Observing the Effects of Instructional Screencasts to Support Students Learning Computer Networks Using Packet Tracer.

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Third level computing students are often exposed to a lot of new information between theory and the computer programs used to teach it. This project explored the impact of using screencasts to assist for ninety first year IT students learning about computer networking using Cisco Packet Tracer, a program that simulates computer networks. Student's satisfaction with the quality of screencasts, how they used them, and their ability to process the information contained in the screencasts were measured using surveys and focus groups. Student performance in assessments using Packet Tracer were compared to previous years' results who did not have access to the screencasts. The screencasts not only provided a supplementary study aid but they enabled students to revise and review the material in their own time, and were considered a trustworthy source of information. Performance in student assessments also improved although it must be stated that there are other possible factors which could have influenced this improvement. The lecturer was able to observe a decrease in interruptions during tutorials, and an increase in time available to assist students with content-related issues, as opposed to operational questions about the software program. The lecturer has changed notes and teaching practice based on the lessons learned in the project and will be expanding the use of screencasts to other modules in the Institution where software programs are used as teaching tools.

Categories: K.3.2 [Computer and Information Science Education]: Computer Science Education, Data Communication, Information Systems Education.

Additional Key Words and Phrases: Learning Preferences, Screencasts, Cognitive Load, Computer Networking, Packet Tracer.

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1. INTRODUCTION

In third-level education students are introduced to a myriad of new skills and subjects. Novice learners require scaffolding when acquiring new skills and knowledge [Bruner 1977]. First year IT students have to learn a lot of novel concepts such as programming and computer networks which are both perceived as difficult [English *et al*. 2014]. To teach these skills, a combination of hardware and software programs are used. In computer networking the ideal teaching experience would be to use physical equipment to show the students [Goldstein *et al*. 2005] for all practical activities but in large computer classes this is seldom possible [Joubert and Goede 2012]. To assist teaching these abstract concepts many lecturers use

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simulation programs to build large and complex virtual networks which would otherwise be beyond the grasp of students.
Packet Tracer is a software program written by Cisco systems and used as part of their Cisco Network Academy Program (CNAP) The CNAP boasts over a million students worldwide in over 160 countries [Frezzo *et al*. 2014]. The program gives students the ability to connect virtual devices, configure them, and observe the flow of network traffic between them. The program has been used by teaching staff in the institution that this experiment is being conducted in since 2006 when it was first released. One of the major advantages of using the program is the ability to allow each student to configure their own networks and work on them on their own computers.

However, the interface is complicated for a new learner [Nihalani *et al*. 2011] and there is a risk that the student will spend too much time learning the interface and not on learning computer networks, or the student will disengage due to the complexity of the program. There are help files in HTML format, and some animated tutorials using flash video, but these are not included by default and must be downloaded separately.

2. BACKGROUND TO THE COURSE

2.1 Data communications Module

Data communications is a first year module which lays the foundations for computer networking subjects taught throughout the course. The 95 students in the current experimental cohort are first year, first semester IT students studying on a three year Degree course. Some of the students are from outside of Ireland, and English would not be their first language, but they have proficiency in English to International English Language Testing System (IELTS) level 6. On completion of the module it is envisaged that the learner will be able to do the following:

1. Define and Describe the OSI and TCP/IP Network Models.
2. Identify examples of Protocols in use at different layers.
3. Provide examples of different types of Network Addressing.
4. Calculate network addresses in Binary, Decimal and Hexadecimal.
5. List and connect the components of Local Area Networks.

The module objectives are to provide the learner with understanding of Network Protocols and Services, Network and Machine Addressing, Protocol Data Units and Data Formatting, Basic Local Area Network Design. This final objective requires students to familiarise themselves with basic network equipment and connections and to understand how these devices should be linked. To do this a combination of exposure to physical equipment and the use of computer based simulation programs are employed. The main simulation program is Packet Tracer.

