How Instructor-Developed Screencasts Benefit College Students' Learning of Maths: Insights from an Irish Case Study

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ABSTRACT

This qualitative case study explored how students learning Maths at an Irish institute of higher education benefited from their instructor's use of self-developed screencasts. The screencasts (47 in total) were posted on the institute's Maths Moodle site for students to access. One hundred and thirty-eight (n = 138) students participated in an online open-response survey. Students' commentary was analyzed using thematic content analysis (TCA). Themes that represented different types of screencast benefit to students were generated from the data. Consistent with previous studies, the findings show that a vast majority of students (88.4%) used the screencasts for many different purposes and viewed the videos as an extremely useful tool that enhanced their Maths learning experience. Ten primary benefits of screencasts emerged, namely allowing flexible and personalized learning, supplementing lectures and enhancing understanding of Maths keyskills, facilitating exam revision and material review, providing multimodal support for Maths learning, helping students to keep track with the Maths modules, providing a tighter match with course content, delivering a vicarious learning experience, serving as a memory aid, filling in gaps in class notes, and making Maths more enjoyable. The findings support the use of screencasts in facilitating and enhancing students' learning of Maths in higher education.

Keywords: *Instructor-Developed Screencasts, VLE, College Students, Maths Learning, Irish, Case Study*

INTRODUCTION

The rapid and widespread adoption of virtual learning environments (VLEs) in higher education has enabled Web 2.0 tools, such as screencasts, to be used innovatively to support and enhance traditional teaching and learning. Screencasts are a digital recording of a computer screen activity accompanied by a voice-over or concurrent audio commentary (Winterbottom, 2007). The recording can be created using a variety of software, such as Camtasia Studio, Screencast-o-matic, ScreenR, ScreenFlow4, and iShowU. In Maths learning, screencasts are especially useful as they allow the recording of handwritten step-by-step solutions of problems including specialist mathematical notation (Jordan, Loch, Lowe, Mestel, & Wilkins, 2012).

The nature of screencasts is in keeping with Paivio's (1986) dual coding theory, which posits that meaningful learning occurs when students process information simultaneously through two discrete input channels, namely the visual and auditory channels. The fusion of visual and audio elements together in screencasts support the way the human brain learns, which is by making associations between what is being seen (visual stimuli) and heard (auditory stimuli). This makes screencasts particularly beneficial for Maths learning. The combination of visual stimuli (images, handwriting, and on-screen movements) and audio stimuli (sound, narration, and voice-over description of steps and movements) also aligns perfectly with some of Mayer's principles of multimedia learning, which state that individuals learn better from animation and narration than from animation and on-screen text (modality principle); when a multimedia-aided lesson is presented in learner-paced segments rather than as a continuous unit (segmenting principle); when corresponding words (narration) and pictures are presented together at the same time rather than in

succession (temporal contiguity principle); when the narration is done by a friendly human voice rather than a machine voice (voice principle); and when the narration sounds conversational rather than formal (personalization principle) (Mayer, 2005).

Based on these learning principles, Maths screencasts that demonstrate how to solve problems in a well-paced, step-by-step procedure backed by the friendly and familiar voice of the instructor should optimize Maths learning and enhance the student experience. Screencast features that allow for infinite pausing and replaying also help students to handle, at their own pace, the cognitive load present in typical mathematical narratives such as that shown in Figure 1:

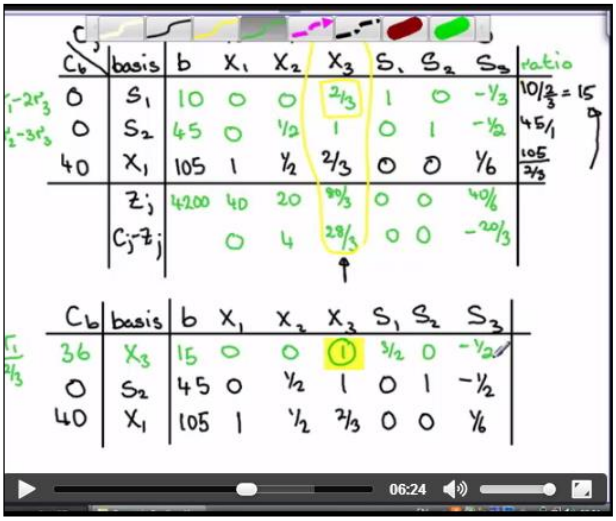

Figure 1*:* Many Maths problem solving steps, for example the Simplex Method,

contain heavy cognitive load

In this qualitative case study, we examined the views of Irish college students taking Algebra and Calculus courses under one instructor regarding the use of screencasts in their Maths learning. We looked specifically at how the students used the screencasts to support their myriad learning needs. The students were working toward a degree in sports and nutrition science, engineering and computer-related academic programs in which Algebra and Calculus were a mandatory component.

DESCRIPTION OF THE MATHS SCREENCASTS USED IN THE CASE STUDY

The screencasts demonstrated fundamental keyskills and were created to help students overcome the stumbling block they faced when attempting to solve Maths problems on their own. They were developed using Camtasia Studio 8.0 and SMART Notebook, and ranged between 1:49 minutes and 11:20 minutes in length. A total of 22 screencasts were created for the Year 1 class group, 14 for the second year group, and 11 for the third years. The specific topics covered in the screencasts are shown in Table 1.

