# An investigation into how STEM students use learning resources in different formats, and how this use develops over time

**Keywords** digital content; books; learning resources; virtual learning; distance learning

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# Executive Summary

An overall summary of our findings would be that:-

**For OU STEM students the ideal package of study materials would be a combination of books and digital content, particularly digital quizzes and visual content such as videos, animations and recordings of lectures. Students also want the option to access the content of any books digitally, both online and offline.**

1198 students on 3 different stage-2 (second year undergraduate) modules in Physics, Maths and Computing were asked to complete questionnaires around how they used the different learning resources on offer to study both their current modules and their stage-1 (first year undergraduate) modules. 225 students responded to the survey.

Key findings were that:-

1. Students use a mix of digital and paper-based study methods, regardless of whether a module is presented entirely digitally, or has a mix of paper and digital resources.
2. The most popular ways of learning for STEM students were 'online quizzes and iCMAs (interactive Computer-Marked Assignments)', and 'doing exercises and activities on paper', followed by 'taking notes on paper' and 'using module software'
3. a) Students who have previously studied an entirely digital module at stage-1 are less likely to need to change the way they study when they meet an entirely digital module at stage-2.
   b) Students who have previously studied an entirely digital module at stage-1 are less likely to find that any changes they need to make to study their stage-2 module causes them problems.
   c) However, considering only students who have studied an entirely digital stage-1 module, now studying an entirely digital stage-2 module, their main concern was a desire for more books, showing that while previous experience of entirely digital study helps students with subsequent digital study, most students would still prefer to have access to books as well.
4. Students studying an entirely digital module seem to shift from annotating module textbooks to annotating printed pdfs and making more notes on paper, rather than developing ways to annotate information online or making notes electronically
5. Students value digital resources, particularly audio-visual digital content and online quizzes, and would like more of these alongside books for textual content. They would also like digital content to be available offline.
6. Age is not a predictor of whether students would prefer more books or more digital content.

Further in-depth interviews were carried out with 12 students to explore some of these issues further. These highlighted that for STEM subjects, OU students:-

1. Prefer to have a combination of book based and digital resources.
2. Particularly value digital visual content and online quizzes
3. Find two devices with large screens are required to study entirely digital material
4. Find books better for studying while travelling, both for ease of use and because of poor internet connectivity while travelling

5. Want to be able to access digital module material offline
6. Want to be able to access a digital version of any paper module books.
7. Don't seem to find digital note-taking easy/effective – and to get it to work at all for them, need access to expensive technology (~£1000 on top of the cost of their main PC)

In addition, for some students, too much time spent looking at a screen does cause issues, but that is not the case for all students. This is not age related but seems to be particularly an issue for those who use a screen all day at work.

In summary, in the STEM faculty, module teams should be aware that students prefer a combination of books and digital resources to entirely digital resources, and this is not age related. Students would like more non-textual (audio-visual) digital resources, and more online quizzes. Qualification leads and module teams should be aware that students meeting an entirely digital module for the first time are likely to have problems adapting their study methods, particularly if this happens after stage-1. In addition, the impact on students from poorer backgrounds of entirely digital modules should be considered, since entirely digital modules seem to require at least two different digital devices for effective study, as well as a good broadband connection and access to a printer.

# Contents

# Aims and Scope of the project

## Original aims of project

The central research questions for this project were:

1. What is the impact of students being required to develop different learning strategies part way through their studies due to meeting modules which rely on different media for learning resources?
2. What are the possible ways to mitigate this impact?

The plan was to answer these questions by investigating what learning resources students on a range of STEM modules use, how students use the learning resources the OU provides, and how this use may evolve over time, as described below.

## Additional aims subsequently developed

It became clear that due to new curriculum developments there was the opportunity to repeat the questionnaire in the subsequent year, and gather data on the impact that having studied an entirely digital module at stage-1 had on students who studying an entirely digital stage-2 module. Additional research questions were therefore:-

3. Does having studied a module at stage-1 presented entirely digitally mean students are less likely to need to change their learning strategies on a subsequent stage-2 entirely digital module?
4. Does having studied a module at stage-1 presented entirely digitally mean students are less likely to have problems if they need to change their learning strategies on a subsequent stage-2 entirely digital module?

## Goals

- identify and where possible, quantify, the use students make of the broad spectrum of learning resources provided
- identify similarities and differences between the different approaches that schools in STEM take
- identify the similarities and differences between students' learning strategies in the different schools
- highlight any difficulties that students may experience when transitioning from stage-1 to stage-2, perhaps due to different school philosophies on the type of resource which should be available

- identify how the use that students make of different types of learning resource evolves over time
- investigate whether students' preferences for specific types of resource have any correlation with factors such as age, gender, first language/mother tongue
- use individual interviews to investigate whether any correlation has an underlying causality.

# Activities

## Background

At the Open University there are 3 stages of study at undergraduate level, corresponding to 1st/2nd/3rd year study at a standard English university, with 120 credits of study to be completed at each stage. Open University students may study at a part-time rate (anything from 30 credits a year to 90 credits) or full-time rate (120 credits a year), and this can vary from year to year. All Open University modules have a virtual learning environment, with online tutorials, forums and learning resources. However, not all modules also send out study materials in paper form, some are designed to be studied entirely digitally, that is, onscreen.

## Overall approach – phase 1

Samples of students were selected who were studying stage-2 modules in the STEM faculty starting in October 2017; approx. 200 students on a module in each of Physics, Mathematics and Computing. The three modules were chosen to provide contrasting data. One was entirely onscreen and digital; one relied primarily upon purpose-written textbooks with additional digital resources; and one offering a blend of digital resources, texts in the public domain and texts specifically developed for the module. Students coming onto these modules might have come from stage-1 modules which offered entirely digital stage-1 study resources, a mix of digital and book-based study resources or mostly book-based study resources. This allowed comparison between students who met a new approach when they reach stage-2 study with those who did not.

599 students were asked to complete an online questionnaire and then for a small subset of these students (12), further in-depth telephone interviews were conducted

## Overall approach – phase 2

It was decided to repeat the questionnaire on a similar sample of students on the same modules starting in October 2018. Again, n=599. The main reason for this was that, due to curriculum changes, a far higher proportion of students on these modules in 2018 would have studied an entirely onscreen and digital module at stage-1, allowing further investigation of issues surfaced in phase 1 of the project.

## Detail of Activities and Methods

Initially three samples of students were selected who were studying stage-2 (i.e. second year undergraduate degree stage) modules in starting in October 2017; one sample from each of Science, Mathematics and Computing. The students were drawn from modules
M269: Algorithms, Data Structures and Computability (Computing).
MST224: Mathematical Methods (Mathematics)
S217: Physics, from Classical to Quantum (Physics)

These were chosen as offering contrasting combinations of modules, as shown in Table 1. The aim was to make it possible to compare students who have met a new approach when they reach stage-2 study with those who are not meeting a new approach.

| Subject | Physics | Mathematics | Computing |
|---|---|---|---|
| **Stage-1** | Up to 2016 students' first module (S104) involved a combination of book based and online.<br>From 2016 most students first module (S111) was entirely online, (followed by a combined book based and online module). | Mostly book-based study resources, with forums, quizzes, screencasts and other additional resources available online. | A mix of book based and online study resources, including programming practice. |
| **Stage-2** | **S217**<br>Entirely online<br>(Note, most OU students are part time, so in 2017 would have started their studies with the combined book based/online module) | **MST224**<br>Purpose-written text-books with forums, quizzes, screencasts and other additional resources available online. | **M269**<br>Blend of digital resources, texts in the public domain and texts specifically developed for the module |

***Table 1 Modules from which the samples were taken in the project, from three different schools within the STEM Faculty at the Open University***

Students were asked to reflect on the type of learning strategies they developed during their stage-1 studies, and, if and how these had evolved and changed during their stage-2 studies. The focus was on eliciting where learning strategies developed at stage-1 have a positive impact on how students learn and progress at stage-2, and conversely, to identify the points where students might need support and additional time to adapt to different learning environments.

599 students (approximately 200 from each of the chosen modules), were asked to complete an online questionnaire. Detailed telephone interviews were then carried out with a small subset of these students.

## Timescales

Questionnaires were sent out in the spring of 2018 to the 2017/18 cohort, and the in-depth interviews carried out in the summer and autumn of 2018. In phase 2, identical questionnaires were sent out in the spring of 2019 to the 2018/19 cohort on the same modules.

## What did the questionnaires ask?

A combination of tick box and open text questions were used, to encourage maximum participation. Over 70% of students who responded chose to give additional comments in the open text boxes.

The questionnaire started by establishing the first stage-1 module the student had studied, and then asked them to say what methods they had used to study it, and to what extent. Students were also asked whether they changed how they studied for subsequent stage-1 modules, and if so why.

