self-regulatory behaviours foster the development of life-long learning skills and, as such, are an important outcome of schooling in its own right. Zimmerman (2002) in his brief overview of self-regulation proposed that self-regulation could be a way to compensate for individual differences in learning and, if taken as central to the process of schooling, implementation of self-regulated learning could facilitate access to the same curriculum for a wider pool of students. Given the evidence of students' positive attitudes to mathematics associated with learner appreciation and use of the self-regulated strategies in this study, one may further be encouraged to ask if the self-regulation as a process enabling one to deal with a subject many students find difficult is also important for students' mathematical development.

At the time of writing, implementation of blended learning at school level (EEF, 2020) and self-regulation (Hattie, 2020a), as a personal resource for managing learning in different circumstances, became of interest because of school closures in response to the COVID-19 pandemic. The findings of our study agree with other evidence (see, e.g., EEF, 2020) indicating that affordances of blended learning at school level, among other things, depends on student capabilities and efficient learner support. The factors that are important for achieving this include stimulating peer interaction and improving learner study skills (Escueta *et al.*, 2017; Thalheimer, 2017; Means *et al.*, 2020).

In relation to developing self-regulation, Hattie claims that Australian schools that implemented his Visible Learning framework with the focus on learners becoming their own teachers, found the approach helped during the COVID-19 school closures (Hattie, 2020b). A recent systematic review of published research on the self-regulation of learning (Lawson *et al.*, 2019) stated that despite wide recognition of self-regulation framework, the promotion of self-regulation by teachers and its use by students is less common than might be expected. In view of this a hypothesis that blended learning courses when designed with fostering learner self-regulation in mind could be suitable and beneficial to post-16 mathematics learners would benefit from further investigation.

In terms of transition to university, previous studies on FM qualifications (see, e.g., Darlington & Bowyer, 2016; Lyakhova & Neate, 2018) found the positive impact of FM was mostly due to the relevance of the mathematical content. The present study may imply that learner self-regulation, whether developed or practiced during an FM course, could be considered as a factor in positive experiences in transition. From the perspective of a blended learning mode of studying, one may further agree with Harnisch and Taylor-Murison (2012) who proposed that blended courses delivered through a partnership of schools and universities to post-16 learners' schools have a potential of not only improving transition in terms of academic skills but also developing independence both socially and as a learner.

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Appendix: Interview Questions

1. Describe your FMSP course.
2. How do you feel overall about your experience?
3. What was the most enjoyable experience you had?
4. What was the least enjoyable experience you had?
5. How did you choose to study it?
6. What other A-levels did you study?
7. What do you think about the workload associated with Further Mathematics?
8. What did your family and friends think of the FMSP course?
9. What advice would you give to someone considering an FMSP course?
10. Is there anything else relevant to your experience of the FMSP course that you would like to talk about?

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