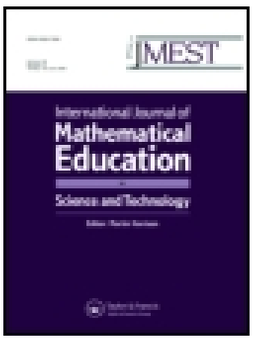

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Live lectures or online videos: students' resource choices in a first-year university mathematics module

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ABSTRACT

In *Maths for Business*, a mathematics module for non-mathematics specialists, students are given the choice of completing the module content via short online videos, live lectures or a combination of both. In this study, we identify students' specific usage patterns with both of these resources and discuss their reasons for the preferences they exhibit. In 2015–2016, we collected quantitative data on each student's resource usage (attendance at live lectures and access of online videos) for the entire class of 522 students and employed model-based clustering which identified four distinct resource usage patterns with lectures and/or videos. We also collected qualitative data on students' perceptions of resource usage through a survey administered at the end of the semester, to which 161 students responded. The 161 survey responses were linked to each cluster and analysed using thematic analysis. Perceived benefits of videos include flexibility of scheduling and pace, and avoidance of large, long lectures. In contrast, the main perceived advantages of lectures are the ability to engage in group tasks, to ask questions, and to learn 'gradually'. Students in the two clusters with high lecture attendance achieved, on average, higher marks in the module.

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KEYWORDS
Resource usage patterns; live lectures; online videos; undergraduate mathematics education

1. Introduction

We investigate the reasons behind students' choices of resource usage in a large first-year undergraduate mathematics module, *Maths for Business*. This is a module for non-mathematics specialists and is compulsory for approximately 550 students, who represent a wide range of prior mathematical achievement. Students in *Maths for Business* are given the option of completing the module content through online videos, live lectures or a combination of both. In this paper, we use a mixed-methods approach to firstly identify students' resource usage patterns with the live lectures and online videos, and secondly examine the reasons behind students' decisions to use one or both of these resources. Watt and Goos [1,p.135] explain that 'behavioural engagement refers to the extent to which students participate, including actual or intended enrolments, and degree of effort applied'. In comparison, we more simplistically refer to a student's resource usage pattern as the type(s) of module resources the student regularly accesses or interacts with. Through gathering

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and analysing 522 students' resource usage data (live lecture attendance and online video accesses), we identified four distinct clusters: high lecture usage; high video usage; high video and lecture usage; and a cluster where students interacted with the content using a combination of both videos and lectures, but with little overlap. We also conducted an online survey, which examined students' perceptions of live lectures and online videos. The 161 survey responses were then linked to each cluster and analysed using thematic analysis [2]. The majority of students used videos as their main resource; however, students belonging to the two clusters with high lecture attendance had higher overall achievement in the module.

Lecturers are often concerned that if they put resources online then students will stop attending lectures [3]. The second author (MM) is one of the module lecturers, in addition to being Module Coordinator for the module. MM spent much of her 20-year career as a lecturer committed to the ideal that all students must attend all lectures. For her, the decision to provide students with a choice of how to engage in the module required a reversal in mind-set about compulsory lecture attendance and she was only willing/able to proceed if she could study the consequences of this decision. Thus, the impetus for this study was our curiosity to see whether students would use lectures or videos; investigate how their choices might impact their learning; and understand the reasons behind their choices. Students' choice of resource may have been impacted by their lecturer's personality or teaching style. However, from the module evaluation survey, the two lecturers received feedback scores of 4.38 and 4.45 out of 5 for the question: 'The teaching on this module supported my learning.' The difference between the lecturers' scores of 0.07 is negligible, and suggests that both student cohorts found the teaching in *Maths for Business* equally beneficial.

Studies have been undertaken to identify students' resource usage patterns through the statistical technique of clustering [4–6]. However, a shortcoming of these studies is the lack of explanation provided for the occurrence of the identified study patterns. We, by contrast, link the resource usage clusters identified, through the analysis of quantitative data, to qualitative survey data aimed at investigating the rationale behind students' resource usage patterns. Furthermore, for the identification of clusters, electronically recorded resource usage data, rather than self-reported data, was used. Self-reported data, which may be unreliable, has been used more often than log-files in studies on technology usage in mathematics lectures [7].

A study of students' resource usage patterns is of little relevance to practitioners if the nature of the resources, and the rationale for including them in the module, is not discussed. We explain how the lectures and videos in this study were designed and incorporated in such a way as to provide students with different types of learning experiences. In addition, we explain how the module is organized to enable students to navigate easily between resources, and we advocate that consistent engagement should be incentivized, especially if the student chooses not to attend scheduled lectures. It is our hope that this study will be of practical use to mathematics lecturers of large first-year classes of non-mathematics specialists, who are interested in combining face-to-face and online elements in their modules.

In Section 2, we discuss clustering as a method of identifying resource usage patterns and present reasons from the literature for students' choices of learning approaches when multiple resources are available to them. Section 3 outlines the design of the *Maths for*

Business module and the study; explains how students' resource usage clusters were identified; and describes how the qualitative data was analysed using thematic analysis [2]. In Section 4, we first discuss the identified resource usage patterns for the module. We then examine the relationship between a particular resource usage pattern and academic achievement (final module mark), before discussing students' perceptions of the disadvantages and benefits afforded by both resources. In Section 5, we discuss our findings in terms of how they might be of practical use to university mathematics lecturers of non-specialist mathematics modules, and offer some insights for lecturers who may wish to implement a similar system.

2. Previous research on online learning and live lectures

2.1. Online learning in third-level mathematics

Trenholm et al. [7] recently undertook an investigation of the literature specifically related to the use of technology in undergraduate mathematics teaching/learning. They found a limited number of empirical studies investigating students' use of technology, and most of these mainly relied on student surveys, self-report data and lecturer reflection. Trenholm et al. [7] identified benefits of online learning for students including the flexibility and convenience it provides; however, some drawbacks are the lack of mathematical community development and interaction between peers. However, Trenholm et al. [7,p.709] warn 'more research is needed to help clarify the nature of this relationship so that the profusion of self-report studies does not lead to the creation of a mirage of benefit'. They conclude that the use of technology in lecturing needs to be planned and not a 'bolt-on' feature. Overall, the studies they considered suggested a negative correlation between online lecture usage and achievement, and they ask whether this is because struggling students tend to choose online lectures in preference to other methods or whether video flexibility caters for surface learning strategies. The survey studies Trenholm et al. [7] reviewed, showed that students enjoy and value online learning. Furthermore, they highlight that solid research in this area is lacking owing to the scarcity of controlled experiments and owing to the difficulty of comparing/generalizing study results as the exact nature of online learning is not fully described.