Next they were asked about their current stage-2 module, i.e. either:-
M269: Algorithms, Data Structures and Computability (Computing)

MST224: Mathematical Methods (Mathematics)
S217: Physics, from Classical to Quantum (Science)

They were first asked about the methods they used to study it, as in Table 2, then whether they had had to change how they had studied as they moved from stage-1 study to this stage-2module. If they had changed their approach, they were asked how they had changed it, and whether having to do so had caused them any issues (and if so, what these were). The questionnaire finished with a couple of open text questions designed to give students the opportunity to give any additional feedback they felt was relevant.

| Method | Never (1) | Rarely (2) | Sometimes (3) | Often (4) | All of the time (5) |
|---|---|---|---|---|---|
| Made notes on paper | | | | | |
| Annotated module books | | | | | |
| Used personal blog on OU StudentHome | | | | | |
| Took notes using word processing software on computer/tablet | | | | | |
| Annotated pdf or other module files on screen | | | | | |
| Accessed additional books on the subject | | | | | |
| External digital resources e.g. Khan Academy | | | | | |
| Printed out pdfs and annotated those | | | | | |
| Ordered print version of module material (only available for some modules) | | | | | |
| Worked through module exercises and activities on paper | | | | | |
| Completed online quizzes/iCMAs | | | | | |
| Used module software e.g. Interactive online activities, Maxima, Python programming software | | | | | |
| Discussion on forums | | | | | |
| Other, please explain (open text) | | | | | |

***Table 2 Example of how students were asked to give information on how they studied***

Data was also collected on age, first language, sex, ethnicity, disability, geographic region, educational background, study motivation, occupational status and Index of Multiple Deprivation score

## Follow-up one to one interviews

51 students offered to take part in follow-up interviews. From these 12 were selected covering all 3 stage-2 modules and as wide a range as possible of other characteristics. The interviews were conducted by phone and took 30 minutes to an hour. Each interview began by asking the student 'Can you imagine that you have a two hour study session available for [stage-2 module name] to study a new topic in the module which you know you will be assessed on. Can you describe what materials you would typically set out and how you would use them?'. A range of questions followed asking about how they studied, how they took notes, any external resources used, any constraints on studying online or on paper etc. Each student was then asked, 'What do you think makes a well-integrated package of learning resources?'

# Findings

## Findings from the questionnaires

### Who responded

113/599 students responded in 2018(19%), and 112/599 in 2019(19%) as shown in Table 3. Note that there are fewer female students than male students studying these modules, on M269 and S217 in particular.

| | | Age | | | | | Gender | |
|---|---|---|---|---|---|---|---|---|
| **2017/8** | **Number of respondents** | **Mean** | **SD** | **Median** | **IQR** | **Range** | **Male** | **Female** |
| **M269** | 35 (31%) | 33.2 | 10.4 | 30 | 9.5 | 50 | 29 (82.9%) | 6 (17.1%) |
| **MST224** | 33 (29%) | 44.5 | 14.4 | 45 | 24 | 46 | 23 (69.7%) | 10 (30.3%) |
| **S217** | 45 (40%) | 32.3 | 11.5 | 35 | 18 | 52 | 31 (68.9%) | 14 (31.1%) |
| | | **Age** | | | | | **Gender** | |
| **2018/9** | **Number of respondents** | **Mean** | **SD** | **Median** | **IQR** | **Range** | **Male** | **Female** |
| **M269** | 26 (23%) | 37.7 | 10.2 | 37 | 10 | 42 | 20 (77%) | 6 (23%) |
| **MST224** | 45 (40%) | 41.9 | 13.0 | 40 | 18 | 54 | 23 (51%) | 22 (49%) |
| **S217** | 41 (37%) | 43 | 16.3 | 38 | 32 | 54 | 35 (85%) | 6 (15%) |

***Table 3 Demographics of respondents to surveys carried out in 2018 and 2019***

### Quantitative responses – approach to study at stage-1

Students were questioned about their first stage-1 OU module, the format of the learning resources and how they used these resources to study.

We then questioned students about the stage-1 modules they had studied with the Open University previously, and in particular, their first stage-1 OU module. For their first OU module, we asked students whether the OU had posted textbooks to them, or whether the module was entirely online. Table 4 shows which students studying each stage-2 module had studied an entirely digital stage-2 module. Note the increase in S217 students who had previously studied an entirely digital stage-1 module in 2018/9

| **Module currently being studied in 2017/8** | **Textbooks in 1st stage-1 module** | **Entirely digital 1st stage-1 module** | **No previous stage-1 module studied** | **Total** |
|---|---|---|---|---|
| **M269** | 31 | 4 | 0 | 35 |
| **MST224** | 29 | 0 | 4 | 33 |
| **S217** | 32 | 6 | 7 | 45 |
| **Total** | 92 (81%) | 10 (12%) | 11 (6%) | 113 |
| **Module currently being studied in 2018/9** | **Textbooks in 1st stage-1 module** | **Entirely digital 1st stage-1 module** | **No previous stage-1 module studied** | **Total** |
| **M269** | 25 | 0 | 1 | 26 |
| **MST224** | 37 | 6 | 2 | 45 |
| **S217** | 24 | 17 | 0 | 41 |

| | | | | |
|---|---|---|---|---|
| **Total** | 86 (77%) | 23 (21%) | 3 (3%) | 112 |

***Table 4 Format of learning resources available in 1st stage-1 Module, split by year and current module.***

Students were also asked how they studied this first stage-1 module, and whether they changed their approach in subsequent stage-1 modules. Less than a fifth of students said they needed to change their approach when moving to subsequent stage-1 modules. The results did not show any statistically significant link for students studying different subjects. More detailed data on this can be found in Appendix 1. Figure 1 shows how many students used each method of studying either all the time or often. In every case online quizzes and iCMAs were most popular, followed by exercises and quizzes on paper.

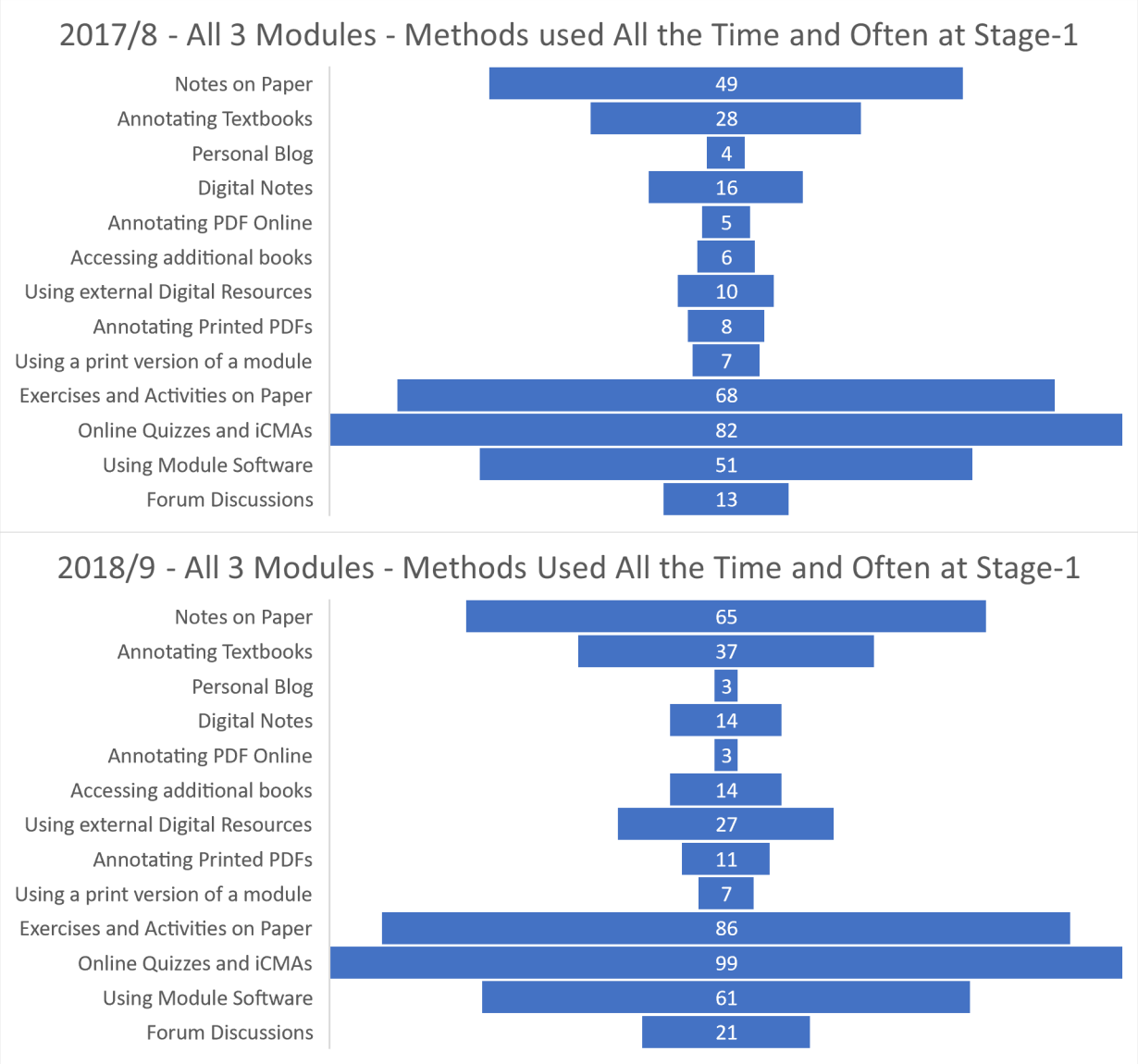

*Figure 1 Methods used by stage-1 students across all three modules (total number of students shown on bars)*