Table 1: *Summary of Screencasts Developed for the Algebra and Calculus Courses*

Year	Topics	Screencast Duration (minutes)	No of Screencasts
1	**Algebra, Trigonometry, Differentiation, Series, Integration, and Complex Numbers**	**1:49 to 11:20**	**22**
2	**Matrices, Numerical Methods, Differential Equations and Laplace Transforms, Series and Partial Differentiation**	**2:18 to 8:01**	**14**
3	**Calculus, Fourier Series and Fourier Transforms, Laplace Transforms and Double Integrals**	**1:59 to 10:27**	**11**
	Total Number of Screencasts		**47**

Each screencast focused on only one specific keyskill, and had the following features: a clear descriptive title, a statement of purpose stating the problem to be solved and explaining what students will see in the demonstration, a problem solved by the instructor in a clear, step-by-step fashion, the instructor's voice-over description of the steps and results, and a brief conclusion. Some screencasts contained annotations to help students understand the steps more clearly. Screenshots of some of the screencasts are shown in Figures 2 to 6.

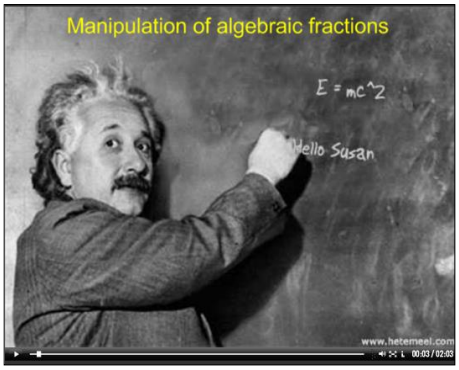

Figure 2: The title was stated clearly at the beginning of the screencast with an interesting visual stimulus

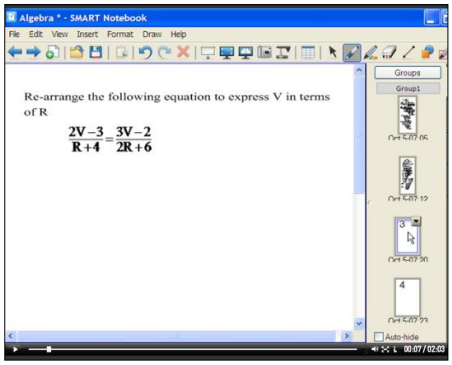

Figure 3: A statement of purpose explaining what students will see was given after the title

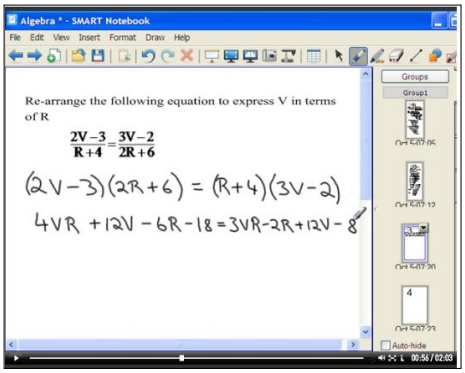

Figure 4: A step-by-step solution of the problem was demonstrated with a voice-over description

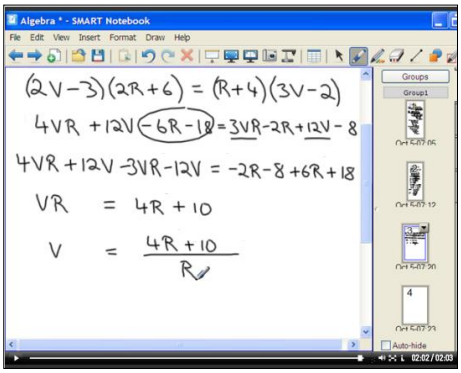

Figure 5: A brief conclusion summarizing the results was given at the end

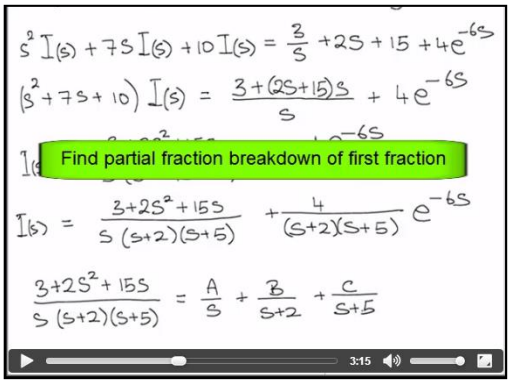

Figure 6*:* Some of the screencasts contained annotations

RESEARCH OBJECTIVES

The case study attempted to fulfill the following objectives:

1. To determine the percentage of screencast use and non-use among the students;
2. To determine the reasons for non-use of the screencasts;
3. To explore users' perceptions of the Maths screencasts; and
4. To determine the ways in which the screencasts had benefited the students, and addressed their learning needs.

