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An exploration of the relationship between continuous assessment and resource use in a service mathematics module

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Previous research has shown that students' use of module resources strongly relates to the timing of the module's continuous assessment. In our case study of a large first-year mathematics module for Business students, Maths for Business, we examine this relationship and the resources relied on by students for completing their continuous assessment. In Maths for Business, students have the choice of using live lectures or online videos or a combination of both. We find that students who incorporate lectures into their approach engage consistently throughout each week with module resources, while others adopt a just-in-time approach for each weekly quiz. We also show that the introduction of remediation of quizzes can boost participation with resources, in particular feedback resources.

Keywords: Continuous assessment, student participation, remediation, undergraduate mathematics, service mathematics.

Introduction

Research shows that student engagement in a module is strongly related to the timing of assessment (Rust, 2002; Marriott & Lau, 2008; Holmes, 2018). In this study, we focus on this relationship in a service mathematics module, showing that through module design which includes frequent continuous assessment, students can be encouraged to consistently access resources both prior to, and post assessment (through feedback). While this relationship seems evident, we analyse electronic data to demonstrate it. To this effect, we analyse resource usage in a large first-year undergraduate module entitled *Maths for Business* (based on the 2015/16 student cohort). Continuous assessment is an integral component of *Maths for Business*, with 40% of the final module mark designated to a student's best eight (out of ten) weekly quizzes. We investigate which resources students access when preparing for the assessment; and when specific resources (lectures, online videos, worksheets, Maths Support Centre and quiz solutions) are accessed; and, whether the approach taken relates to a surface or a deep learning approach to learning (Rust, 2002).

While some research focuses on resource usage in preparation for continuous assessment (Holmes, 2018), we also wish to investigate the relationship specifically with feedback resources. In 2016/17, we introduced a 'remediation system' whereby students who did not receive the full five marks on their weekly quiz, had the opportunity to resubmit their quiz one week later with an explanation of their error(s) and corrections for one additional mark. We examine how the introduction of the

remediation system increased students use of feedback resources. Subsequently our research questions are:

1. In *Maths for Business*, what is the relationship between the timing of continuous assessment and module resource usage?
2. In *Maths for Business*, what resources do students access when preparing for their continuous assessment?
3. Is there a relationship between students' choice of resource and their learning approach?
4. Through incentivising remediation, can students be encouraged to access module resources?

Unlike our prior work on *Maths for Business* (Howard, Meehan, & Parnell, 2018; Howard, Meehan, & Parnell, 2019), this study focuses on examining resource usage in the context of the timing of continuous assessment, rather than the reason behind students' choice of module content resources (Howard et al., 2018), or, whether the remediation system benefitted students based on their end-of-semester examination (Howard et al., 2019).

Theoretical Framework and Related Literature

Engagement and participation

In educational literature (Fredricks, Blumenfeld, & Paris, 2004), student engagement is considered under three sub-themes or constructs: behavioural, cognitive and emotional. Behavioural engagement (Fredricks et al., 2004) encompasses positive student conduct and participation or on-task behaviour for example effort, persistence, concentration, attention, asking questions, and contributing to class discussion. Fredricks et al. (2004) note there is a difference between active and passive behaviour. In this study, we refer to participation as the interaction students have with resources which is measured by log or attendance data. When we consider students' participation or resource usage, we are considering a narrow, limited definition or application of behavioural engagement.

Continuous assessment and engagement

Holmes (2018) argues for the importance of student engagement owing to its relationship with student satisfaction and the quality of the student experience. Her research aims to improve the student experience by influencing the relationship between resource-use and assessment. Holmes (2018) shows that the introduction of frequent low-stakes assessment leads to a consistent increase in the use of online resources in a university geography module. This particularly benefits students with "weaker" prior knowledge in a module, as research suggests that they benefit more from participation with resources than their peers (Nordmann, Calder, Bishop, Irwin, & Comber, 2018). Marriott and Lau (2008), and the references within, argue that assessment is the main variable in accounting for how students approach their learning. Rust (2002) expands on this relationship, by noting that students will study the content or resources that they believe will be examined. Anastasakis (2018) uses activity theory to explore in detail engineering and mathematics undergraduates' resource-use. Anastasakis (2018) found that assessment rules were the main regulator of students' use of resources. Other, less significant factors included: students themselves including their learning preferences, degree and year of study; resources' usability; the level, nature

and familiarity of the mathematics; and, lecturers and past members of students’ community. In addition to encouraging pre-assessment resource usage, continuous assessment can also encourage engagement through the feedback provided for assessment.