## Quantitative response, studying at stage-2 – did students need to change approach?

Students were then asked to consider the stage-2 module they were currently studying and state whether they had needed to change the way they used module materials for this module. (If they were studying more than one relevant stage-2 module, they were asked to choose the one they found most challenging). Table 5 shows the results of this. Overall, 98/214 students, 46% felt their approach to study changed when they moved to stage-2. Students studying the entirely digital S217 were most likely to need to change approach, and students studying the book based MST224 were least likely to need to change approach. This is consistent with the information in Table 1 showing that the MST224 students were being presented with materials in the same format as their stage-1 modules.

| 2017/8 | No, approach did not change at stage-2 | Yes, approach did change at stage-2 | If Yes, did this cause a problem? |
|---|---|---|---|
| **M269** | 13 | 17 | 9/17 (53%) |
| **MST224** | 22 | 9 | 3/9 (33%) |
| **S217** | 14 | 27 | 23/27 (85%) |
| **Total** | 49 | 53 | 35/53 (66%) |
| **2018/9** | **No** | **Yes** | **If Yes, did this cause a problem?** |
| **M269** | 12 | 14 | 4/14 (29%) |
| **MST224** | 39 | 6 | 2/6 (33%) |
| **S217** | 16 | 25 | 15/25 (60%) |
| **Total** | 67 | 45 | 21/45 (47%) |

***Table 5 Data on whether approach to study changed between previous modules and current stage-2 module, split by current module (note some students either did not answer, or the question wasn't applicable because this was their first OU module).***

Note that, from Table 5, in 2018/9, significantly more S217 students had previously studied an entirely online stage-1 module, and there is a significant decrease in the number of students for whom changing approach caused them a problem in the 2018/9 group. This indicates that it is unlikely that it is just the change in level of study which causes the problems, but the combination of that and having to change their *approach* to study at the same time.

## Quantitative responses – further investigation of issues for students on entirely digital modules

Further analysis was carried out to allow comparison between those students on the entirely digital S217 who had previously studied an entirely digital stage-1 module, and those who hadn't. The results are in Tables 6 and 7, and Figure 2. S104, the predecessor to S111, was a book-based module with additional digital resources. It contained more physics and more applied mathematics than S111, and so the expectation would be that it would prepare students better for the stage-2 physics module S217.

| S217 students who: | Total | Didn't have to change approach for Stage-2 module | Did have to change approach for Stage-2 module | Percentage responding in this category who had to change approach | Changing approach caused issues | Changing approach did not cause issues | Percentage changing approach in this category for whom this caused issues |
|---|---|---|---|---|---|---|---|
| Did an entirely online Stage-1 module | 31 | 15 | 14 | 48% | 6 | 8 | 43% |
| Did not do an entirely online Stage-1 module | 45 | 17 | 33 | 66% | 27 | 6 | 82% |

***Table 6 Simple table demonstrating impact of completing an entirely digital stage-1 module before attempting the S217 entirely digital stage-2 module***

| | Total | Didn't have to change approach for Stage-2 module | Did have to change approach for Stage-2 module | Percentage responding in this category who had to change approach | Changing approach caused issues | Changing approach did not cause issues | Percentage changing approach in this category for whom this caused issues |
|---|---|---|---|---|---|---|---|
| **S217** | | | | | | | |
| First module S111 online science | 23 | 13 | 9 | 41% | 4 | 5 | 44% |
| First module S104 book based science | 31 | 5 | 25 | 83% | 21 | 4 | 84% |
| First module Stage-1 maths | 22 | 7 | 12 | 63% | 8 | 4 | 67% |
| ***These can be subdivided into*** | | | | | | | |
| *Maths followed by S111* | *8* | *2* | *5* | *71%* | *2* | *3* | *40%* |
| *Maths followed by S104* | *5* | *0* | *4* | *100%* | *4* | *0* | *100%* |
| *Maths only at Stage-1 ie some credit transfer* | *9* | *5* | *4* | *44%* | *2* | *2* | *50%* |

***Table 7 Results for S217 students in both cohorts combined, by first stage-1 modules studied***

Figure 2 shows this in graphical form, and clearly highlights that if an entirely digital module is studied first, then both the likelihood of a student needing to change their approach is reduced, and more importantly, that there is a significant reduction in a change of approach causing issues. This was despite the fact that most of those who had not studied an entirely digital stage-1 module had instead studied a module (S104) with more relevant physics content, and more opportunities to apply maths skills to physics problems.

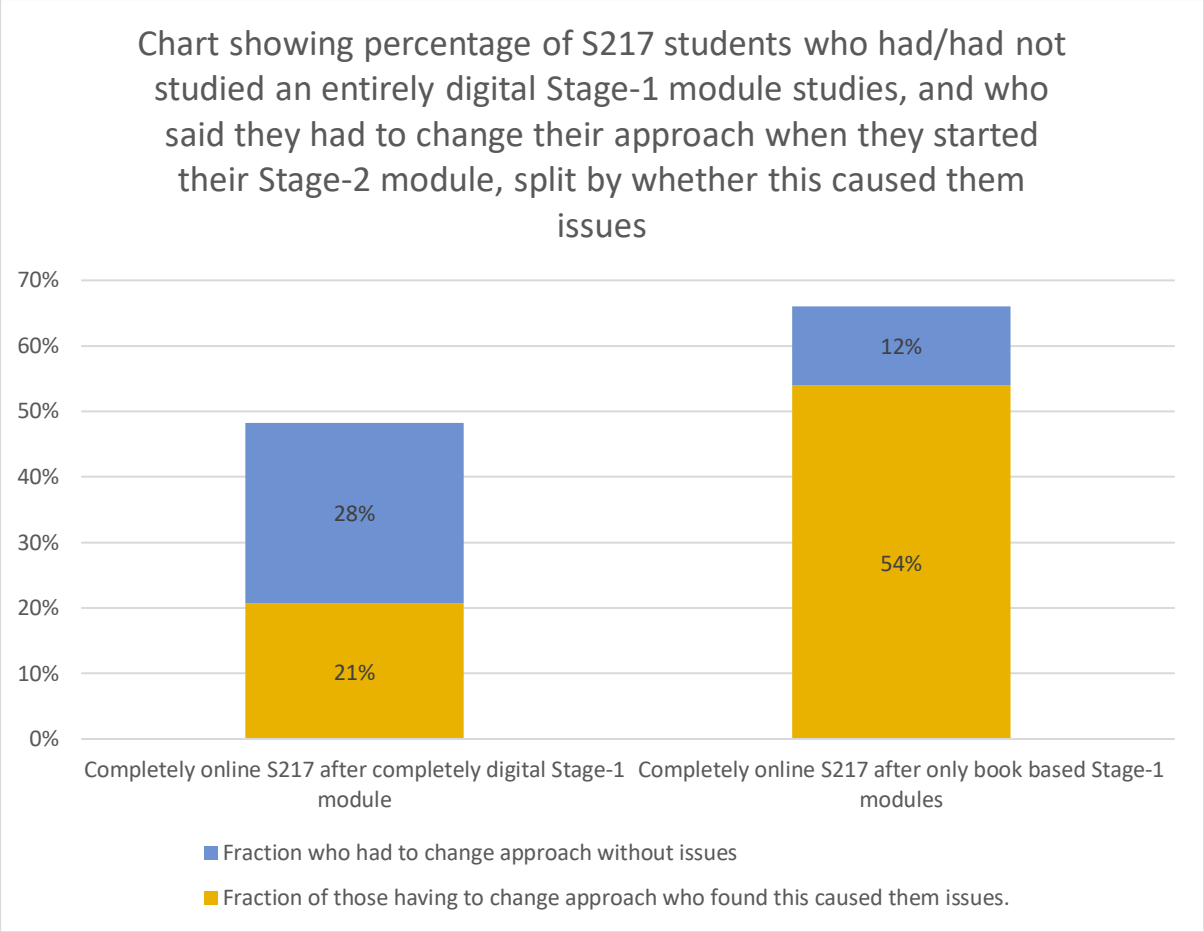


***Figure 2 S217 students across both cohorts, split by whether they had completed a stage-1 entirely digital module, looking at whether they had to change their approach, and whether this caused them issues***

Chang & Ley (2006) have shown that on a digital module, learners who chose to study digitally, rather than printing out the material, performed best, and suggested that learners with a preference for onscreen learning may already have developed effective digital learning strategies. The evidence in figure 2 supports the idea that developing effective digital learning strategies is possible for students who have not necessarily chosen to study digitally, but, this takes time.