LITERATURE REVIEW

Myriad studies on screencasts show students having favorable perceptions of the videos as a learning support tool. O'Malley (2010) encourages adoption of screencasts as a pedagogical tool, seeing its immense benefits to both students and lecturers. He maintains that the biggest advantage of screencasts lies in the flexibility of learning afforded by the technology, where students can sit in the comfort of their own home, replay difficult segments of a lesson, listen to any lecture time and again, and catch up with missed classes. For most students, the luxury of being able to view lecture material at their convenience and in their own time is a welcoming change. The same benefits were reiterated in Comiskey and McCartan (2011), where students regarded the videos as an ideal learning medium that allowed them to review at their own pace what had been covered in previous classes, and do some catching up before the next class meeting. Boffey, Gerrans, and Kennedy (2006) note that students particularly liked having access to lecture content outside of the classroom and the flexibility in watching lectures at their own pace. According to Gibbs (1992), this trend of independent, self-paced learning represents an important shift toward student-centered pedagogy as the instructional medium *"gives students greater autonomy and control over choice of subject matter, learning methods and pace of study"* (as cited in Comiskey & McCartan, 2011, p. 30).

Pinder-Grover, Millunchick, and Bierwert (2008) used screencasts to re-explain ideas students had difficulty with and discovered that the videos were instrumental in improving students' overall learning outcomes and final exam performance. Their students reported using the videos to clarify misunderstandings, supplement the lecture material, and review for exams, which collectively helped them to perform better in the course. Similarly in Green, Pinder-Grover, and Millunchick (2012), screencasts were used as a study resource, particularly for exams, and had helped raise students' competency with particular topics. The authors also discovered that students tend to watch a screencast in its entirety from start to finish if it was a short presentation, and that those who watched the screencasts completely tend to report gaining a significantly deeper understanding of the material. The same positive perception was reported in Wilkes (2012), where students found Maths easier to comprehend through screencasts which they thought were easy to use and follow, and especially useful for revision.

In a large lecture environment, screencasting technology is an effective way to reach a large number of students (Educause, 2006; Falconer, Nicodemus, DeGrazia, & Medlin, 2012), and has a huge potential for addressing their myriad academic needs, which are impossible for a single lecturer to address. The efficacy of screencasts in fulfilling diverse students' needs was demonstrated by Pinder-Grover, Green, and Millunchick (2011), who documented the strategic use of screencasts in a large introductory Materials Science and Engineering course, and examined their impact on student usage and course performance. Students in the course perceived the screencasts as helpful and tended to use the resources as a study supplement. Screencast usage was positively and significantly correlated with course performance as indicated by the final grade. Students with the least prior knowledge and competency in the subject appeared to gain the most from the screencasts. At the James Cook University in the U.S., screencasts have been used successfully to supplement lectures in large Maths and engineering classes, deliver mini-lectures explaining topics identified by students as unclear, and give feedback on homework and quizzes (Mullamphy, Higgins, Belward, & Ward, **2010).** In education programs where students are remote from the instructor, screencasts provide a simple yet effective means of delivering rich content to distance students to support various types of learning, as shown in Peterson (2007).

Guerrero, Baumgartel, and Zobott (2013) illustrate how innovative uses of screencasting can have a positive impact on student learning and attitudes. The authors transformed their traditional Maths classroom into a constructivist one by making the videos available to students in advance of class so that face-to-face instructional time could be freed up for more meaningful learning activities, such as working through problems, advancing concepts, and engaging in collaborative learning. The results were interesting. The transformed pedagogy had a positive impact on the students' understanding of course content and attitudes toward Maths. They valued the inverted classroom as class time was freed up from passive elements of instruction to focus more on actually doing the Maths. The students

appreciated that they had more time *"to process and think about course content prior to applying it in class, and that they could watch lectures anywhere, anytime at their own pace"* (p. 186). The latter finding seems to be consistent across many studies on screencasting.

Not only do screencasts improve learning outcomes, they are also found to be engaging and effective in delivering content. Compared to other learning technologies such as PowerPoint and podcasts as well as to chalk-and-talk methods, screencasts are considerably more engaging for students (Mullamphy et al., 2009). With the instructional benefits of screencasting clearly established, recent trends in the technology usage are taking a new direction. Of late, screencasts are increasingly being employed to provide feedback to students and promote assessment for learning (e.g. Haxton & McGarvey, 2011; O'Malley, 2011; Séror, 2012; Thompson & Lee, 2012), and to engage them in higher-order metacognitive processes (e.g. McLoughlin & Loch, 2012; Ro, 2011). Extant research suggests that positive learning outcomes associated with screencasts are more likely caused by how they are used as a learning resource, rather than by the pure technology itself. While there is much empirical evidence documenting the advantages of screencasts as a learning technology, no work has researched the benefits using a thematic content analysis. Hence in this case study, we addressed this gap in the literature by examining what these thematic benefits may be for Irish college students learning Maths aided by instructor-developed screencasts.

METHOD

DATA COLLECTION AND INSTRUMENT

To capture students' views of the screencasts and usage patterns, an open-ended survey was administered online through the Maths courses' Moodle pages, and was kept open for two and a half months. The questionnaire contained two sections, A and B. Section A asked for demographic details such as age, specialized degree program, year of study, and first language, as well as off-campus Moodle accessibility from the students' home locations. This was an important question since the screencasts were only accessible from the Moodle pages. Section B requested students to indicate how the screencasts aided their learning of Maths in the said courses. Students were prompted to write as much as they wished about the screencast uses and benefits. The open-response survey format allowed for capture of rich narrative data from a large number of students, as it enabled focused and elaborate feedback which would give us insight into their opinions of the uses and benefits of the technology. Out of the 266 students enrolled in the courses, 138 responded (a response rate of 52%).