2.2. Identification of resource usage patterns

Studies have been undertaken to identify students' resource usage patterns through the statistical technique of clustering [4–6]. Inglis et al. [5], for example, examined students' patterns of usage with lectures, online videos and the university mathematics support centre, in three similar undergraduate Engineering Mathematics modules at Loughborough University ($n = 534$). The authors recorded each student's attendance at live lectures (via swiping their university card), the number of times they viewed online lectures (via log-files on their Virtual Learning Environment (VLE) server), and their number of visits to the mathematics support centre. The authors, however, cannot confirm that the visits in respect to the mathematics support centre were in relation to the module of interest. On performing a statistical cluster analysis, they identified four categories of student: those who primarily attended live lectures; those who primarily accessed the online lectures;

those who primarily use the mathematics support centre; and, those who made little use of any. In summary, their study found that either students availed heavily of a single resource or made little use of any resource. They found 'no cluster that could be described as being engaged in genuinely "blended learning"' [5,p.495], leading them to propose that what they observed may be better described as "blended teaching" [5,p.500]. As part of their study, Inglis et al. [5] examined if there was any statistically significant difference in the academic performance of each cluster. They found that students who often attended live lectures or the mathematics support centre were more successful than students who predominantly used online resources. One shortcoming of the study is highlighted by Inglis et al.: 'what remains poorly understood is the overall pattern of study choices made when students are presented with many options' [5,p.490]. They emphasize how valuable research into understanding student choices would be.

2.3. Reasons behind resource usage patterns with live lectures and online videos

Although studies have focused on identifying resource usage patterns or data mining VLE resources in order to establish whether some resources are more beneficial to students than others, there have been some suggestions as to why students might opt for a particular pattern including: proficiency of IT skills [8]; convenience [8]; learner type [9]; gender [10]; personality type [8,11]; and perception of complementary or competing resources [12].

Bassili [8], through the use of surveys, investigated how both 'promotion and prevention' factors influence students' choices in pursuing short online videos or live lectures in an introductory psychology module. He suggested one of the main reasons behind students' choice to watch online videos is convenience. Bassili [8] measures convenience through how many hours of part-time work students undertake during the semester, and the distance they have to commute to their university.

Yoon et al. [12] conducted a survey in two undergraduate mathematics modules for non-mathematics specialists to investigate factors impacting students' choices to attend live lectures or/and view a recording of the lectures. They considered students' perceptions of whether the two resources were complementary or competing. They administered the survey during a lecture (35% lecture attendance on selected date). Overall, they found that 'personal learning styles, study habits and esteem for the lecturer can make some students view live lectures as more attractive learning opportunities to the recordings' (p.239). Yoon et al. [12] discuss the potential for interaction in live lectures; however, this is heavily dependent on the skill and teaching approach of the lecturer. After attending the lecture, some students perceived the live-lecture recording as redundant; however, a significant number of students (51% of 337 survey responses) intended to use both resources. The main reasons students gave to using both resources were for improved understanding of the material (owing to pace of lecture, missed part of lecture, difficulty of material); to help with preparation for the exam; due to their preferred learning strategy; and, to overcome shortcomings of the live lecture (including the ability to pause the recorded lecture).

Prior studies focus on identifying students' resource usage patterns with live lectures and lecture recordings by analysing either quantitative data or qualitative data to examine and discuss learning approaches. Lust et al. [6] found only 2 studies of 12 which addressed blended learning, investigated both aspects. Furthermore, they found that both of these

studies [13,14] recommend studying both the face-to-face and online elements of blended learning rather than one element/resource in isolation.

Our study advances the current literature on resource usage patterns by linking quantitatively identified patterns with qualitative survey data in order to provide an understanding for students' choices of resource. The research addresses both the offline and online components of the undergraduate module. This study seeks to address Inglis et al.'s [5] identification of a lack of understanding in literature of the reasons behind students' resource choices. Subsequently, the research questions are as follows:

(1) Which resources do students use when studying the module content?
(2) Is there a correlation between the resources a student uses and his/her final mark in the module?
(3) What are the reasons given by students for choosing a particular resource usage pattern?

We will discuss our findings in the context of the implications for a university mathematics lecturer who wishes to combine both live lectures and online videos, particularly in modules for non-mathematics specialists.

3. Method

3.1. The module

This study took place in University College Dublin (UCD). Data were collected from a large first-year undergraduate module, *Maths for Business*. As the name suggests, this is a mathematics module for non-mathematics majors, and is core for students from a number of undergraduate degrees in Business. Consequently, the main aim of the module is that students will master mathematical techniques, mainly from Calculus and including one- and two-variable differentiation and optimization, and will be able to apply them to problems, primarily taken from Economics. The module has an annual enrolment of 500–550 students and, due to the size of the cohort, students are assigned to one of two offerings of lectures for the module, each taught by a different lecturer from the UCD, School of Mathematics and Statistics. MM has almost 20 years of experience teaching this, or very similar, first-year mathematics modules to business students. The lecture schedule consists of three 50-minute lectures per week for a 12-week semester. Both lecturers aim to engage students in tasks for at least part of each lecture and, while we have not kept data on this, it is usual for such tasks to last at least 15 minutes. For MM, the lectures were scheduled for Monday at 2 pm, Tuesday at 10 am and Thursday at 10 am. For the second lecturer, they were scheduled for Monday at 10 am, Wednesday at 1 pm and Thursday at 3 pm. Both lecturers worked closely together and used the same set of lecture notes to prepare their lecture slides, resulting in the same examples and problems being used. Of necessity, they maintained a similar pace as the entire cohort of students was examined on the same content in the weekly quizzes. Both lecturers received high satisfaction scores from their end-of-year student feedback forms; with a score of 4.51 and 4.45 out of 5 on the question: 'Overall I am satisfied with this module.' The difference in their scores of 0.06 can be considered trivial.

In addition to lectures, MM made online videos to accompany the module. These videos were released online a few days prior to the corresponding lecture. A key feature of the module is that students are given the choice to attend lectures and/or watch the videos. There are 67 videos/screencasts in total with an average length of seven minutes. These videos, which were produced on a tablet, are similar in nature to Khan Academy style videos – the students see MM's writing as she works through problems and hear her as she narrates what she is doing. To encourage students to consistently engage, especially those who are not attending lectures, there is continuous assessment consisting of 10, weekly, 15-minute, written quizzes, with each one examining the previous week's learning outcomes. Worksheets are provided online which give students the opportunity to practise questions before the quizzes. The quizzes are administered during the *Maths for Business*' tutorial time. The tutorial format consists of the tutor administering and supervising the quiz, returning the previous week's graded quizzes, and providing feedback on the common errors from these. Each quiz is worth 5% and the best eight are counted towards a final assessment mark of 40%. The remaining 60% is assessed through a two-hour final written examination that examines the entire content. The pass mark for the module is 40% and students are required to answer all questions correctly in their eight included quizzes and final examination to obtain full marks. We have anecdotal evidence that some students' objective is to do enough work to achieve the minimum pass mark, and to this end, may only study a portion of the content, with a view to answering the subset of questions related just to this content.

To assist students in navigating the module resources, each resource or activity (lecture, video, worksheet, weekly quiz) has associated learning outcomes. Thus, each lecture and video commences with the list of learning outcomes (typically between two and four for a lecture and one and two for a video) that the lecture/video will address; and each worksheet and quiz also list the learning outcomes being assessed.