### Quantitative responses, approach to study at stage-2

Figure 3 shows how many students used each method of studying either all the time or often on their stage-2 module.

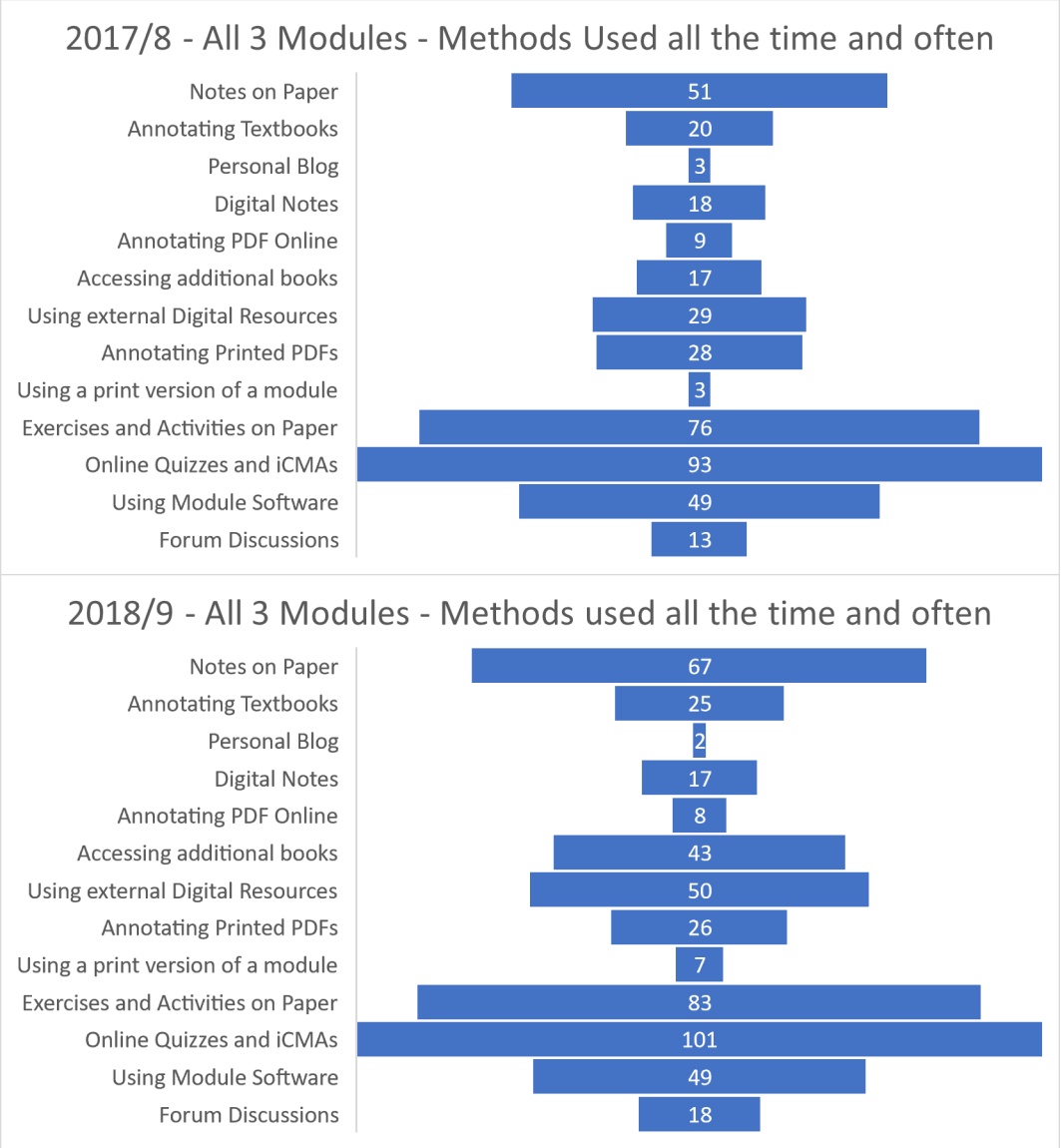


***Figure 3 Methods used by stage-2 students across all three modules (total number of students shown on bars)***

As at stage-1, online quizzes and iCMAs (Computer Marked Assignments) were most popular, followed by exercises and quizzes on paper, and then notes on paper and using module software. It is notable that this is one digital and one non-digital method, and that this mix of digital and non-digital persists throughout. Considering all the possible methods of studying, averaged across all modules, there was a fairly even split between using digital and non-digital resources at stage-1, and this did not change significantly as they moved to stage-2

This is interesting in the context of the findings above that 46% of all students who responded felt they had to change their approach to study as they moved to stage 2 study. It may indicate that students find an alternative method which still falls into the same category. For example, as you can see from Figure 4 below, S217 students, (whose S217 module material was entirely digital), appear to have changed from annotating module textbooks at stage-1 to annotating printed pdfs and

making notes on paper when studying S217, rather than developing ways to annotate information online or making notes electronically.

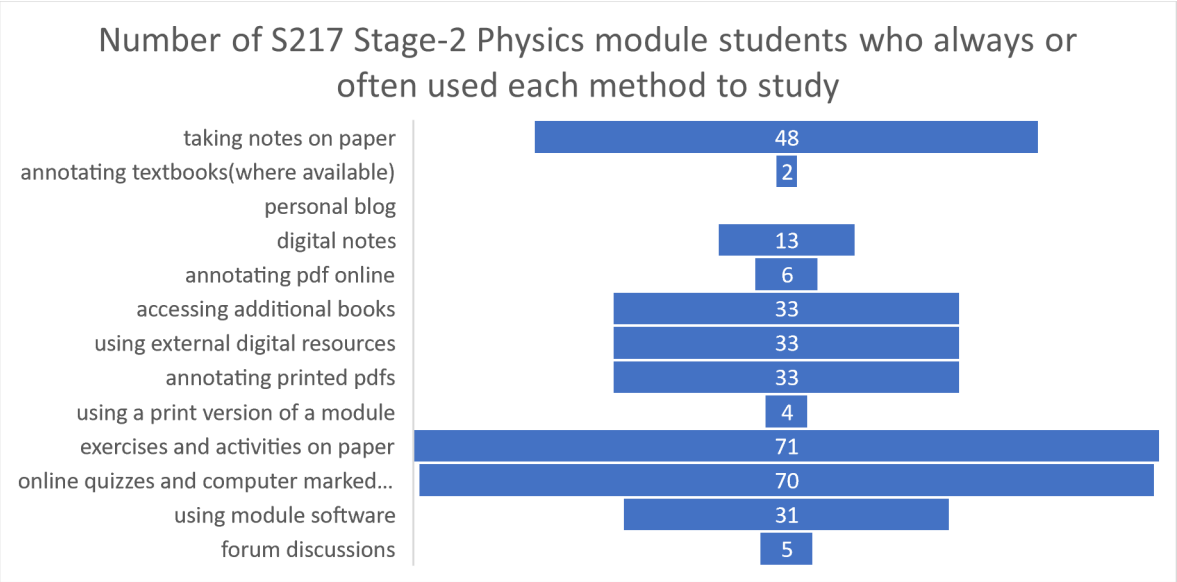


***Figure 4 Methods used by stage-2 students on S217 across both cohorts (total number of students shown on bars)***

## Analysis of qualitative comments from questionnaires

Students were given the opportunity to give open text comments on the survey on why and how they had changed their study approach over time, and what else would have helped them. For the 2017/18 cohort, 82 students (out of 119) commented in this way. A detailed analysis of these comments was carried out looking at both their primary and secondary concerns

### *Primary Concern*

The comments were classified first into 3 broad groups, by whether their main concern was around Content of the module, Presentation of the module, or Tutorial provision of the module. For over two thirds of students, the Presentation of the module was the main concern, rather than the Content or the Tutorial provision.