PARTICIPANTS

The participants were 138 undergraduate students from four different degree programs, namely Electronic and Computer Engineering (ECE) (n = 78), Computer Network Management (CNM) (n = 46), Mechanical and Renewable Engineering (MRE) (n = 61), and Sports and Nutrition Science (SNS) (n = 81). They were taught mandatory Calculus and Algebra courses by the same instructor who developed the screencasts. The ECE, CNM and MRE student groups were taking the courses in the semester that the case study was conducted, while the Sports and Nutrition Science group had taken them in the semester before. Their mean age was 27 years. Eighty-two percent (n = 113) were native English speakers, while the remaining 18% (n = 25) were speakers of Arabic, Russian, Slovakian, Romanian, Turkish, Polish, Portuguese, Spanish, Urdu, Yoruba, Finnish, Vietnamese, and Thai. Figure 7 shows the breakdown of participants by degree program.

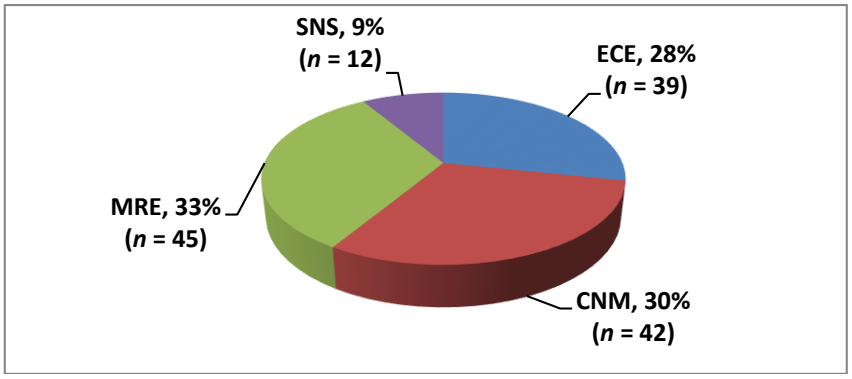

Figure 7: Breakdown of participants by degree program.

The highest response rate (91.3%) came from the Computer Network Management group, where only 4 students did not respond, followed by Mechanical and Renewable Engineering (73.8%), and Electronic and Computer Engineering (50%). The Sports and Nutrition Science group recorded the lowest response rate (11.1%). In terms of year of study, half of the responses came from the third year students (50%), most likely due to their higher degree of familiarity with the Moodle pages and screencasts. The first and second years each recorded a 25% response rate.

DATA ANALYSIS

Descriptive statistics were employed to present student demographics and percentage of screencast use, while the qualitative data (student commentary) were analyzed using thematic content analysis, an inductive approach that allowed themes to emerge from the data. In this analysis, students' written responses were thoroughly reviewed to identify recurrent patterns that would constitute themes. An appropriate name was then given to each theme to represent a key benefit of screencast use.

FINDINGS

REASONS FOR NON-USE OF THE SCREENCASTS

Only 11.6% of the participants (n = 16) said they never used the screencasts, or rarely used them. Although the Maths Moodle page was very well laid out and systematically organized with clear headings for screencasts and other learning objects (Figure 8), some students were surprisingly unaware of their presence on the page, claiming that they had *"never seen one on the Maths Moodle site"* (3rd year, MRE).

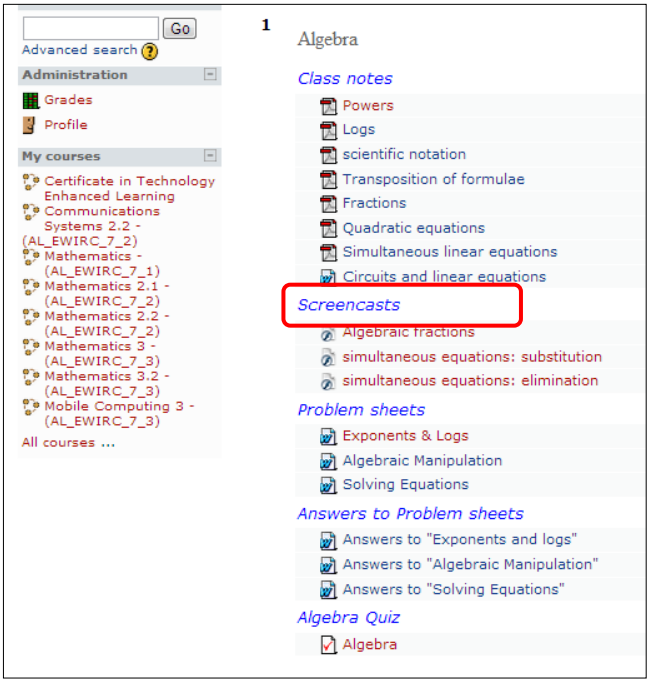

Figure 8: The Maths Moodle page was well laid out with a clear heading for screencasts

A few found the videos to be of *"little significance"* (3rd year, MRE), most likely because they had already grasped the keyskills from the lectures, and therefore did not need the explanation provided in the screencasts. This was explained by a mature Computer Network Management student:

> The lectures are explained well enough that I don't use them often.