Prior knowledge for *Maths for Business* is outlined in terms of Ireland's State Leaving Certificate (LC) Examination. This examination is taken by most post-primary students in Ireland at the end of their post-primary education, around the age of 17–19. Students typically study 6–8 subjects for the examination and entry to higher education institutions in Ireland is based on a student's score in his or her best 6 subjects. Almost all students take the Leaving Certificate Examination in Mathematics which is offered at three levels (Foundation Level, Ordinary Level (OL) and Higher Level (HL)). Students are required to have a minimum grade of a B3 (equivalent to a B- or 70%–74.99%) in OL Mathematics or a D3 (equivalent to a D-) in HL Mathematics to be eligible for entry to the Business undergraduate programmes. In *Maths for Business*, 481/522 took LC Mathematics and of those, 13% did OL and 87% did HL, with 11% of these achieving an A1 or A2 grade (minimum of 85%).

Finally, UCD hosts a mathematics support centre that provides a free drop-in support service for students. The UCD mathematics support centre keeps detailed records of which modules students are accessing the centre for help with and details on students' mathematical difficulties [15,16]. Students in *Maths for Business* have an additional three-hour drop-in centre available for them every week. This is similar to a mathematics support centre however the service is exclusively for *Maths for Business* students and has dedicated tutors. Students referencing mathematics support or the drop-in centre could be referring to either

of these, hence for the purpose of the study these are grouped under one heading as 'maths support'.

3.2. Quantitative data collection and analysis

In order to develop an understanding of students' resource usage patterns, the data collected for this study broadly covered three areas: students' background information; survey response data and resource usage data of students (lecture attendance, maths support attendance and number of video views). While we collected electronically recorded quantitative data, there are limitations surrounding the quality of students' engagement with the resources and the accuracy of records. Students' attendance at lectures was recorded through students scanning their student cards. This module consisted of 31 lectures; however, student attendance was not recorded at two lectures owing to human error. For this study, only the 29 lectures with recorded attendance were included in the data. For data on video usage, the log-files from Blackboard were retrieved. Each row in the log-file provides the name of a student, details on the online resource accessed by that student and the date of access. The time spent accessing the resource is not recorded by Blackboard. Maths support attendance was also recorded; however, as the average weekly attendance was 5%, we have not considered maths support as a main resource to be clustered upon. The resource usage data included in the study (from 522 students) was based up to the end of week 12 of the semester. After this point, in revision week and exam week, there was a significant increase in the number of videos viewed which, if included, would have skewed the results of the study.

Considering the research questions, we define variables (lecture usage, video usage, and overlap of lecture and video usage) to measure whether a student used lectures or online videos or both to cover the learning outcomes that they chose to interact with [17]. For example, a student may choose to cover 50% of the module content, and these variables measure whether they chose to cover it with lectures and/or online videos. All three variables are standardized measures between 0 and 100 inclusive. These variables are calculated based on the module's predefined lecture learning outcomes [17]. Each lecture is associated with multiple learning outcomes, and together the learning outcomes for a lecture are known as a 'Learning Outcome Group' or LOG. Each video is also associated with specific learning outcomes. Hence, a LOG can be completed by viewing (multiple) videos or by attending the lecture. For a LOG to be completed by video, over half of the associated videos must be viewed (as often learning outcomes are covered over multiple videos). We have the following definitions for an individual student:

$$\text{Lecture usage} = \frac{\text{Number of LOGs completed by attending lectures}}{\text{Total number of LOGs completed}} * 100$$

$$\text{Video usage} = \frac{\text{Number of LOGs completed by watching videos}}{\text{Total number of LOGs completed}} * 100$$

$$\text{Overlap of resources} = \text{Lecture usage} + \text{Video usage} - 100$$

Clustering was performed on the three variables using model-based clustering [18]. Limiting the number of clusters to at most six, an optimal number of four clusters were selected

based on the approximated Bayesian Information Criterion. These variables do not distinguish between a student who watches a video once and a student who watches a video multiple times.

3.3. Qualitative data collection and analysis

In the three weeks prior to the end-of-semester examination, all students were invited to complete a survey on resource usage patterns. The 161 students (30.8% of total cohort) who responded to the survey were assigned a random number for reference, and included in the study. The survey distributed to the students consisted of three sections; two of these sections are of interest to this study and will be discussed. The first section asked students to respond to questions relating to convenience, access to Internet and time commitments. These have been highlighted in literature as potential factors which influence students' choice to use videos or live lectures [8]. The second section consisted of three open-ended questions, designed to give greater insight into why students chose a particular resource, and how students approached their study. The open-ended questions were specifically chosen to elicit students' perceptions towards lectures/videos. For this study, survey responses of the 161 respondents were linked with their VLE data of online resource usage, lecture attendance and attendance at the maths support centres. The responses to the following open-ended survey questions were coded under Braun and Clarke's [2] thematic analysis framework with an inductive approach:

(1) In what ways, if any, do you believe that face-to-face lectures are beneficial for this module?
(2) In what ways, if any, do you believe that online videos are beneficial for this module?
(3) Please use the box below to input other comments you have about studying in an online environment.

Students' responses to the questions were direct and straightforward. Subsequently, a semantic approach was adopted whereby we are not considering a deeper meaning to participant responses. NVivo qualitative software was used in this stage [19]. We followed the steps in Braun and Clarke's table on phases of thematic analysis [2,p.35]. First, the responses were read repeatedly in order to identify important references, and initial ideas from the research were noted. Second, initial codes were generated, and the survey responses were coded based on these codes. The third phase involved merging codes; combining codes into themes; and recognizing relationships between themes. At this stage, some codes which did not contribute to the study were removed. Each theme was named and provided with a definition. At the end of this stage, a second round of coding occurred. Phase 4 involves reviewing the themes to check the themes work in context of the coded extracts and the entire dataset. Subsequently, we had 22 subthemes under 6 themes (see Appendix 1). Each theme and subtheme were further defined, and a written analysis produced for each theme in the context of the resource usage clusters identified through quantitative analysis (stage 5). NVivo software allows for references relating to (sub) themes to be viewed in respect of a particular variable category i.e. we can view (sub) theme references for each individual cluster. Finally, an analysis was completed for each resource usage cluster based on which (sub) themes were recognized in stage 5 as being meaningful for that cluster.

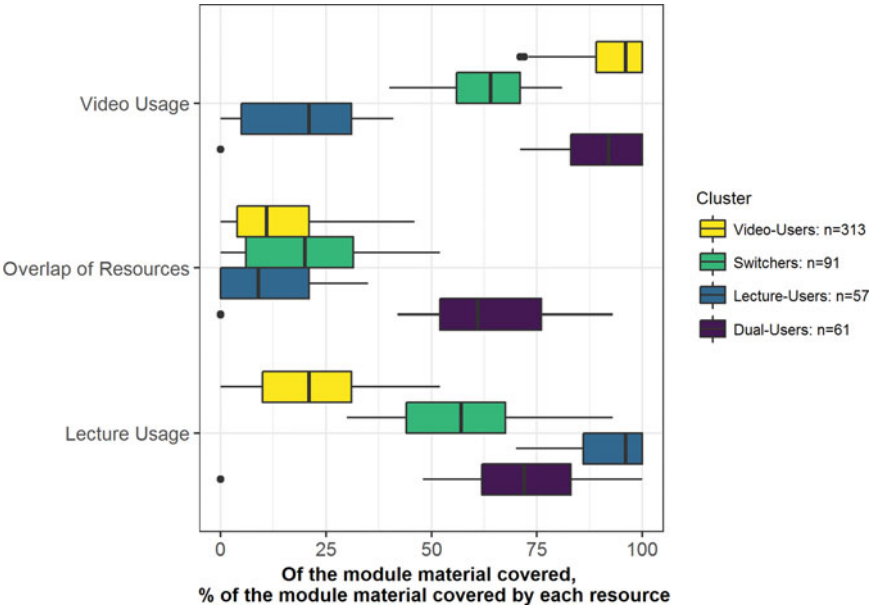

Figure 1. Boxplot showing of the learning outcomes covered by students, the percentage covered by each resource for each cluster. For example, a student who completes five learning outcomes with three completed by videos and four through lectures would have scores of 60% video usage, 80% lecture usage and 20% overlap of resources.