Within each group, these key concerns were subdivided further. As shown in Table 8 and Figure 5, for over half of the 70% of students who chose to give free text comments, their main concern was around wanting more access to books.

| **Basic grouping of main concern** | **Number of students** | **Detailed breakdown of main concern** | **Number of students** |
|---|---|---|---|
| Content | 22 | Difficulty of understanding material | 6 |
| | | Lack of integration of materials (M269) | 4 |
| | | More detail needed in module materials | 5 |
| | | More opportunity to practice needed | 4 |
| | | Takes too much time | 2 |

| | | | |
|---|---|---|---|
| | | Study skills, around note taking | 1 |
| Presentation | 57 | Pro books | 45 |
| | | Pro digital | 7 |
| | | Pro offline digital | 1 |
| | | Likes combination of books and digital | 1 |
| | | Pro videos and more none textual digital content | 3 |
| Tutorial Provision | 2 | More face to face tutorials | 1 |
| | | Better online tutorials | 1 |

***Table 8 Primary concern raised by each 2017/8 student who made open text comments***

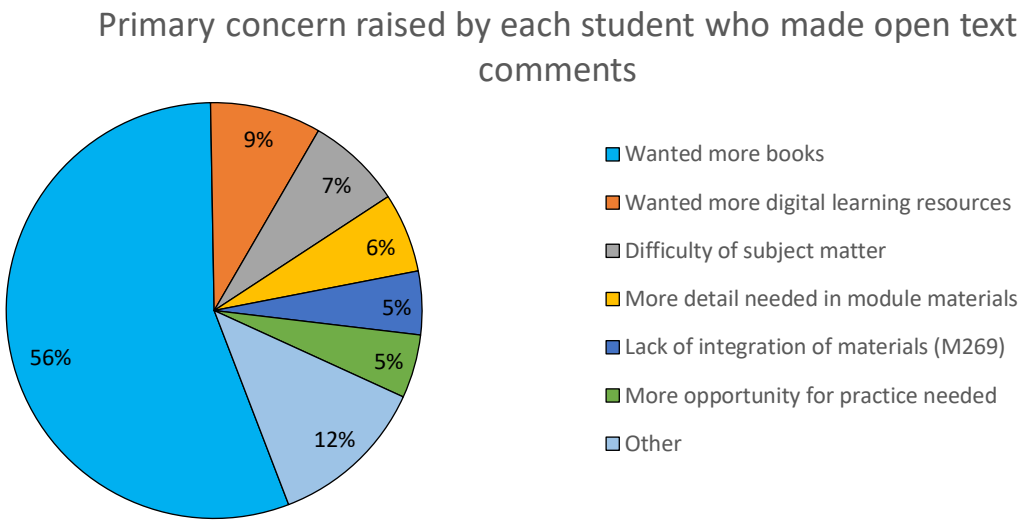


***Figure 5 Pie chart showing primary concerns raised by 2017/8 students in free text comments***

### *Secondary Concerns*

A further analysis was carried out to record any secondary concern, where present. Looking at both primary and secondary concerns gave the numbers in Table 9:-

| Broad grouping | Number of students for whom this was either a primary or secondary concern | Detailed breakdown, combining both primary and secondary concerns | Number of students |
|---|---|---|---|
| Content | 29 | Difficulty | 7 |
| | | Lack of integration of materials (M269) | 6 |
| | | More detail needed in module materials | 6 |
| | | More opportunity to practice needed | 5 |
| | | Takes too much time | 2 |
| | | Study skills, around note taking | 3 |
| Presentation | 84 | Pro books | 52 |
| | | Pro digital | 8 |
| | | Pro offline digital | 9 |
| | | Likes combination of books and digital | 6 |
| | | Pro videos and more none textual online content | 9 |
| Tutorials | 4 | More face to face tutorials | 1 |
| | | Better online tutorials | 2 |
| | | More tutorials (new entry) | 1 |

***Table 9 Primary and secondary concerns mentioned in free text comments***

Issues around Presentation were still far more important to students than Tutorials or Content, and students wanting books was still the main concern overall. However, some other important themes emerged, particularly around students wanting materials which were digital, but available offline, and students wanting more visual digital content (i.e. non-textual). Research by Brunken, Plass & Leutner, (2003) and Chen, Woolcott & Sweller, (2017) supports the use of more audio-visual digital content. These results indicate a need for more nuanced analysis than just digital versus books. An emerging theme is that students want both books and digital content, and they use the two differently. This was an area which was explored further in the in-depth interviews, as discussed below.

### Analysis of qualitative comments from questionnaires focussing on S217 students

A similar analysis was carried out focusing on S217 students from both cohorts, comparing the comments made by those who had previous studied an entirely onscreen module at stage-1, and those for whom S217 was their first entirely onscreen module. In the 2017/8 cohort, almost all the students had not studied an entirely onscreen module before, and for 88% of these students wanting more books was the primary concern mentioned in their free text comments. The data for the 2018/9 cohort can be found in Table 10.

| Detailed breakdown of primary concerns, S217 students | Entirely digital stage-1 module, 23 total | % | No entirely online stage-1 module, 33 total | % |
|---|---|---|---|---|
| Lack of integration of materials (M269) | | | | |
| Wanted offline digital access | | | | |
| More detail needed in module materials | 1 | 4% | | |
| Wanted more digital learning resources | 2 | 9% | 2 | 6% |
| Other (including tutorials) | | | 1 | 3% |
| Difficulty of subject matter | 1 | 4% | | |
| Wanted more non-textual digital content | 3 | 13% | 1 | 3% |
| More opportunity for practice needed | 1 | 4% | | |
| Like combination of books and digital | 1 | 4% | 1 | 3% |
| Wanted more books | 14 | 61% | 28 | 85% |

***Table 10 Primary concerns mentioned in free text comments by S217 students in 2018/9 cohort***

This indicates that those who have not previously studied an entirely digital module were more likely to raise wanting more books as their primary concern. It fits with the data in Figure 2, which showed that students who have not completed an entirely digital module previously perceived themselves as more likely to have to change their approach when they were asked to study one, and more likely to have problems as a result.

## Does age make a difference to how students prefer to study?

An analysis of those whose primary concern was whether module material was better presented online or in paper form by age was carried out, combining data from both cohorts. This showed that age did not appear to be a predictor of whether a student would prefer online or paper module materials. This fits with the evidence from recent studies (Rockinson-Szapkiw, Courduff, Carter & Bennett, (2013) & Mangen, Olivier & Velay (2019)) showing that 'contrary to assumptions of "digital natives" becoming better screen readers with increasing screen exposure and experience, the meta-analysis found that the advantage of paper-based reading in fact increased from 2000 to 2017' However, it should be noted that there were relatively small numbers of students who said they preferred online materials, so further data would be needed to confirm this finding.

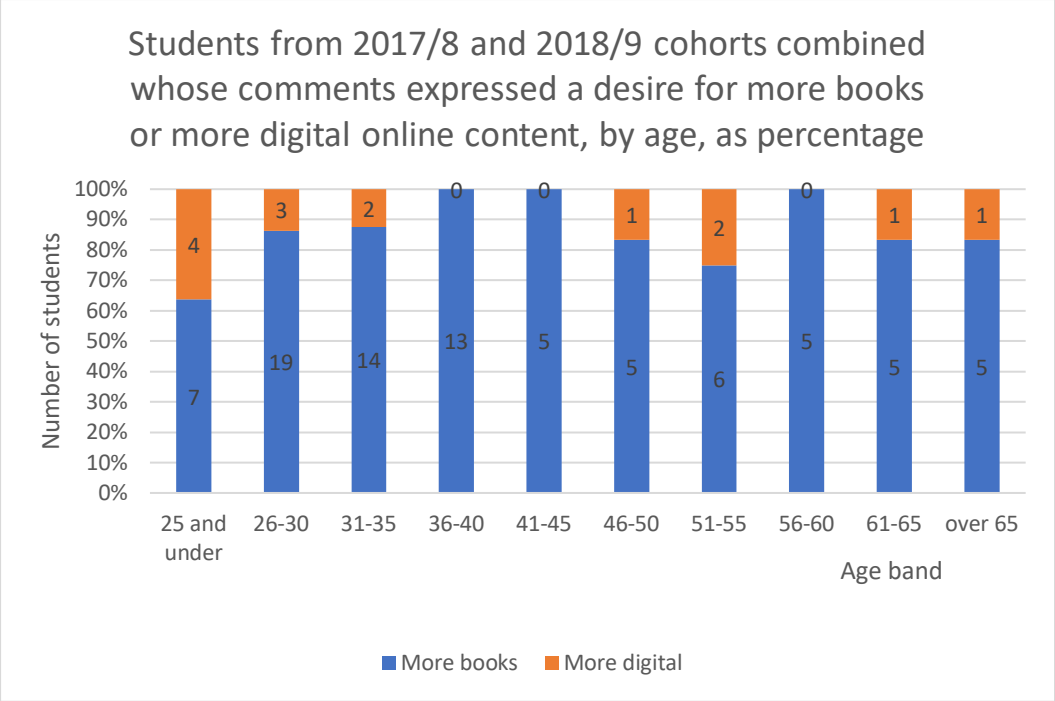


***Figure 6 Bar chart showing preferred study material format by age, as a fraction of all students who expressed a preference in that age category. Numbers on bars are actual number of students***

## In depth interviews

All students who completed the survey were asked if they would be willing to take part in follow up interviews. 50 students offered to do this. From this list we chose 12 students who between them covered as wide a range of attributes as possible, considering age, ethnicity, educational background, geographic location, gender, mother tongue, stated disability and employment status. The interviews were conducted by phone and were around 30 minutes to an hour in length.

The interviewer started off with a list of questions as a framework, the first of which was 'Imagine you have a two hour study session available for (S217/MST224/M269) to study a new topic in the module which you know you will be assessed on. Describe what materials you would typically set out, and how you would use them'.

Subsequent questions focused on note taking, the transition between modules with different learning resource formats, what would improve the digital and non-digital resources, what issues they might have with different formats, use of forums and peer support as well as asking 'What do you think makes a well-integrated package of learning resources?' The full list of questions can be seen in Appendix 2. Nothing in the interviews contradicted the survey results, but it did give further insights.