Wilkes (2012) also reported the same reason for students' non-use of screencasts in her study, in addition to other causes such as slow Internet connection, difficulty with opening and downloading the videos, and lack of plug-ins. The consistency in the finding suggests that screencasts tend to be used mostly by students needing further instructional

support for Mathematical understanding, and less by those who are already quite proficient in the subject and those who learn well from lectures.

OVERALL PERCEPTIONS OF THE SCREENCASTS

More than 88% of the participants (n = 122) were regular users of the screencasts. In general, they responded positively to the videos, claiming them to be *"very useful," "extremely helpful," "very informative and legible," "very practical,"* and *"easy to use."* Two students commented:

> It is very helpful to hear the lecturer go through the solutions step by step *(1st year, SNS).*

> These (the videos) have been a huge and continuous help *(1st year, CNM).*

The same positive student experience was reported in Falconer et al. (2012), Green et al. (2012), Pinder-Grover et al. (2008), Pinder-Grover et al. (2011), and Wilkes (2012). In this study, many felt that the videos provided an alternative form of instruction that played a significant role in easing their Maths learning process:

> It (learning from the screencasts) is much easier than looking at questions on paper already done *(3rd year, ECE).*

> The screencasts are good because they help me learn (*2nd year, CNM).*

> (They are) very easy to learn from and (provide) good step-by-step procedures *(2nd year, CNM).*

> I find it very easy to learn using these *(3rd year, ECE).*

Students used the screencasts for many purposes to accommodate their learning needs, and found them good and useful for these reasons. A first year entrant said the video tutorials helped him to practice and keep up with the Maths module, while a more mature student wrote:

> The screencasts were very helpful indeed as they give a clear example of the work that we are covering in the classroom *(2nd Year, ECE).*

The positive reactions were likely due to the well-paced and orderly explanation given in the videos, and the direct connection of the content with what was covered in the Maths modules. The comments of three particular students summed up the general views of the student groups:

> Visual step-by-step examples of the subject materials are very informative and easy to follow *(2nd Year, ECE).*

> They are a brilliant asset to have *(3rd Year, ECE).*

> Definitely the best part of the Maths Moodle page *(3rd Year, ECE).*

KEY BENEFITS OF THE SCREENCASTS FOR MATHS LEARNING

Ten key benefits emerged from the data. Each benefit represents a distinct utility of the screencasts that fulfilled a particular learning need. As students had varying Maths learning needs, the precise manner in which they used and benefited from the screencasts also varied according to their needs.

BENEFIT 1: ALLOWED A FLEXIBLE AND PERSONALIZED LEARNING

The most recurring theme from the data highlighted flexibility and personalization as a major benefit, a finding consistent with Boffey et al. (2006), Winterbottom (2007), Mullamphy et al. (2010), O'Malley (2010), Comiskey and McCartan (2011), Wilkes (2012), and Guerrero et al. (2013). Being constantly available on the Maths Moodle pages, the screencasts enabled students to enjoy flexible learning hours in the comfort of their own home:

> The screencasts are very helpful for figuring out problems at home *(3rd year, ECE).*

> I find it very easy to learn using these as I can sit in the comfort of my own home and go over them as much as I want *(3rd year, ECE).*

Students also benefited from a self-paced independent learning mode where they could pause and restart the videos, and rewind at difficult sections of a lesson as much as they needed to until they gained satisfactory understanding of the Maths keyskills:

> The screencasts allow me to go over in detail the steps involved in a particular question because it is possible to pause the video and play it again until I am satisfied that I understand what is going on *(3rd year, MRE)*.

You can pause them and look at them as much as you want, unlike class *(3rd year, MRE).*

Being able to pause, rewind and replay the videos means that students could control the rate of information absorbed. This gave them greater autonomy over their own learning and allowed them to move at a pace most suited to their ability:

(The screencasts are) good as you can follow full worked examples at your own pace, pausing and restarting as you go *(3rd year, MRE).*

These are easy to follow, and allow myself to learn at my own speed *(3rd year, MRE).*

They are excellent for helping you understand in your own time *(2nd year, ECE).*

As the screencasts could be remotely accessed from the Moodle pages, downloaded and viewed offline anytime, anywhere, they enabled learning that extends beyond the classroom and transcends the boundaries of time and space. A mature student mentioned that the videos were *"very helpful if you are stuck on a problem outside class hours"* when the lecturer was not directly accessible for help. They also afforded *"a sort of one-on-one tuition,"* as stated by one male student, a point further illustrated by a first year entrant who found them *"to be the biggest help as it's the same as a private tutor (that allows) you to pause and take notes."* For students with limited notetaking skills, the screencasts would be of tremendous help. In these instances, the screencasts take on the role of a private virtual tutor who can accommodate the varied paces of students' understanding, ability, and learning styles. This flexibility and personalization of learning represents a shift toward greater student-centered education articulated by Gibbs (1992), and was a very critical factor influencing students' ability to adequately understand the Maths.