Alternative to examining students’ specific resource-use, one could consider whether students take a surface or deep learning approach to learning. A surface approach is often associated with rote learning and extrinsic motivation, whereas a deep approach is associated with learning for understanding and intrinsic motivation. Biggs, Kember, and Leung (2001) presents a survey to examine these approaches, the ‘Revised Two Factor Study Process Questionnaire: R-SPQ-2F’. Trenholm et al. (2019) used the R-SPQ-2F to examine learning approaches in two mathematics modules where students had the option of attending lectures or/and viewing recorded lecture videos. Despite the modules being located in different universities, they found in both cases that a decrease in live lecture attendance combined with regular use of the recordings was associated with an increase in surface approaches to learning.

Module Context

Maths for Business is a large first-year undergraduate module with approximately 500 business students enrolled annually. In *Maths for Business*, students have the choice of completing the module material by attending approximately 32 live lectures or watching 67 online videos or a combination of both. Each short video (average length of 7.5 minutes) was designed and created by the lecturer – second author of the paper. These videos were created using the *Explain Everything* app (<https://explaineverything.com/>), and consisted of the lecturer writing on “skeleton” slides while explaining the topic. Students also have access to the Maths Support Centres (the university drop-in centre and a dedicated module drop-in centre). All resources in *Maths for Business* – worksheets, lectures or online videos – list the specific learning outcomes which they address. The module is examined through an end-of-semester written 2-hour examination and ten weekly quizzes. These contribute 60% and 40% respectively towards a student’s final mark. Students best eight (out of ten) quizzes contribute 5% each to the continuous assessment mark of 40%. From week three of the twelve-week teaching semester, all students sit the weekly quizzes on Tuesdays

Date	Oral feedback by TA for quiz	Quiz completed	Quiz returned	Remediated quiz submitted	Feedback resources made available
27 th of September	-	1	-	-	-
4 th of October	1	2	1	-	Quiz 1 pdf & video solutions
11 th of October	2	3	2	1	Quiz 2 pdf & video solutions

under the supervision of a teaching assistant. Further detail on the module can be found in Howard et al. (2018). Between 2015/16 and 2016/17, there were no changes to the learning outcomes of the

module. While the content and aims remained the same, the quizzes were changed to ensure students did not copy from the prior year's quizzes.

In *Maths for Business* in 2016/17, a 'remediation system' was introduced (Howard et al., 2019). In the remediation system, any student who did not receive the full five marks on a quiz, had the opportunity to resubmit their quiz with corrections and an explanation of their error(s) for one additional mark. Table 1 provides an example of the remediation time-frame. Both the pdf and video solutions highlighted relevant video resources for the quiz questions. Owing to the fortnightly remediation cycle, students only had the opportunity to remediate the first eight quizzes. Students were encouraged to use the Maths Support Centre for help with their remediation, particularly students who received a low score on their quiz.

Data Collection and Analysis

We use a case study approach as we are not controlling the behavioural approaches of students and it allows for a mixed method approach. The case study approach allows for the examination of the real-life relationship between continuous assessment and resource usage in the context of *Maths for Business*. In accordance with our permission from the UCD Ethics Committee, for two years of *Maths for Business*, we collected students' lecture attendance, log data for online resources, Maths Support Centre attendance, Irish post-primary terminal mathematics examination grade (as an indicator of prior mathematics learning) and marks in the module. In total, there were 522 students in 2015/16 and 480 students in 2016/17. In addition, a survey that included the 'Revised Two Factor Study Process Questionnaire: R-SPQ-2F' (Biggs et al., 2001) was distributed to the 2015/16 cohort at the end of the teaching semester. We received 161 survey responses. For this paper, we are examining the results from the 'R-SPQ-2F' and one open-ended question from the survey, "How do you study for the weekly quiz, making specific reference to the resources you use (online videos, lecture slides, external sources, friends, worksheets, class notes, Monday drop-in session, Maths Support Centre)?" These survey results are beyond our prior research (Howard et al., 2018).

To examine the time dynamic between continuous assessment and resource usage, we use descriptive statistics in the form of graphs. We do not include resource usage data relating to the revision and examination period of the semester (prior to the end-of-semester examination) as the number of views increases substantially during this time as expected. To analyse the open-ended survey question on which resources are used in studying, we use thematic analysis (Braun & Clarke, 2006).