In terms of note taking, only 3 of the 12 students said they made notes digitally. In each case this was using an iPad and Apple pen. Two of the students were annotating pdfs, one was also typing notes as they studied. One student working in this way using Notability commented that this hadn't worked, the notes hadn't 'stuck'. In the week before the exam they had to resort to making notes with paper and pen as they realised this was more effective. Only one student had gone through the whole course (M269, computing) without needing to make notes on paper, and this very digitally confident student used the Onenote and Apple note apps. Two students on the maths module MST224 said they either made no notes, or made minimal notes on the module handbook. All the students on the maths and physics modules said they needed to work through the in-text examples and questions using paper and pen. Wang, Sundararajan, Adesope & Ardasheva, (2017), Novak, Daday & McDaniel (2018) and Stoop, Kreutzer & Kircz (2013) have some interesting insights on the importance and benefits of note-taking which help set this in context.

Of the 6 students interviewed who had been studying the entirely digital S217, 4 had resorted to printing off the pdfs so they could study them, and a fifth had bought a second-hand set of textbooks from the previous version of the module so they could study from paper formats. The sixth commented several times that they would have preferred books for the main study material.

All of the students were explicitly asked if they found looking at screens for too long caused them any issues. Three of the students (25%) said that they found looking at a screen to study was a problem, in each case because they spent so much time looking at screens at work already. They referred to headaches and eye-aches, one referring to wearing varifocals. The remaining students said they did not find this was a problem. This included one who said they already spent all day looking at screens for work, so no clear pattern here. See Kopper, Mayer & Buchner (2016) and Delgado, Vargas, Ackerman, & Salmerón (2018) for recent research in this area.

All but one of the 12 interviewees responded to the question 'What do you think makes a well-integrated package of learning resources?' by saying they wanted books plus online quizzes and

visual content, (for example videos, animations and recordings of lectures). The twelfth student wanted everything online but felt that books should be an option for those who preferred them. Most of the students wanted the option to access the content of any books online for occasional use when away from their books, and several wanted to be able to download digital material so it could be accessed offline.

Several students commented that books were more portable than digital study resources, largely because to study the digital resources they needed two screens, generally a PC/laptop and a tablet, (and in many cases also paper and pen). The need for two screens was due to the difficulty in navigating digital resources on a single screen:-

*'if I'm using the online books is I'll have two windows open of the same pdf'*

Or to allow them to take advantage of interactive content without losing where they were in the core material. Students also commented that while travelling, they didn't have reliable internet access, and so couldn't access the interactive online content anyway. There was a desire for downloadable digital content for that reason.

### Summary of what was learned from in depth interviews

In summary then, based on the feedback from the interviews, students want the best of both worlds. For STEM subjects, this study shows that OU students:-

1. Prefer to have a combination of book based and digital resources.
2. Particularly value digital visual content and quizzes
3. Find two devices are required to study entirely digital material
4. Find books better for studying while travelling, both for ease of use and because of poor internet connectivity while travelling
5. Want to be able to access digital module material offline
6. Want to be able to access a digital version of any paper module books.
7. Don't seem to find digital note-taking easy/effective – and to get it to work at all for them, need access to expensive technology (~£1000 on top of the cost of their main PC)

In addition, for some students, too much time spent looking at a screen does cause issues, but that is not the case for all students. It seems to be particularly an issue for those who use a screen all day at work.

## Impact

For the 2019/20 cohort of S217, books of the core module teaching material were printed and sent to every student. One print run was carried out, printing enough books to cover the next 3-4 years of students. The estimated cost per student was only around £20, because the module materials had been written to be pdf compatible from the start.

The School of Physical Sciences is currently rewriting several of its level 2 and 3 modules. As a result of this study evidence was available to argue for the inclusion of some printed materials for all of these modules, and the retention of books for the core content for the level 3 modules. This has been well received by students.

The findings from this project are also being used to inform a further eSTEeM project on usability and accessibility of Jupyter Notebooks in Computing modules.

Dissemination of these results at internal and external conferences has helped other schools, faculties and universities to justify their decisions about the balance of digital vs paper-based materials for distance learning modules. These have included:-

2018 eSTEeM conference poster (Alexander & Lansbury)
2019 Advance HE Conference session (Alexander & Lansbury)
2019 eSTEeM SPS Roadshow presentation (Alexander)
2019 eSTEeM conference workshop (Alexander & Lansbury)
2019 Share First Friday (Lansbury)
2020 eSTEeM Scotland Roadshow presentation (Alexander)
2020 ALStaff Development event presentation (Alexander)
2020 ViCEPhEC 2020 poster (Alexander)

## List of deliverables

Alexander, Laura, Should Virtual Learning Mean Onscreen Learning, ViCEPhEC 2020, URL https://vicephec.org/2020/wp-content/uploads/2020/07/VICE-PHEC-poster-Alexander-Final.pdf

Alexander, Laura and Lansbury, Alexis How do STEM students use digital and non-digital learning resources? In: *Advance HE STEM Conference 2019*, 30-31 Jan 2019, Birmingham UK. URL https://www.heacademy.ac.uk/system/files/downloads... or http://oro.open.ac.uk/69107/

Alexander, Laura and Lansbury, Alexis, An investigation into how STEM students use learning resources in different formats, and how this use develops over time – progress so far, On p67 of eSTEeM_2018_conf_booklet, URL https://openuniv.sharepoint.com/sites/units/lds/scholarship-exchange/documents/eSTEeM_2018_conf_booklet_FINAL.pdf

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This is a list of other relevant papers used during the project. These formed the basis of the literature review carried out, there is not space in this report to include this, but they are included as a useful starting point for others carrying out research in this area.

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## University approval processes

- *SRPP/SSPP – Approval from the Student Research Project Panel/Staff Survey Project Panel was obtained according to the Open University's code of practice and procedures before embarking on this project. Application numbers 2017/005 and 2018/130*
- *Data Protection Impact Assessment/Compliance Check – A Data Protection questionnaire was completed and on 12 January 2018 the university Equality, Diversity and Information Rights, Academic Policy and Governance area confirmed that there were no Data Protection issues for this project.*

# Appendices

Appendix 1. Detailed data on study methods used in first stage-1 module and whether students found they needed to change how they studied when they moved to subsequent stage-1 modules; split by module and cohort

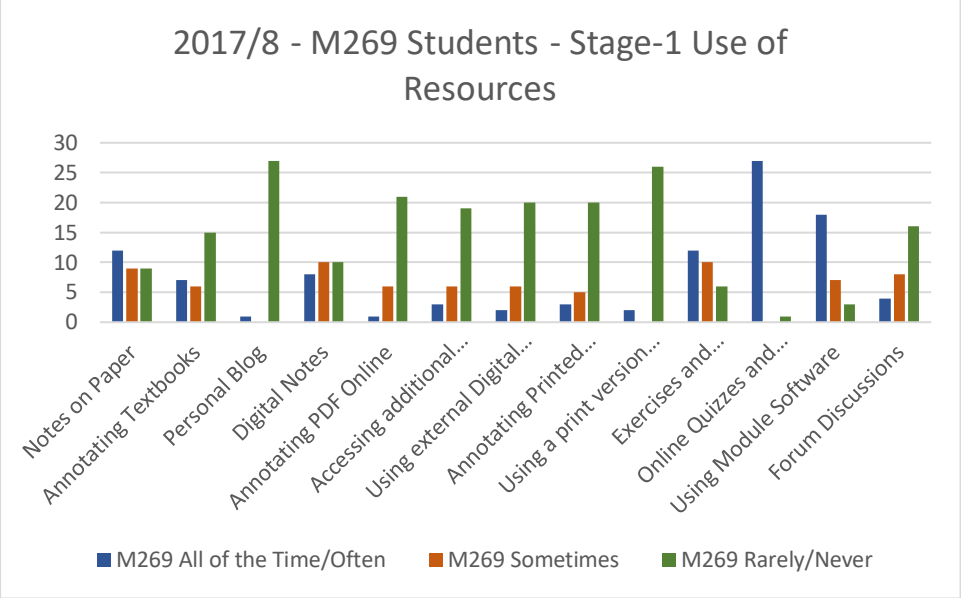
Appendix 2, Questions used as a framework for in depth interviews