4. Results and findings

4.1. Identifying students' resource usage patterns

Four distinct clusters were identified from the resources the 522 students used (see Figure 1). We have named each cluster based on the cluster's resource usage pattern: Dual-Users; Lecture-Users; Video-Users and Switchers. Dual-Users ($n_1 = 61$, 11.7%) contained students who used both lectures and videos to cover the learning outcomes. An identifying feature of this cluster is the high level of overlap between resources. By this we mean that students were covering the module content using both videos and lectures rather than just one of these resources. This is shown on Figure 1 by Dual-Users having high Video Usage, high Overlap of Resources and high Lecture Usage boxplots with medians of approximately 75%. Students in Lecture-Users ($n_3 = 57$, 10.9%) chose to attend lectures and used the videos sparingly. Video-Users ($n_2 = 313$, 60%), the largest cluster, contained students who chose to cover the module material through videos and did not use lectures as a resource. Switchers ($n_4 = 91$, 17.4%) included students who covered learning outcomes using both lectures and videos but with little overlap. These students either attended the lecture or watched videos but were unlikely to do both.

In comparison to our results, Inglis et al.'s [5] largest cluster is the cluster which has above-average attendance at live lectures. Unlike their findings, we identified a small cluster of students who appear to be engaged in 'blended learning' (Dual-Users). As there were two lecturers for *Maths for Business*, we considered whether there was a significant

Table 1. Summary statistics of final marks by each resource usage cluster.

Summary statistics of final mark	Dual-Users	Lecture-Users	Video-Users	Switchers
Mean	72.5%	74.4%	64.9%	66.1%
Standard deviation	20.4%	19.4%	17.6%	17.5%
Standard error	2.6%	2.6%	1.0%	1.8%
95% confidence interval	(67.3%, 77.6%)	(69.4%, 79.4%)	(62.9%, 66.8%)	(62.5%, 69.7%)

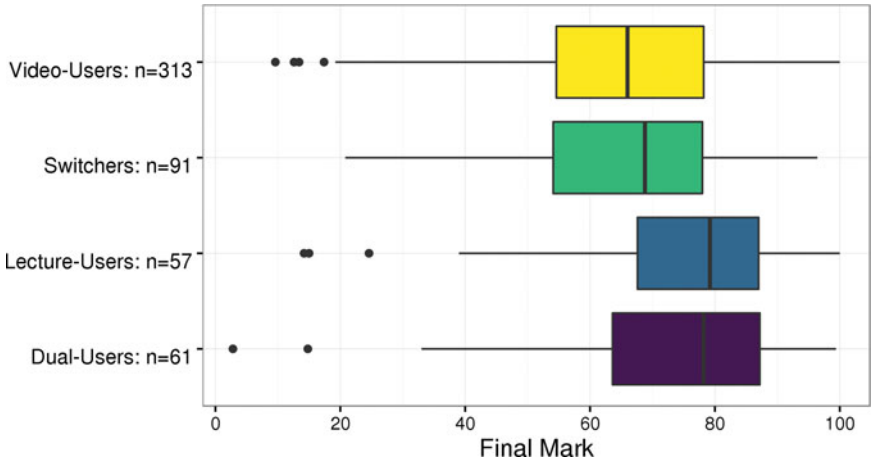

Figure 2. Boxplot based on the median of students' final module mark by resource usage cluster.

relationship between students' lecturer and their cluster membership. This relationship was not significant, $\chi^2(3) = 4.05$, $p = 0.2561$.

For this study, we were interested in linking *Maths for Business* students who completed the survey with their resource usage cluster. The number of students who completed the survey and percentage response rate for each cluster are: Dual-Users ($n_1 = 29/61$, 47.5%); Lecture-Users ($n_3 = 20/57$, 35.1%); Video-Users ($n_2 = 86/313$, 27.5%) and Switchers ($n_4 = 26/91$, 28.6%).

4.2. Relationship between resource usage pattern and academic achievement

To analyse the relationship between resource usage pattern and academic achievement, we investigated summary statistics for the final mark for each cluster (see Table 1) and created a boxplot of final marks based on the resource usage cluster (see Figure 2). There was a strong positive relationship between continuous assessment and examination marks ($r = 0.74$). The students who used lectures to a high level (either as a complement or main resource) achieved on average the highest marks. This is similar to the findings of Inglis et al. [5] and Trenholm et al. [7]. Investigating the reasons (for example, whether lectures or videos are more effective) behind this correlation is beyond the scope of the study. However, we can make a few comments. We note that Dual-Users have a significantly higher proportion of students who completed ordinary level mathematics examination rather than higher level examination for the State Examination (Appendix 2). 'Stronger' students have a tendency to use a single resource, either lectures or videos. We cannot say

that strong students chose lectures and subsequently had higher final marks. Possibly, students who chose to use lectures were more willing to actively engage with module content. However, we have not considered the impact of engagement level or quality on module marks.

4.3. Sample bias

Overall, the survey had a response rate of 30.8%, with approximately an equal number of respondents from either lecture cohort (79 respondents from MM's students and 82 respondents from the second lecturer's students). Differences between lecturer cohorts were considered unimportant as: a chi-squared test found no significant differences in the relationship between students' lecturer and their cluster group; an approximately equal number of survey respondents came from either lecturer's cohort; and, only three students surveyed referred specifically to their lecturer. For each (sub) theme and cluster, students were contributing an approximately equal number of comments per lecture cohort.

As we have performed stratification (division of the population into resource usage clusters), consideration should be given to whether the survey respondents for each cluster are representative of their cluster population. There were instances where the sample characteristics differed from the population characteristics (see Appendix 2), for example, the Dual-Users female response rate for the survey (83%) was notably higher than the actual cluster female proportion (62%). The survey respondents achieved, on average, higher final module grades and higher continuous assessment than the entire *Maths for Business*' student cohort. In general, for each cluster sample, the percentage of students who took OL mathematics was in line with the cluster population except in the case of Video-Users whereby 6% of the survey respondents completed OL mathematics compared to the actual proportion of 12%. Also, there was a tendency for those students, in all clusters, who attended the maths support to respond to the survey.