Results

RQ1: What is the relationship between continuous assessment and module resource usage?

Based on the 2015/16 cohort, analysis of the video views shows that students access videos prior to the weekly Tuesday continuous assessment (on Monday and Tuesday). Similarly, students mainly

Table 1: Example of the remediation timeframe

access the worksheets and Maths Support Centre prior to the weekly quiz. Alternatively, we could investigate the timing of resources based on a finer scale which considers students' main content

resources. If we classify students according to their use of live lectures or online videos or combination of both (see Howard et al. (2018) for details of the classification by clustering analysis), we have four distinct groups: Dual-Users, Lecture-Users, Video-Users and Switchers. Switchers either start the semester predominantly using lectures and progress to predominantly using videos or choose between videos and lectures for content based on the timing of a lecture. Lecture-Users and Video-Users predominantly use lectures and videos respectively, while Dual-Users use both lectures and videos to review the same material. Figure 1 shows the standardised number of video accesses for each cluster over the semester (views are divided by the number of students in each cluster). When examining video accesses in relation to the time in the semester for Dual-Users, Video-Users and Switchers, the distribution is of weekly peaks prior to the continuous assessment albeit with increasing peaks for Switchers as the semester progresses. However, for Lecture-Users, this pattern is not maintained initially. As the semester progresses, the limited number of videos seem to be accessed for assessment purposes. Dual-Users, and to a lesser extent Lecture-Users, use resources throughout the semester whereas Video-Users and Switchers use them on Mondays and Tuesdays. There are limited accesses of resources once their associated quiz has occurred.

RQ2: What resources do students access when studying for their continuous assessment?