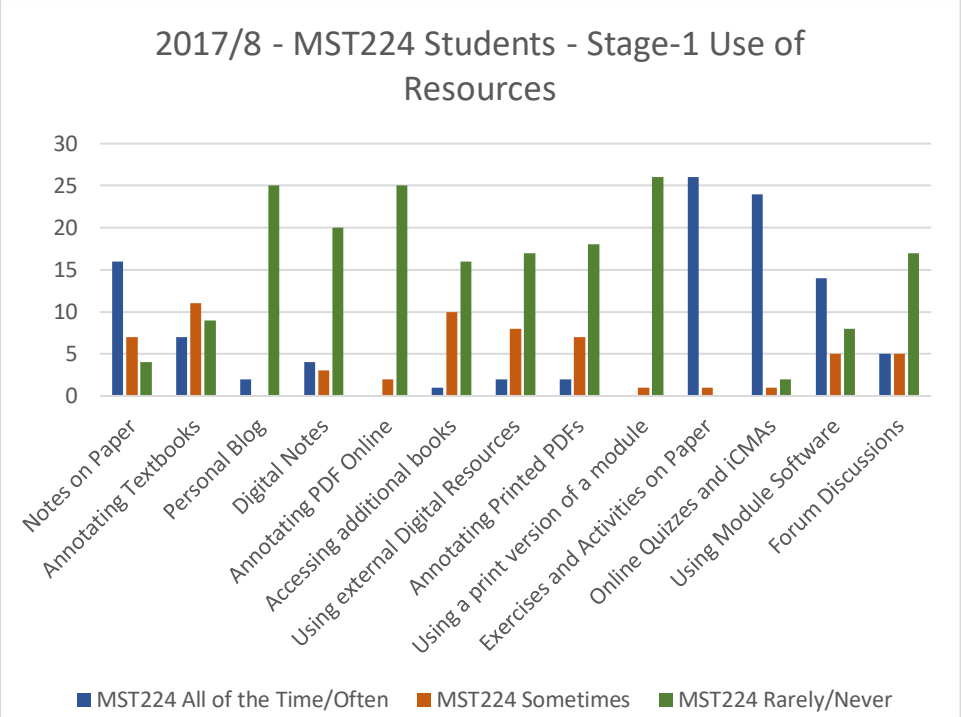
## Appendix 1

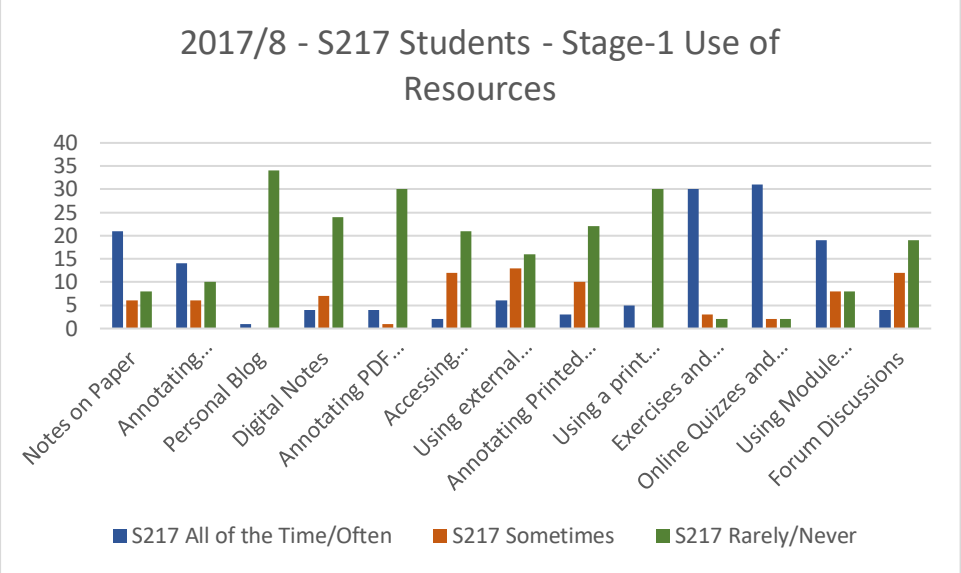
Detailed data on study methods used in first stage-1 module and whether students found they needed to change how they studied when they moved to subsequent stage-1 modules; split by module and cohort

**2017/8 cohort Data**

| | | 2017 Data | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Method | M269 | | | MST224 | | | S217 | | | All 3 Modules | | |
| | | | All of the Time/Often | Sometimes | Rarely/Never | All of the Time/Often | Sometimes | Rarely/Never | All of the Time/Often | Sometimes | Rarely/Never | All of the Time/Often | Sometimes | Rarely/Never |
| ND | 1 | Notes on Paper | 12 | 9 | 9 | 16 | 7 | 4 | 21 | 6 | 8 | 49 | 22 | 21 |
| ND | 2 | Annotating Textbooks | 7 | 6 | 15 | 7 | 11 | 9 | 14 | 6 | 10 | 28 | 23 | 34 |
| D | 3 | Personal Blog | 1 | 0 | 27 | 2 | 0 | 25 | 1 | 0 | 34 | 4 | 0 | 86 |
| D | 4 | Digital Notes | 8 | 10 | 10 | 4 | 3 | 20 | 4 | 7 | 24 | 16 | 20 | 54 |
| D | 5 | Annotating PDF Online | 1 | 6 | 21 | 0 | 2 | 25 | 4 | 1 | 30 | 5 | 9 | 76 |
| NK | 6 | Accessing additional books | 3 | 6 | 19 | 1 | 10 | 16 | 2 | 12 | 21 | 6 | 28 | 56 |
| D | 7 | Using external Digital Resources | 2 | 6 | 20 | 2 | 8 | 17 | 6 | 13 | 16 | 10 | 27 | 53 |
| ND | 8 | Annotating Printed PDFs | 3 | 5 | 20 | 2 | 7 | 18 | 3 | 10 | 22 | 8 | 22 | 60 |
| ND | 9 | Using a print version of a module | 2 | | 26 | 0 | 1 | 26 | 5 | 0 | 30 | 7 | 1 | 82 |
| ND | 10 | Exercises and Activities on Paper | 12 | 10 | 6 | 26 | 1 | | 30 | 3 | 2 | 68 | 14 | 8 |
| D | 11 | Online Quizzes and iCMAs | 27 | | 1 | 24 | 1 | 2 | 31 | 2 | 2 | 82 | 3 | 5 |
| D | 12 | Using Module Software | 18 | 7 | 3 | 14 | 5 | 8 | 19 | 8 | 8 | 51 | 20 | 19 |
| D | 13 | Forum Discussions | 4 | 8 | 16 | 5 | 5 | 17 | 4 | 12 | 19 | 13 | 25 | 52 |






2017: Moving from the first stage-1 module to the next stage-1 Module – did students change their approach?

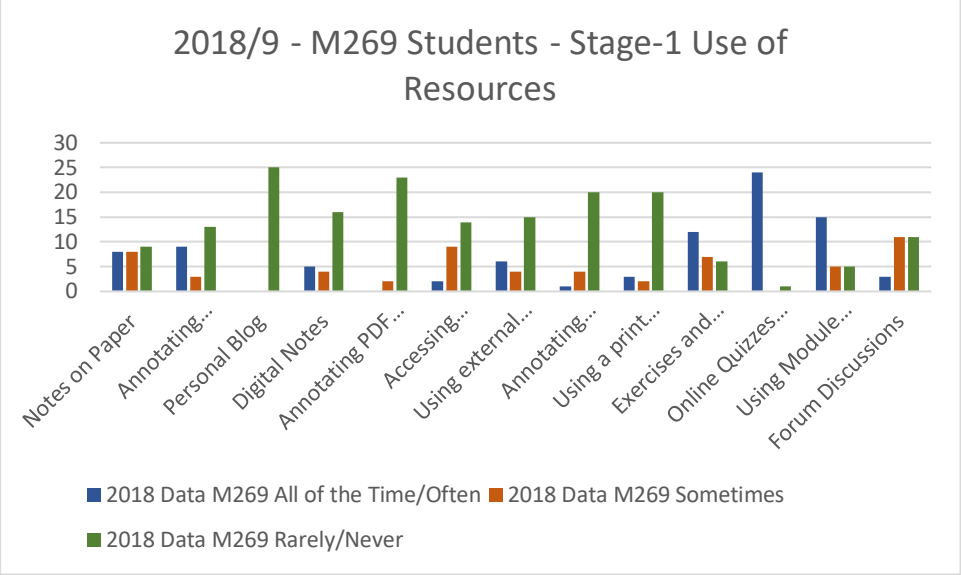
| | No | Yes | NA (No stage-1 modules) |
|---|---|---|---|
| **M269** | 23 | 5 | 2 |
| **MST224** | 22 | 5 | 4 |
| **S217** | 26 | 9 | 6 |