To prevent response bias, we weighted the survey responses for each individual cluster using an iterative raking method as outlined by DeBell and Krosnick [20]. The variables for consideration in weighting the data were gender proportion; proportion of maths support centre attendance; proportion of non-Irish fee students; proportion of OL Mathematics students and module marks. As in line with weighting methods, no more than five variables were used to reweight the responses for each cluster; however, the minimal number of variables was used such that the reweighted characteristics were in line

Table 2. Weighted demographics for students who responded to the survey by each resource usage cluster where '*' represents a difference from the population characteristic of more than 3%.

Demographic	Dual-Users	Lecture-Users	Video-Users	Switchers	Overall
Number of students surveyed	29	20	86	26	161
% female	62%	32%	44%	34%	44%
% who accessed maths support	48%	16%	15%	23%	22%
% non-Irish fee students	15%	29%	9%	7%	11%
% OL mathematics	25%	15%	15%	14%*	16%
Average final mark	73%	78%*	67%	68%	70%
Average continuous assessment	80%	81%	70%	74%*	74%

with the population characteristics and the weights were considered stable. Table 2 contains a detailed breakdown of each cluster's weighted demographic based on the students surveyed.

Following from this point in the study, all qualitative analysis and discussion will only relate to the 161 students who replied to the survey. The following subsections will present each cluster individually in order to address the third research question on students' reasons for their resource usage pattern.

4.4. Dual-Users

Dual-Users covered module material through both lectures and videos, as well as accessing maths support. In fact, this cluster had the highest percentage (48%) for the drop-in centre, female percentage (62%) and OL Mathematics students (25%). Possibly as a result of the students using videos and lectures in a complementary manner, in their survey responses they did not focus on the disadvantages of either. Rather they focused on how they used both resources to reinforce their learning. These students attended the lectures first and used the videos as a refresher, or to clarify difficult topics or to expand on notes they rushed in class. They describe the video content as clear, concise, straightforward and helpful.

Unsurprisingly, the lecture environment was commented on heavily by Dual-Users. In particular, students focused their discussion on the engaging face-to-face nature of lectures; their perceptions of advanced coverage of material; the lecture content in comparison to video content and the lecture pace. Dual-Users commented on the depth of the lecture content. As well as module content, some students commented on how they perceived that the lecturer prepares you for the weekly quizzes through extra examples and tips, and how lecturers reviewed feedback from the previous week's quiz. Students liked that different examples were used in the lectures compared to the videos as this meant that if they are using both to study they have a greater variety of examples. Students recognized that by attending lectures they were not leaving studying to the last minute, and could learn 'maths gradually' [Student 71]. This also left time for revision of material through videos and visiting maths support. The lecturers' attempt to make the *Maths for Business* lecture environment interactive is reflected in comments by the respondents: students can ask questions in lectures; students can work through example questions under supervision; and, students are encouraged to collaborate with colleagues on questions.

> It is really helpful how she gives us questions to do and comes around to help. This is a great opportunity to ask for help and get to understand the topics better. [Student 695]

There were a few comments from Dual-Users about the fast pace of the lectures; however, students can remedy the fast pace by accessing the videos to review topics they found difficult. Overall, their reliance on lecture support and use of both resources suggest a number of 'struggling' active students opt for this usage method. However, analysis of Leaving Certificate Mathematics marks and *Maths for Business*' marks suggests strong students also opt for this usage pattern.

4.5. Lecture-Users

Lecture-Users had the highest average continuous assessment and highest average final examination mark. Lecture-Users avoided discussing the lecturer, lecture pace, maximizing

available time or maths support. Instead they heavily focused on the perceived benefits of lectures, particularly as an interactive environment between lecturers and students, where friends can collaborate. One aspect of lectures highlighted in contrast to videos is the ability to have your questions answered in class. Furthermore, students acknowledged and appreciate the benefit of having the opportunity to practice example questions as it, 'makes you actually do the work' [Student 105]. Lecture-Users felt that by attending the lecture they were automatically learning, and some liked the routine of having a scheduled time to work on a specific module. This may be particularly relevant for students in their first semester of university who may be struggling to cope with the transition to more independent learning. It may also be relevant for first-time users of online environments who can feel lost without a fixed schedule, and students that may not have the discipline needed for online learning:

> It's a familiar classroom environment, it's timetabled which gives it precedence over other things. [Student 67]

There was very little discussion around videos and general online studying, either the benefits or the disadvantages. They view videos as a secondary revision tool; a tool for 'augmenting study' [Student 872]. The videos are used simply to clarify a question, point or method from the lectures that one may have forgotten, found difficult or missed. Overall students felt that the lecture content goes into more depth and complexity than video content, and therefore, they placed more trust in lectures. Some emphasized the bond/connection students have with the traditional face-to-face methods, and this is supported by the general perception among all clusters that lecturers provide a greater number of examples in the lectures than in the videos, and that the lecture prepares you better than videos for the weekly quiz*:*

> There is definitely a greater feeling of security and trust that all exam material will be covered in face-to-face. [Student 125]

4.6. Video-Users

In this cluster, students acknowledge video features including the ability to pause, rewind, replay the videos and, consequently, the ability to cover the material at their own pace and preferred time. Students that used lectures to a high degree did not discuss these advantages of videos to the same level. Video-Users often contrasted these benefits with the rigid nature and inconvenience of time-tabled lectures. They discussed using the pause function of videos to great effect by: creating their own notes, and completing video questions and worksheet questions while the videos are active. In contrast to the students who attended lectures and were given questions to work on in the lectures, a number of Video-Users described attempting the questions in the videos before they viewed the answer. A portion of students in this cluster strongly believed videos are superior to lectures in maximizing their learning for the time available owing to a more concise format with less repetition, flexible use, efficient and faster pace. However, a few students did express a desire for the videos to be more directed towards the weekly quiz.

While students in the other clusters discuss the positive and engaging lecture environment, Video-Users emphasized negative issues with the lecture environment including: large class size; pace; fear to ask questions and having to concentrate for long periods:

> However as the lectures are so big I find them unbeneficial as I struggle with math … Math should only be taught to small groups. [Student 16]

In fact, one in five Video-Users surveyed implied/stated there was no benefit to lectures. However, not all the comments from Video-Users in regards to the lecture environment were negative. This suggests a split in the type of students opting for videos as their main resource. There appears to be a group of students who perceive themselves as 'strong' opting for the videos, and a group of students who choose videos because they are 'weak'. This theory is supported by the opposing views of the lecture pace; either too fast or too slow. No other cluster commented on the slow pace of lectures. The students who consider themselves 'strong' achieved a minimum final mark of 70% and had completed HL LC. They may have chosen videos as 'strong' students may coast their way through service mathematics courses. Some 'strong' students associated going to lectures with needing additional assistance:

> I believe face to face lectures are beneficial if you are really struggling however it is my opinion if you have a good basis in maths and find it easy to understand then I believe that the lectures are not that important and that the videos are all you need. [Student 119]

4.7. Switchers

This cluster had an unusual pattern whereby students in the cluster used both lectures and videos but with little overlap between them. One survey response in particular provided insight into this:

> At the start of the semester (weeks 1-5) I did little study since most of the topics were based on the leaving cert, I also went to the lectures. As the week passed, I found myself not going to the lectures. This was due to them being at awkward time in my timetable and I felt the videos were as useful. I invariably used the videos for the final five tests. [Student 226]

Since this student used lectures initially, and switched to only using videos, he or she had little overlap between their use of lecture resources and video resources. Approximately half of the students in this cluster had a similar pattern whereby they attended the majority of lectures in the first few weeks and subsequently switched to videos. The first few weeks of *Maths for Business* condenses material from the HL LC Mathematics syllabus, hence students may stop attending lectures if they have 'covered' the material before. Students, therefore, might convert to videos, and remain with videos for the rest of the semester. Second, an analysis of lecture attendance shows a consistently lower attendance at the 10 am Tuesday lecture slot for one cohort of the class and 3 pm Thursday lecture for the other cohort. These students covered the material they missed by not attending lectures through the videos. The remaining students have low–medium overlap. They have high overlap in comparison to the rest of Switchers, but not to the degree of Dual-Users so they have been included in Switchers.