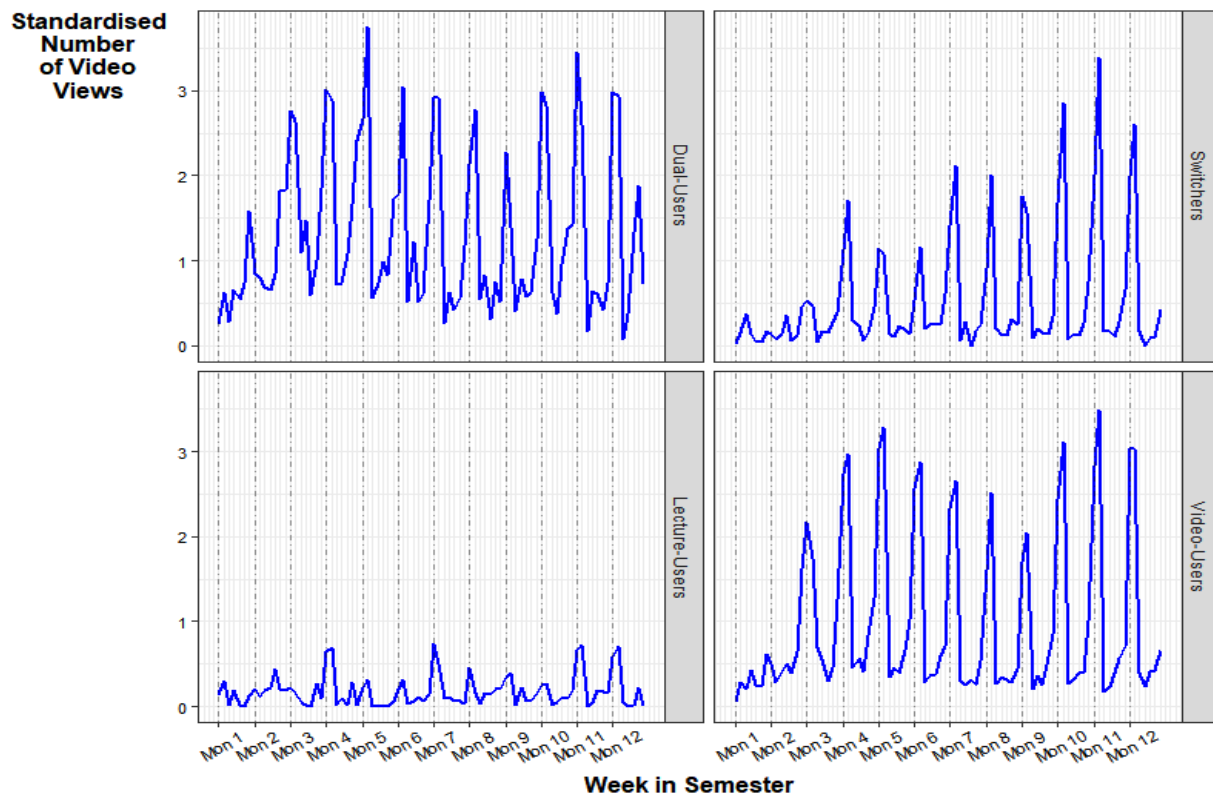


Figure 1: *Maths for Business* video accesses for 2015/16. The number of accesses for each cluster has been divided by the number of students in each cluster to allow for comparisons

Our findings from the first research question suggests a strong relationship between the time when students’ access module resources and the date of the continuous assessment. After each quiz, students prepare for the next quiz rather than revising past quizzes. In order to understand the resources students use to study, towards the end of the 2015/16 semester, we asked students how they studied for the weekly quiz. From thematic analysis (Braun & Clarke, 2006) of the responses, a central and important theme identified is ‘Order of Study’. Students often explained the order of their study approach using the word “then”. For example, one response consisted of:

Firstly I go through all the videos and write out notes. Then I attempt the worksheet and highlight all the good examples and things that I need to remember. I then look back over the notes I took and the completed worksheet. I went to the math support centre when I couldn’t get the answer to a question.

Generally, students’ study pattern for the weekly quiz fall into three stages:

- Stage 1: Review the relevant module material - this is completed through videos or/and lectures. Students may also create their own notes at this stage.
- Stage 2: Attempt/complete the worksheet, may refer to videos to help with the worksheet.
- Stage 3: If stuck on the worksheet, seek assistance from friends and Maths Support Centre.

There are students who deviate from this, for example students who listed a single resource as their response such as worksheets or videos. Male students were more likely to list a single resource, whereas in contrast female students or Dual-Users were more likely to seek support as described in stage 3. Similarly to Figure 1, worksheets and Maths Support Centre were accessed in the days prior to the quiz. We have no data for when friends were consulted.

RQ3: Is there a relationship between student' choice of resource and their learning approach?

Using Biggs et al.'s (2001) 'R-SPQ-2F', for the 2015/16 cohort, we examined students' approaches to learning, namely surface versus deep approach. The results from the five-point Likert scale questions were summed (as outlined in Biggs et al., 2001) to extract a numerical measure for students' surface and deep approach to learning. Surprisingly, using an analysis of variance approach, there was no statistical difference between the surface and deep approach of Lecture-Users, Dual-Users, Video-Users and Switchers. Following Trenholm et al.'s (2019) methodology, we also divided users into regular or low video users using the median number of videos accessed. Upon examination, there was no difference in the learning approach of these two groups. However, Trenholm et al. (2019) measured the learning approaches of students at two points in the semester whereas we measured the learning approach at one point, the end of the semester. They found an increase in the surface approach of students who regularly used lecture-capture videos combined with lower lecture attendance. The difference in results could possibly be caused by our lack of examining learning approaches at two time points or an innate difference between lecture-capture and short-designed videos for mathematics courses or possibly owing to a difference in survey respondents as our survey respondents were biased towards higher marks in comparison to our overall population.

RQ4: Can students be encouraged to consistently use module resources?

In 2015/16 cohort, resources were accessed prior to the quizzes. In 2016/17, we introduced the remediation system where students could gain an extra mark out of five quiz marks if they resubmitted their quiz within one week of having it returned with an explanation of their error(s). While the primary motive of this was to encourage students to identify and learn from their errors in a timely manner (Howard et al., 2019), a potential side-effect was students engaging with quiz or/and feedback material post-quiz i.e. within a week after the quiz. The feedback resources