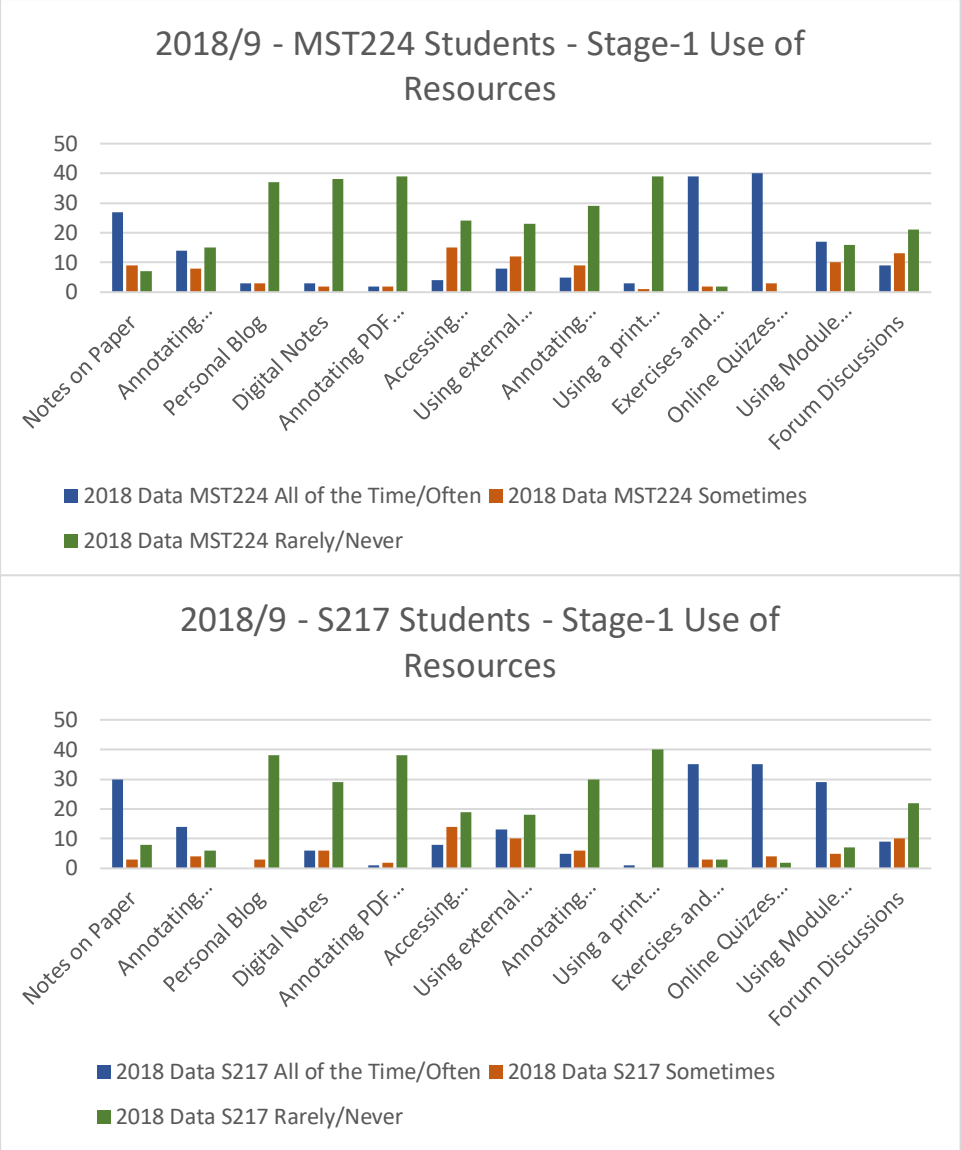
2017: What reasons did students give for changing their approach? Students could choose as many options as were relevant.

| | Original method ineffective | Ideas from other students | Subsequent stage-1 module had resources in a different format |
|---|---|---|---|
| **M269** | 2 | 1 | 3 |
| **MST224** | 2 | | 3 |
| **S217** | 3 | | 5 |

## 2018/9 Data

| | | 2018 Data | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Method | M269 | | | MST224 | | | S217 | | | All 3 Modules | |
| | | | All of the Time/Often | Sometimes | Rarely/Never | All of the Time/Often | Sometimes | Rarely/Never | All of the Time/Often | Sometimes | Rarely/Never | All of the Time/Often | Sometimes | Rarely/Never |
| ND | 1 | Notes on Paper | 8 | 8 | 9 | 27 | 9 | 7 | 30 | 3 | 8 | 65 | 20 | 24 |
| ND | 2 | Annotating Textbooks | 9 | 3 | 13 | 14 | 8 | 15 | 14 | 4 | 6 | 37 | 15 | 34 |
| D | 3 | Personal Blog | 0 | 0 | 25 | 3 | 3 | 37 | 0 | 3 | 38 | 3 | 6 | 100 |
| D | 4 | Digital Notes | 5 | 4 | 16 | 3 | 2 | 38 | 6 | 6 | 29 | 14 | 12 | 83 |
| D | 5 | Annotating PDF Online | 0 | 2 | 23 | 2 | 2 | 39 | 1 | 2 | 38 | 3 | 6 | 100 |
| NK | 6 | Accessing additional books | 2 | 9 | 14 | 4 | 15 | 24 | 8 | 14 | 19 | 14 | 38 | 57 |
| D | 7 | Using external Digital Resources | 6 | 4 | 15 | 8 | 12 | 23 | 13 | 10 | 18 | 27 | 26 | 56 |
| ND | 8 | Annotating Printed PDFs | 1 | 4 | 20 | 5 | 9 | 29 | 5 | 6 | 30 | 11 | 19 | 79 |
| ND | 9 | Using a print version of a module | 3 | 2 | 20 | 3 | 1 | 39 | 1 | 0 | 40 | 7 | 3 | 99 |
| ND | 10 | Exercises and Activities on Paper | 12 | 7 | 6 | 39 | 2 | 2 | 35 | 3 | 3 | 86 | 12 | 11 |
| D | 11 | Online Quizzes and iCMAs | 24 | 0 | 1 | 40 | 3 | 0 | 35 | 4 | 2 | 99 | 7 | 3 |
| D | 12 | Using Module Software | 15 | 5 | 5 | 17 | 10 | 16 | 29 | 5 | 7 | 61 | 20 | 28 |
| D | 13 | Forum Discussions | 3 | 11 | 11 | 9 | 13 | 21 | 9 | 10 | 22 | 21 | 34 | 54 |






2018/9: Moving from the first stage-1 module to the next stage-1 Module – did students change their approach?

| | No | Yes | NA (No stage-1 modules) |
|---|---|---|---|
| **M269** | 19 | 6 | 1 |
| **MST224** | 34 | 9 | 2 |
| **S217** | 32 | 9 | 0 |

2018/9: What reasons did students give for changing their approach? Students could choose as many options as were relevant.

| | Original method ineffective | Ideas from other students | Subsequent stage-1 module had resources in a different format |
|---|---|---|---|
| **M269** | 2 | 4 | 4 |

| | | | |
|---|---|---|---|
| **MST224** | 2 | 2 | 4 |
| **S217** | 0 | 2 | 5 |

## Appendix 2, Questions used as a framework for in depth interviews

1. Imagine you have a two-hour study session available for (S217/MST224/M269) to study a new topic in the module which you know you will be assessed on. Describe what materials you would typically set out, and how you would use them. (*Prompt if necessary: Would you have computer, (online or offline?) tablet, phone, books, paper….)*

2. Would you take notes during this session, if so, how, and in how much detail (*prompt if necessary: on paper, on screen (what tool), on textbook)*

3. Do you work through each step on the study planner in order or do you tend to jump about? If you hit a topic you really didn't understand, what would you do?

4. If you had a choice of study materials and formats, how would you choose to study? *If they say they would do it entirely from books, ask would you want any digital content, e.g. screencasts, interactive quizzes, forums?*

5. Why would you choose to study this way, what are the disadvantages of the alternative ways for you? (*Health issues, accessibility issues, keeping track of where you are, moving around materials easily, how easy is to take in what you are studying, timing of study)*

6. *If they changed their approach*

   You said you changed your approach to studying when you moved to (S217/MST224/M269). Can you explain in more detail how and why *(looking for things like:-because the content was harder; because I was forced to by available formats; because I needed to remember things for an exam etc)*

7. Thinking about the resources for (S217/MST224/M269), which do you use most, and are there any you don't use at all? Can you explain why that is?

8. Can you find the resources you want when you need them? Do you use the Resources tab on the module website? How often do you estimate you go to this area, could you tell us what you access when you go there? (*For M269 do you use the summary and companion, for S217 do you use the glossary, for MST224 do you use the exercise booklets?)*

9. Have you been using any other external resources for (S217/MST224/M269) other than the materials provided by the OU? What were these? (*Books, online resources, Khan Academy, YouTube videos etc)*

10. What would improve the digital resources for this module? (*prompt if necessary: more screencasts/recorded lectures, more visual content, more interactive quizzes, links to external visual content, links to external resources, availability of materials on screen but offline, indication of length of each section, availability of materials in ebook form, more online tutorials, more forums*).

11. What would improve the non digital resources for this module? (*prompt if necessary: better indexing, better cross referencing to digital materials, more practice exercises, full module texts available in paper form*)

12. What do you think makes a well integrated package of learning resources?

13. Thinking about your own experiences moving from module to module, what could we have done to help you to make these transitions?

14. How much use do you make of forums? *(post, respond, lurk, ignore, group activities assessed, group activities not assessed, tutorgroup forums vs cluster forums vs module forums).*

15. If you use the forums, is this for general support or to directly help with your study of this particular topic.

16. Do you meet up with/talk to fellow students on this module anywhere other than on module forums or qualification forums (*eg Facebook groups, face to face support groups etc*)? Why do you choose to do it in this way?

S217 only

1) Do you use the ebook versions of the module books electronically?
2) Do you use printed versions of the pdfs of the module books?
3) Do you use the QR codes while studying using the pdfs on paper?