Switchers discussed the videos with various opinions: how videos are a good refresher/clarifier/complement to the lectures; that videos are 'fairly perfect already' [Student 226]; how videos allow for maximizing time or; how videos can leave one feeling as if they are 'missing out' in contrast to the in-depth lectures. Despite Switchers using the video resources, no student remarked that they paused the videos to complete

questions or create notes while studying. Instead they discussed being unable to ask questions and the discipline required to use videos. Generally, there was a lack of commentary from students on the advantages of lectures. Switchers acknowledged the benefits of the lecture for complex topics but feel that lectures are not relevant/needed for simple topics:

> [Lectures are] Beneficial when relating to complex topics but wasted when dealing with simple process orientated topics. [Student 53]

Some students focus on using the resources in context of assessment rather than in context of learning. Supporting this theory is the emphasis of students on the theme 'weekly quiz' and the link to lectures and/or videos. There are several references to specific resources being useful for the 'weekly quiz', and comments implying that the lecture gives more help towards quizzes than the videos provide.

5. Discussion

Maths for Business is a first-year mathematics module for non-mathematics majors from Business who bring with them a diverse range of prior mathematical achievement. Such a module should be familiar to any lecturer who has taught mathematics to non-specialists and we discuss our findings as they might relate to the practice of such lecturers. Our findings suggest that lectures and videos both have roles to play in the teaching of mathematics to non-specialists, especially if they are embedded in the module in a way that offers students different types of learning experience. We discuss these, and related issues, further.

5.1. Role of live lectures

It is naïve to speak about 'lectures' as if they are a well-defined concept. In his critical review of lectures, Pritchard [21] takes lecture to mean 'a class involving one teacher and a large group of students … in which the dominant direction of communication is from the lecturer to the students' (p.610). He further explains that in-class activities should be considered as a secondary element of a lecture. In this module, both lecturers attempted to include at least one interactive task per lecture. Students were encouraged to work on tasks in groups, while the lecturer tried to engage with as many groups as possible. Our results show that despite the presence of videos, there was a group of students who chose to attend lectures (Dual-Users and Lecture-Users) precisely because they enjoyed the interactive environment and appreciated being able to ask questions. They also felt that by using scheduled lectures, they were being supported in managing their time, and felt that they were learning 'gradually'. Furthermore, a cohort of these students expressed a distrust of using videos only as they felt all material might not be covered comprehensively. This was in contrast to the sense of security they felt from attending lectures. Perhaps this is unsurprising since these students are navigating the transition from school to university, and a face-to-face environment may feel more familiar and secure to them. We also found that students who attended most lectures (Dual-Users and Lecture-Users) achieved, on average, the highest marks. Whilst correlation does not imply causation, it is tempting to suggest that some of the reasons discussed above – actively engaging in tasks and asking questions

during scheduled times each week – might explain this, although we expect there are many more factors at play.

In any discussion of attendance, it is worth noting that a fall in lecture attendance over a semester is an issue for many undergraduate modules [22]. We recorded a decrease in attendance and our findings suggest that some of the Switchers may be responsible for some of this decrease – attending lectures in the first half of the semester and then switching to videos. We did not keep attendance data in the years previous to the introduction of online videos and therefore cannot say if the decrease is considerably lower than then, although MM recalls a poorer attendance in the latter half of the semester in previous offerings. She also recalls that 10 am lectures generally had lower attendance than the 2 pm lecture. From our data, a cohort of Switchers exhibited this pattern – they used videos to substitute for lectures that they did not attend because they found the scheduling inconvenient. Finally, MM, who kept fieldnotes throughout the study, noted that disruptive behaviour during lectures observed in previous years, was now almost non-existent. This may be because only those students who wanted to attend lectures came, and those who might have attended infrequently, were now not attending at all. An advantage of the drop of attendance means that it is much easier for the lecturer to interact with a smaller group of students provided he or she capitalizes on the opportunity. Indeed, one could argue that those who chose to attend lectures are getting a better experience than they might if lectures were compulsory for everyone.

5.2. Role of online videos

Trenholm et al. [7] noted that many studies do not describe in detail what they mean by online resources, and therefore, they can be difficult to compare. To be clear, rather than use lecture-capture, we chose to make short videos that addressed a small number of learning outcomes per video in a targeted way. Rather than source videos online, MM chose to make them for a few reasons. First, her experience with the module meant that it was quicker for her to record an informal, conversational video in one take, than spend time scouring for a suitable one online. Second, her interactions with students in lectures in previous years meant that she was familiar with students' mathematical misconceptions and preconceptions and hence she applied her pedagogical content knowledge [23] to the videos' design, making them especially suitable for students with a LC Mathematics background. Finally, we argue that the fact that they were 'homemade' means that students who did not attend lectures, could still feel like they knew the lecturer, even if they never met her face-to-face.

Our findings show that a large portion of students used videos instead of going to lectures (Video-Users and Switchers), and it is not surprising that 'convenience' [7,8] was a factor in their decision. However, just as a student may attend a lecture but not engage, a student may passively watch a video and not engage either. Therefore, from an educational perspective, we were particularly interested in some of the Video-Users' in-depth descriptions of how they actively engaged with the videos, for example, pausing to take notes or to work on the problem before viewing the solution. Such explanations did not appear in the other clusters, and just as some students liked the interaction that lectures afforded, there are students who describe interacting with the material through videos. We realize as a result of this study that perhaps we need to explicitly describe to students at the start of the semester, how to actively engage with the online resources.

Our results indicate that some students use lectures and videos in a substitutable manner – Lecture-Users, Video-Users, and Switchers. However, Dual-Users (11.7% of *Maths for Business* students) use the resources in a complementary manner – attending lectures but also viewing videos on the same learning outcomes. The majority of students in *Maths for Business* currently rely on and have a positive perception of the online videos. If the videos were removed, would Video-Users attend the lectures? Would the lectures be enough support for the "weaker" Dual-Users? Considering our findings and the discussion above, the removal of live lectures or online videos would likely have a negative effect on some students' engagement with, and learning in, the module.