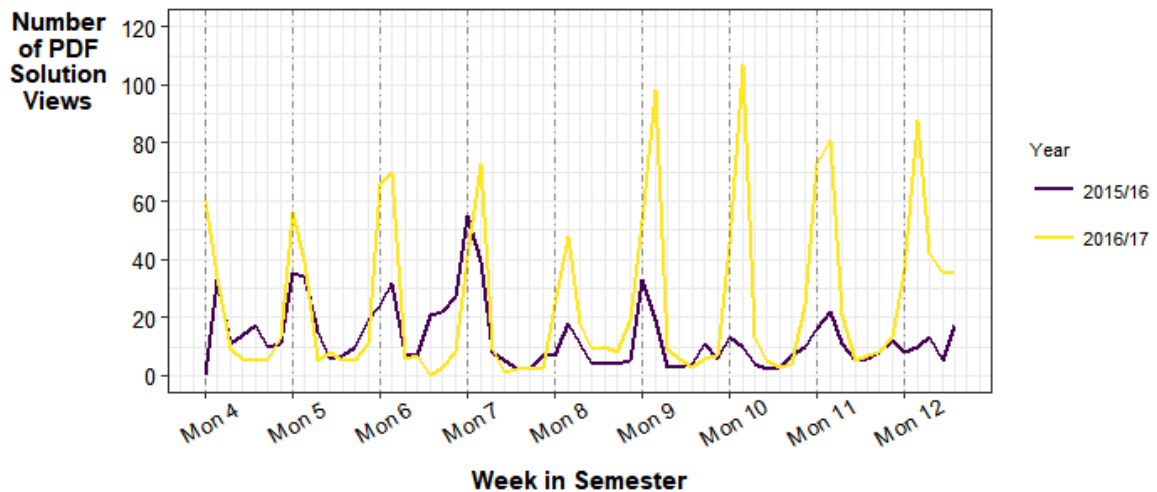


Figure 2: The number of pdf solution views for *Maths for Business* students by year and day. Duplicate views by a student on a specific day have been removed

provided included: the graded quizzes; oral tutor feedback; the lecturer providing a video entitled “Most Common Errors”; and, a pdf copy of the quiz solutions that also highlighted the most relevant online videos from the module. In addition, students could seek help from friends and the Maths Support Centre. We found (Howard et al., 2019) that the main resource students made use of was the pdf solutions, with limited use of the videos and the Maths Support Centre. Upon further examination, with a focus on timing, students accessed the pdf solutions at the end of the remediation cycle i.e. prior to resubmission of their quiz. This just-in-time approach results in a similar distribution or pattern to the video accesses (Figure 1). This is in contrast to the prior year of 2015/16 as seen in Figure 2. For the teaching semester, the number of views for the pdf solutions doubled between the two cohorts (see Figure 2). Figure 2 indicates that students can be encouraged to positively participate with feedback resources.

Discussion and Conclusion

In *Maths for Business*, we have examined resource-use in relation to its main influencer - continuous assessment. Continuous assessment is linked to students’ resource use in two distinct forms: firstly, in preparation for the continuous assessment; and, secondly through students engaging with feedback on their assessment. Resources are accessed prior to the Tuesday quiz except for live lectures which are timetabled. Although the students are using a just-in-time approach, they are still accessing the resources weekly, and in that sense, consistently. The use of resources is divided into three stages or into the following order: module material review; practice questions; and, external help. While not all students will pursue each stage, females are more likely

to seek external help from friends or the Maths Support Centres. For the 2016/17 cohort, a positive outcome of the remediation system was that students were encouraged to use feedback resources (pdf solutions). However, similar to preparing for the weekly quiz, a just-in-time approach was adopted for the feedback resources. As a limitation, we note that without qualitative data, we cannot confirm for what percentage of students this was the case. In comparison in 2015/16, there is no obvious distribution to viewing the pdf solutions (after the initial weeks). However, the number views are significantly lower.

In the broader context, continuous assessment can be used to encourage engagement by students and subsequently student satisfaction and the quality of the student experience (Holmes, 2018). Arguably, continuous assessment may lead to a 'study-to-the-test' approach. In Ireland, students' learning in the post-primary environment tends to be structured, leading to students struggling with the transition to becoming an independent learner at third level. *Maths for Business* is an entry-level module and the continuous assessment within allows students to maintain some structure following the transition between education levels. Students' end-of-semester evaluations show an appreciation for the weekly quizzes and the opportunity to have module marks prior to the final examination through low-stakes assessments. This approach may not be applicable for specialist or higher-level mathematics modules. Currently, there is debate surrounding whether recorded lectures or specialised videos have a negative effect on students' learning when used as a replacement for the traditional lecture. In contrast to the current literature, we found no relationship between surface or deep learning approach and students' choice of resource. More research is needed to identify any influencing factors, for example the nature of the video, in this relationship.

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