BENEFIT 2: SUPPLEMENTED LECTURES AND ENHANCED UNDERSTANDING OF MATHS KEYSKILLS

The second most recurring theme was students' use of the screencasts to supplement lectures and address gaps in their understanding of Maths. This benefit replicates the usage pattern reported in Pinder-Grover et al. (2008) and Mullamphy et al. (2009). Not understanding a lecture or gaining only a partial understanding of it is not uncommon among students as they have various limitations and capacities in absorbing details. The presence of extraneous stimuli in the classroom or language barriers can also lead to non-learning during lectures. In this case study, a non-native speaker of English explained how the language barrier sometimes got in the way of her Mathematical understanding:

Actually I am good in Maths but when the lecturer introduces a new topic like Laplace Transforms or Probabilities, I sometimes can't catch what he is speaking about as I don't know these words in English and need a dictionary to translate them *(2nd year, ECE).*

Fortunately, students could turn to the screencasts for clear, systematic explanations that helped to place the Mathematical understanding needed. Some students admitted that they seldom used the screencasts except for this purpose:

I've only used the screencasts once or twice when I needed a more thorough understanding of the material *(3rd Year, CNM)*.

A 47-year old Electronic and Computer Engineering student valued the explanation as being *"a clear example of the work (covered) in the classroom,"* while another student appreciated that he could *"understand the method (of problem solving) better"* after watching the screencasts. The systematic presentation of the step-by-step solution, coupled with the fact that they could control the screencasts, helped to instill the much needed Mathematical understanding. Turning to the screencasts for learning assistance was reiterated again and again by a good number of students:

(The screencasts are) good for when you want to go over what you did the same day, especially if you didn't quite grasp it the first time *(3rd Year, MRE)*.

The screencasts are are extremely helpful if you do not understand some of the Maths after the lecture *(2nd year, ECE)*

Screencasts give a slower narrated explanation of the mathematical problem which is very helpful if not understood in lectures *(3rd Year, MRE)*.

(The screencasts provide an) extra way of learning if not completely understood in class *(3rd Year, MRE)*.

They clearly explain in great detail topics I have difficulty understanding *(2nd year, CNM).*

You see a step-by-step breakdown of the questions which help you to understand the questions better *(3rd year, ECE).*

> I found that I was able to understand the method more clearly and know where each figure/answer came from *(1st year, SNS).*

Students' testimonies underscore the important role of the videos in supplementing classroom instruction, and in further enhancing their understanding of the Maths.

BENEFIT 3: FACILITATED EXAM REVIEW AND REVISION

Using screencasts for material review and revision was also a common theme throughout students' commentary. A first year CNM student wrote it was *"great to be able to rewatch the Maths and follow along."* Statements such as these and others that described the screencasts as being useful for material review frequently popped up in the comments:

> The screencasts give you a step by step run through sample problems and are very useful for revision *(2nd year, CNM).*

> The screencasts are great especially if you would like to go back and review a topic *(1st year, CNM).*

> I find the screencasts very useful when studying for an exam as they are usually based on the more difficult questions *(1st year, CNM).*

> They were a great preparation for the final exam and helped a lot *(3rd year, ECE).*

The evidence agrees with the findings of Comiskey and McCartan (2011), Green et al. (2012), and Wilkes (2012), all of which pointed to the important function of screencasts in facilitating review and revision. In this study, students also used the videos in tandem with other learning resources available on the Moodle site, such as problem sheets and class notes. One student found them of great benefit as they *"provided a good source of revision for problem sheets and exams"* (2nd year, ECE). These resources were not only useful for exam preparations but they also helped students to digest complex problem solving methods in greater detail to enable working on the problem sheets. According to a third year student, reviewing course material using the screencasts was especially beneficial when the lecturer was not available for help:

> I use them during revision weeks leading up to exams when the lecturer is not on hand. It is possible to email the lecturer but I would tend to reserve that for something I was having great difficulty with *(3rd year, CNM).*

The comments reveal yet another clear advantage of using screencasts, and that is, they release lecturers from the task of having to re-explain concepts, thus freeing up their time for more valuable activities. Lecturers will testify that repeating lectures and re-explaining concepts can be very frustrating and tiresome. Therefore from this perspective, screencasting is an added benefit both to students and lecturers.

BENEFIT 4: PROVIDED MULTIMODAL SUPPORT FOR MATHS LEARNING

Students have varied learning styles and do not learn the same way. Some may benefit more from interacting, discussing, and note-taking; others from watching, listening, and doing. In this case study, students expressed a need for the latter form of learning. They pointed to the visual and auditory elements in screencasts as beneficial to their learning:

> In some cases, it is not enough to learn from written materials. Screencasts are better to learn (from) by watching and listening as in class *(2nd year, CNM).*

> Screencasts are good and useful. The voice and picture together make learning easy *(3rd year, ECE).*

In the Mathematical context, the visual component and on-screen movements incorporated in screencasts are certainly effective in demonstrating typical multistep problem solving approaches in Maths. Seeing the logical progression of problem solving and how the solution is generated reduces the abstraction level and complexity in Maths, and is critical in assisting students to grasp the keyskills:

> The lecturer gives step by step instructions on how to solve various Maths problems. The lecturer's commentary explains exactly what is happening at each stage of the problem. This is useful *(3rd year, ECE).*

> A question is worked out step by step, which you can watch as often as you like until you are 100% confident in that question *(1st year, CNM).*

> They are very helpful as you can see how the Maths are done from start to finish *(2nd year, CNM).*

> They are a great help when you can see the questions being done and explained; you can watch them over and over again *(2nd year, ECE).*

Maths can be abstract and difficult; hence the multimodal support inherent in screencasts renders Maths more manageable for many learners. Students' comments in this study reinforce the ideas articulated in Mayer's multimedia learning principles that graphics and narration presented concurrently aid the understanding and acquisition of complex Mathematical concepts. Some students even regard the multimodal elements as providing a superior form of learning to traditional, didactic methods:

> Seeing how the question is explained is a far better way of learning in my opinion *(1st year, SNS).*

There were others who declared that the *"visual explanation"* (3rd year, MRE) had greatly eased their Mathematical understanding, made the Maths *"more straightforward"* (2nd year, CNM), and was *"much easier (to comprehend) than looking at question on paper already done"* (3rd year, ECE).

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BENEFIT 5: HELPED STUDENTS TO MAKE UP FOR MISSED LECTURES AND KEEP ON TRACK

The availability of the lectures in video forms plays a huge role in helping students to catch up with missed content, thus enabling them to keep on track with the module they were following. An Arabic-speaking, 2nd year ECE student reported relying on the videos for any missed introductory learning episode fundamental to further Mathematical understanding:

> The videos help me when I was absent from lectures to understand the introductory part of a lesson *(2nd year, ECE).*

As found by Loch (2010) and O'Malley (2010), a primary benefit of screencasts is that it offers students the opportunity to catch up on missed lectures. Their findings are corroborated in this study:

> I had missed a few lectures. I went through the notes, and the screencasts. It really helped me to cover up what I had missed *(2nd year, ECE)*.

> (The screencasts allowed) me to see for myself how many classes I missed to keep track (of the Maths module) *(1st year, SNS)*.

> I'll always have the content even when I miss a day *(1st year, CNM)*.

> If I miss a class, the screencasts help me catch up *(3rd year, MRE).*

> If you can't come to class, you can still follow classes easily *(3rd year, ECE).*

The efficacy of screencasts in covering lecture material holds a lot of promise as an instructional tool not only for traditional face-to-face programs as shown by Guerrero et al. (2013), but also for distance education, as indicated by Peterson (2007).

BENEFIT 6: PROVIDED A TIGHTER MATCH WITH THE MATHS MODULES

Students expressed a preference for the instructor-developed screencasts to those readily available on the Internet, such as the Maths videos created by the Khan Academy. This is understandable because the content and keyskills addressed in the screencasts were directly relevant to the concepts and keyskills imparted in the Maths modules. A mature student explained the importance of a close match between the screencast content and the Maths modules extensively:

> While there are seemingly endless YouTube videos available (Khan academy, etc), they usually have a U.S. or U.K-centered focus (terms and examples used). I find the Maths videos/screencasts to provide a tighter match with the course notes. There have been topics where I have used some of the YouTube videos (i.e. Algebra), but these were to elaborate on specific sub-topics *(1st year, CNM)*.

Thus, having instructor-developed screencasts benefits the students as it saves them the time and trouble of having to scour the Internet for video-based learning resources, which might turn out to be irrelevant or not useful at all. Maths videos such as those provided on the Khan Academy website, for example, athough generally useful for Maths learning, are bound to contain variations in their system of explanations and problem solving approaches:

> Having the lecturer create them also means that you're shown the method on how to solve a problem just as you have seen in the classroom, as opposed to watching an external video where another lecturer might have a slight variation on how to solve certain Math problems *(1st year, CNM).*

Students appreciated the value of the screencasts as they covered the exact topics they were learning in the Maths modules, hence making the video contents closely matched with and directly relevant to their learning needs.

BENEFIT 7: PROVIDED A VICARIOUS LEARNING EXPERIENCE

Like many multimedia resources, screencasts can be an effective means for delivering vicarious learning experiences due to their ability to simulate learning in the actual lecture situation. By having an expert model the problem solving just as an instructor would typically do in class, screencasts have the capability to bring the classroom feel to a media presentation. With instructor-developed screencasts, students are more likely to feel a sense of connection with the instructor, and this gives the videos distinct advantages over random or generic videos available on the Internet. Two mature ECE and CNM students aptly described the nature of the instructor-developed screencasts posted on the Maths Moodle pages:

> The screencasts are presented in a fashion that is similar to the actual lectures, where the reasons for taking certain steps are clarified *(2nd year, CNM)*.

> The screencasts are tutorials where the lecturer gives step by step instructions on how to solve various Math problems. The lecturer's commentary explains exactly what is happening at each stage of the problem *(3rd year, ECE)*.