5.3. Opportunity to cater for mixed-ability cohorts

A point of interest from the study is that in contrast to the lectures which have a relatively fixed pace, videos are commented on positively for the flexibility they allow in pacing learning, by those who perceive themselves to be 'weak' mathematically, but also those who describe themselves as mathematically 'strong'. In a large class with a diverse background, the lecture pace can be problematic for both extremes. Videos allow students to set their own pace, be it slow or fast, and this we believe is a critical element in why the majority of students chose to use them. *Maths for Business* assumes that students have a minimum entry-requirement of 70% in OL Mathematics (or equivalent), yet there are many students who must take the module who have over 90% in HL Mathematics. In addition, there are mature students who may not have studied mathematics for a number of years, and international students who may not have English as a first language. We argue that providing a lecture series that caters for all these backgrounds is impossible, but as Khan [24] advocates, videos can help the lecturer address the 'one-size-fits-all' lecture problem, particularly when there is a large group.

Following from Bloom's [25] discussion on providing multiple resources to students, we feel a critical aspect of catering for mixed-ability cohorts is the distinction between the lectures and video resources. Also, as MM has created the videos, the mathematical notation and language used in the videos are consistent with that used in the lectures. She was also able to apply her pedagogical content knowledge [23], developed over 20 years of teaching students at this level, to highlight areas that she knew could cause particular difficultly for students in this course. This provides 'struggling' students with at least two ways of engaging with the same material while 'stronger' students may choose to use a single resource.

5.4. Design of module

We make two points about module design. The first is that we made clear on all resources (lectures, videos, worksheets, quizzes) what learning outcome(s) they addressed. This was to help students navigate easily through the resources. While we did not ask students directly if it was easy to find what they were looking for, there was not one comment that mentioned difficulty in finding a given resource. Second, for students that chose to use only videos, we feel that the weekly quiz ensures they engage with the module consistently and not leave all the videos to watch at the end. Every usage cluster, but especially the Switchers, linked their comments on resources to how useful they perceived them to be in preparing for the weekly quiz or final examination. The module is designed to employ weekly

assessment, combined with learning outcomes, in order to provide structure to the module and to encourage engagement throughout the semester. This structure, we hypothesize, is particularly constructive for first-year students and first-time online users.

5.5. Online learning for mathematics

The final open-ended question on the survey presented students with the opportunity to give general comments towards online learning. In keeping with the findings of Trenholm et al. [7], the comments were of a positive and appreciative nature, focusing on the benefit of online learning as a complement to lectures. Interestingly, students' comments also provide a sense of realism; they know online learning is not suitable or possible in every circumstance:

> I don't think we're ready to learn in a fully online environment in any module, but for now it's a great assistance. [Student 147]

> I think it works very well for maths however I don't know if it would work well for other modules. [Student 444]

The sentiments expressed in this last remark were echoed by a number of students. These students take a mixture of accounting, economics, mathematics and business modules in their degree, and they give the impression that they have considered the potential of online learning in relation to non-mathematics modules, possibly their other course modules.

We conclude by reiterating that the findings of our study only apply to mathematics modules for non-mathematics specialists where there is a significant focus on mastering mathematical techniques. We make no claims, and indeed are not clear about, how such a combination of videos and lectures might work in an advanced mathematics module with a focus on more theoretical and conceptual areas of mathematics. Indeed, a recent study on the impact of eProofs on student learning in an Analysis module has not been encouraging [26].

6. Conclusion

The majority of students in *Maths for Business* predominantly use videos to cover the module content. However, there are small clusters of students who primarily use lectures, or indeed with lectures and videos in a complementary manner. The fourth usage pattern identified is one where students switch from lectures to videos or replace 'ill-timed' lectures with videos weekly. In this study, we investigated students' perceptions of online videos and live lectures. Our findings, resulting from a quantitative analysis followed by a qualitative analysis, suggest students choose live lectures owing to the interaction in lectures, a sense of trust in lecture material, and a belief they are automatically learning by attending lectures. Whereas students choose online videos owing to the flexibility of online videos, concerns involving pace of material in live lectures, and time-tabling considerations. In line with other studies [7], students generally have positive perceptions towards online learning; however, our study does not suggest online learning is superior.

Similar to Inglis et al. [5], our study found that students who attended lectures achieved, on average, a higher overall final mark as well as highest overall continuous assessment

mark. While Inglis et al. [5] found no cluster where students were genuinely engaged in blended learning, we found a small cluster of students (Dual-Users) who use both lectures and videos. Students who had a weaker mathematical background, based on the State Examination results in Mathematics, tended to be Dual-Users whereas 'stronger students' used a single resource to cover the module material (either lectures or videos). This point of contrast between Inglis et al.'s [5] and our study could be a result of differences in universities, educational setting of countries or teaching context. In Inglis et al.'s study [5], they clustered student data from three multivariate calculus modules from mathematics specialist's disciplines (engineering and single or joint honours mathematics), while our study consisted of clustered data from one business mathematics module with non-mathematics specialist students. There may be a fundamental difference in how mathematics and non-mathematics students approach resource usage. Contrasting the results of our study to a mathematics course for specialists rather than non-specialists may raise interesting comparisons concerning the differences in cohorts and their choices.

A serious limitation of this study is the merger of two data-sets from two student cohorts under different lecturers. Both lecturers engaged students regularly in tasks, covered the module material in time with each other, and provided students with the same continuous assessment. However, differences in students' resource choices may have emerged owing to different teaching styles or lecturer personalities. From the module feedback evaluations, both lecturers received similar satisfaction scores (see Appendix 3). This suggests that students from both cohorts were equally satisfied with the module. We further address the issue of two lecturers in *Maths for Business* by comparing the two student cohorts: using a chi-squared test; discussing the similar lecture content and format experienced; examining qualitative differences in (sub) themes and; the detailing the low number of survey responses with references to specific lecturers (see Appendix 3).

This study did not investigate the level or quality of engagement students had with resources. For example, in our study, we did not consider the impact of students viewing the same video multiple times. An extension of this work is to investigate the relationship between students' level of engagement and their resource choice, and subsequently students' level of engagement and their academic achievement. It was beyond the scope of the study to investigate whether live lectures or online videos are more beneficial for students. A controlled design study would provide further insights into this. Another extension of this work is to examine how students interact with online videos in the revision period prior to the module examination, for example, investigating whether Lecture-Users use videos when live lectures are no longer available to them. Our future work will explore effective resource development and practice in light of students' perceptions in this study, and delve deeper into the relationship between students' resource usage choice and their academic achievement. We believe that both live lectures and online videos have roles to play in the teaching of mathematics to non-mathematics specialists, especially when the cohort presents with a diverse range of prior achievement in mathematics. This is not to say that the role of online videos is equivalent to the role of live lectures.

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Appendix 1:
Description of importance of each themes and subtheme identified for each cluster (absent, infrequent, regularly, frequent).

Theme	Dual-Users	Lecture-Users	Video-Users	Switchers
Subtheme				
Comparisons	Regularly	Regularly	Regularly	Regularly
Direct Comparisons	Regularly	Regularly	Regularly	Frequent
Videos as Complementary to Lectures	Regularly	Regularly	Infrequent	Infrequent
Videos as a Replacement for Lectures	Infrequent	Regularly	Regularly	Infrequent
General Comments	Infrequent	Infrequent	Regularly	Infrequent
Recommendations	Infrequent	Infrequent	Infrequent	Infrequent
Online Studying	Infrequent	Absent	Regularly	Regularly
Live Lectures	Regularly	Regularly	Frequent	Regularly
Benefits/Advantages	Frequent	Frequent	Frequent	Frequent
Comments/Opinions	Infrequent	Infrequent	Infrequent	Infrequent
Disadvantages	Absent	Infrequent	Infrequent	Infrequent
Environment	Frequent	Frequent	Regularly	Regularly
Lecture Content	Regularly	Infrequent	Regularly	Regularly
Lecturers	Infrequent	Absent	Infrequent	Absent
No Benefit	Absent	Absent	Regularly	Infrequent
Pace	Infrequent	Absent	Regularly	Infrequent
Perception for Weak	Absent	Absent	Infrequent	Absent
Online Videos	Regularly	Infrequent	Frequent	Frequent
Activities while the Videos are Active	Infrequent	Absent	Regularly	Absent
Benefits	Frequent	Frequent	Frequent	Frequent
Disadvantages	Infrequent	Infrequent	Infrequent	Infrequent
Discipline/Motivation	Infrequent	Infrequent	Infrequent	Regularly
Opinions (General)	Infrequent	Infrequent	Infrequent	Infrequent
Repetition of videos	Regularly	Infrequent	Infrequent	Infrequent
Revision/Weekly Quiz	Regularly	Infrequent	Regularly	Frequent
Video Content	Regularly	Frequent	Infrequent	Frequent
Maximizing Available Time	Infrequent	Infrequent	Regularly	Infrequent
Maths Support	Absent	Infrequent	Infrequent	Infrequent

Appendix 2: Demographic breakdown by population and by sample.

Description of the clusters for all students in *Maths for Business*

Demographic variable	Dual-Users	Lecture-Users	Video-Users	Switchers	Overall
Number of students in *Maths for Business*	61	57	313	91	522
% female	62%	32%	44%	34%	43%
% who accessed maths support	48%	16%	17%	23%	22%
% non-Irish fee students	13%	26%	8%	7%	11%
% ordinary level of Irish	24%	12%	14%	7%	14%
Average final mark	72%	74%	65%	66%	67%
Average continuous assessment	79%	78%	69%	70%	72%

Description of the clusters for student who answered the survey

Demographic variable	Dual-Users	Lecture-Users	Video-Users	Switchers	Overall
Number of students surveyed	29	20	86	26	161
% female	83%	35%	57%	42%	57%
% working part-time	38%	35%	48%	62%	47%
% who accessed maths support	59%	25%	19%	27%	28%
% non-Irish fee students	14%	20%	7%	15%	11%
% ordinary level of Irish	24%	6%	16%	9%	15%
Average final mark	75%	81%	72%	69%	73%
Average continuous assessment	83%	85%	75%	77%	78%

Appendix 3: Discussion on merging data-sets from two lecturers' student cohorts.

A limitation of this paper is the merger of data from both lecturer cohorts. A lecturer's teaching style, personality, etc. could affect whether a student chooses to attend lectures or watch videos. To address some of these concerns, we examined the lecturers' module feedback scores and whether there were differences in the student cohorts' academic background, students' resource usage patterns and qualitative responses based on their lecturer. As there were two lecturers for *Maths for Business*, we considered whether there was a significant relationship between students' lecturers and their cluster membership. Using a chi-squared test, this relationship was not significant, $\chi^2(3) = 4.05$, $p = 0.2561$. This is similar to the approach taken by Inglis et al. [5] when they examined whether there was a statistical difference between their three merged student cohorts (two engineering cohorts and a single or joint honour mathematics cohort) all taking multivariate calculus under one lecturer.

Students are assigned to one of the cohorts for *Maths for Business* based on capacity and timetabling issues only. Significantly, they are not assigned based on prior academic achievement. However, we used a two-tailed t-test to compare prior academic achievement based on the LC mathematics grades of the two student cohorts and found the results to be not significant ($t = -0.14898$, $df = 479$). Note that the Irish education system assigns points to different grades in the LC State Examination, which allows for OL and HL grades to be compared.

As all students had access to the same online videos and mathematics support, differences in usage data most likely would have occurred owing to factors relating to the lectures to which they had been assigned. For example, the lecturers may have different lecturing styles or cover different content. While we cannot account for different lecturing styles among the two lecturers, we have considered differences in lecture content, pace and times. For MM, the lectures were scheduled for Monday at 2 pm, Tuesday at 10 am and Thursday at 10 am. For the second lecturer, they were scheduled for Monday at 10 am, Wednesday at 1 pm and Thursday at 3 pm. Both lectures had decreasing attendance as the semester progressed with one of the time-tabled lectures in each lecturer's case having lower attendance than the others weekly. Both lecturers relied on the same set of lecture notes to prepare their lecture slides which resulted in the same examples and problems being used for each cohort. Both lecturers aimed to engage students in tasks for at least 15 minutes of each lecture. The lecturers maintained a similar pace as the entire cohort of students was examined on the same content in the weekly quizzes. While the content of the lectures is very similar, we have not recorded any data on the lecturers' delivery or presentation of the module material. On the presentation of lectures, we remark that both lecturers have English as their first language but can provide no further comments on their teaching styles. As part of the end-of-semester module evaluation, students are requested to complete a survey for each of their modules. We have compared the two lecturers' results from the three relevant Likert scale (1 = strongly disagree, 5 = strongly agree) questions:

(1) I have a better understanding of the subject after completing this module.
(2) The teaching on this module supported my learning.
(3) Overall, I am satisfied with this module.

One lecturer received mean scores of 4.64, 4.38 and 4.51 (with standard deviations of 0.52, 0.70 and 0.57), respectively, while the other received mean scores of 4.57, 4.45 and 4.45 (with standard deviations of 0.57, 0.72 and 0.61), respectively. The differences between the lecturers' scores of 0.07, 0.07 and 0.06 are negligible. This suggests that both student cohorts enjoyed or perceived their lecturers' teaching style as beneficial.

Examining the number of survey respondents, we found an approximately equal number came from each cohort (79 students from one cohort and 82 students from the other). Of the survey respondents, only three students specifically referred to their lecturer. While quantitatively, we cannot distinguish between the two student cohorts, we examined the qualitative analysis for differences in the data. For the majority of (sub) themes and cluster, students were contributing an approximately equal number of comments per lecture cohort. The main subthemes which emerged included: pace of lectures and videos; lecture versus video content; including examples and questions; flexibility of using online videos; ability to ask questions; and lecture environment. As a similar pace and almost identical content are maintained between both lecture cohorts, the main theme affected by having two different lecturers is the lecture environment. The topics discussed for lecture environment included: lecture size; a sense that the lecture environment forces students to engage on some level; distractions in the lecture room; length of lecture; face-to-face and interactive engagement and; enjoyment of lecturer's teaching style (one student). While we are certain

that lecturers' personality and teaching style impacts students' resource choices, only a limited number of survey responses relate directly to this. Maybe this is not a major factor for *Maths for Business* students or for the survey respondents or alternatively the similarities between the lecture content and design limited the differences in lectures.