Hence, it is not surprising that students found them to be pedagogically equivalent to the face-to-face instruction. Three students explained how their engagement with the screencasts provided an instruction very closely resembling that of the actual lecture:

> It's like catching the lecture again which can be easily forgotten *(3rd year, MRE).*

> It's like attending a lecture. You learn more because you are talked through each stage of the solution. They are very helpful *(2nd year, ECE).*

> You're shown the method on how to solve a problem just as you have seen in the classroom *(1st year, CNM).*

The close resemblance to actual lectures provided a valuable vicarious learning experience, more so because, with the screencasts, students had control over the pace of instruction. Having an expert model the problem solving as in real time instruction also means that students can see and master the Maths in their own time. This is also an important aspect of vicarious learning afforded by screencasts.

BENEFIT 8: SERVED AS A MEMORY AID

Forgetting lectures is not an uncommon occurrence. It is a phenomenon associated with deficits in working memory capacity. A third year MRE student remarked that the lectures *"can be easily forgotten."* In Maths, students typically forget formulas and steps in solving problems. Fortunately, forgetfulness is a prevalent learning limitation that the screencasts helped students to overcome, as illustrated by their feedback:

> The videos help me when I forget steps in how to work out the problem *(1st year, CNM).*

> The screencasts are very useful. Recalling this (how to solve the Maths problems) is (made) easier than looking through textbooks for information *(3rd year, ECE)*.

Another student used the videos to commit formulae to memory:

> The screencasts are very good for helping you memorize equations *(2nd year, ECE).*

Clearly for some students, the screencasts functioned as a learning tool to overcome lapses in remembering lessons. Thorne (n.d) suggests that instruction be provided in multiple formats to help students remember content better. The student feedback obtained in this study illustrates the viability of screencasts as an efficient means of providing one of these formats for Maths instruction.

BENEFIT 9: HELPED TO FILL GAPS IN CLASS NOTES

Due to limitations in working memory capacity, students sometimes find it hard to listen to the lecture, understand and follow the Mathematical narrative, and take good notes at the same time. For students whose first language is not English, this can be an especially challenging task. Two non-native speakers wrote:

> I am not a native English speaker, so it's quite hard for me to catch up with the instructor in class. I usually have to borrow my friend's book (for notes) *(3rd year, CNM).*

> If I were learning Maths in my own language, I could write notes and catch up with the lecture. But in English, it's difficult for me. For example, sometimes the teacher does not write on the board and when he speaks, we have to write with him. It's difficult and I don't know what to write in my notes *(3rd year, ECE).*

However, difficulty taking good notes is not limited to non-native speakers. An English-speaking student also admitted that he sometimes *"took something down wrong in class"* (1st year, CNM). Those who found gaps in their notes turned to the screencasts for help:

> I find the screencasts very useful if I can't find what I need in the notes *(2nd year, ECE).*

> They are very helpful if I missed some of the notes! *(1st year, CNM).*

Written notes are a necessary means to capture information in a traditional classroom where lectures are ephemeral. Students typically experience limitations in their working memory capacity, often resulting in the inability to hold information long enough to take full, constructive notes from lectures. Screencasts helped students to fill the gaps in their class notes when their notetaking ability sometimes failed them.

BENEFIT 10: MADE MATHS LEARNING FUN

Finally, the screencasts added motivational values to students' Maths learning experiences. Mullamphy et al. (2009) had earlier indicated how students liked the engaging nature of screencasts in contrast to traditional forms of learning from printed material. In this study, we found that students liked how the videos made *"the Maths more enjoyable"* (1st year, ECE). A third year MRE student decided that learning with the screencasts was certainly *"more interesting than reading straight from a word page,"* while a Polish student in his first year of Computer Network Management commented:

> I like the video materials presented by our Maths instructor. This is an opportunity to come back to interesting material anytime 24 hours/day and see step by step again how to resolve a problem.

In Maths, it is very important to make the learning enjoyable to sustain students' interest. It is also a factor that influences students' achievement and motivation to succeed in the subject.

DISCUSSION AND CONCLUSION

Screencasts are a great learning resource and an extraordinary supplementary tool to lectures and text-based material. They offer plenty of advantages to Maths students, as indicated by our qualitative data. The findings of our case study show that they were well-received and viewed favorably by students for their usefulness and ease of use, consistent with the results of other studies on screencasts (e.g. Boffey et al., 2006; Green et al., 2012; Mullamphy et al., 2010; Pinder-Grover et al., 2008, 2011). A vast majority of students found huge benefits in being able to personalize their Maths learning with the screencasts, moving at a pace most well-suited to their ability. They used the screencasts mainly to make up for missed lectures, work on further understanding the Maths, review for exams and prime their memory. They also valued the close match between the video content and the course material and appreciated the video presentation format which rendered Maths more interesting and enjoyable.

Although many of these benefits have been documented in previous research, the presentation of the benefits is rather piecemeal. Our findings are an important contribution to the screencast literature as they have presented the advantages as thematic benefits supported by students' testimonies. It might be useful in the next step of research to confirm these thematic benefits with statistical data using construct-validation procedures such as Factor Analysis or Structural Equation Modeling. In essence, our findings underscore the important role of screencasting as an effective learning and teaching technology for the digital age, not only in Maths education but in other fields as well. Thus, it is

really worthwhile to consider screencasting as a content delivery format and assessment tool for both distance and traditional learning programs, and train faculty to use it in order to improve the quality of learning in higher education.

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