2.2 Packet Tracer software

In first year computer networking students are shown how to use Packet Tracer, so that they can build virtual networks. Teaching students with real network equipment would be ideal [Goldstein *et al*. 2005], but is not practical with a large class size. Aside from the equipment outlay, set up and teardown times would consume too much of the tutorials. An ideal compromise is to give students basic

exposure to real equipment, once or twice as part of labs/tutorials, and then use simulator programs to build bigger and more complex networks [Makasirondh *et al.* 2010]. This allows students to compare their experience of using real equipment to the simulated equipment and to aid in them constructing their own internal schema [Janitor *et al.* 2010]. By their nature computer networks are complex and require many different elements to work. Building a software program to replicate this is also complex and the interface (see figure 1 below) for it can be daunting for the novice user.

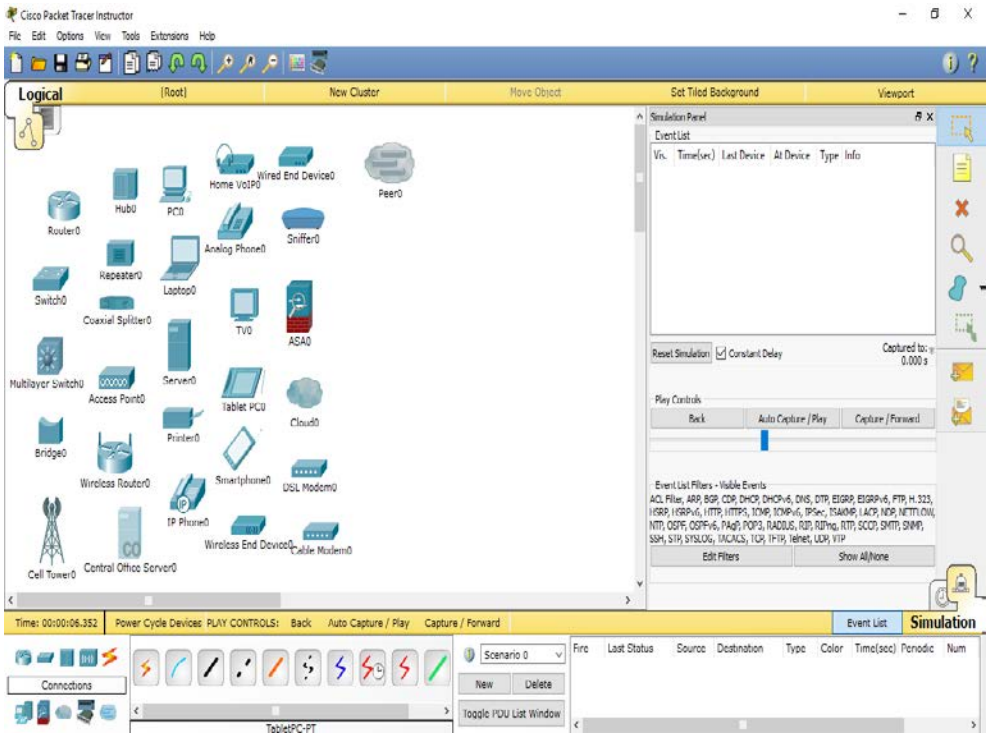

Fig 1. The packet Tracer Interface.

Taking into account the fact that students are already challenged by the introduction of new terms and concepts as part of their networking course [Goldstein *et al.* 2005] and that the value of the simulation program may be outweighed by the work involved to learn it, it is important to teach the program with the least impact on the cognitive load of the learners [Chandler and Sweller 1996].

The teaching approach that is used is initially aligned to behaviourist theory, steps are shown on screen and are repeated by students. All decisions are made for them and they are simply expected to replicate them. However, once the steps have been repeated a few times, then students are expected to know which equipment and which connections to choose.

The software allows them to create replicas of network equipment which they have to use to connect to each other and examine the traffic that travels across the network. The software allows the student to select devices, and cables and connect them together by selecting from a range of ports on the device. The software also allows for manipulation and configuration of the equipment through a range of menu options, configuration dialogs, and commands.

3. LITERATURE REVIEW

Firstly it was important to identify the key areas of the research and to understand a number of aspects. The software used to teach networking had to be confirmed as a valid teaching tool. The approach to the research had to adhere to a recognised research method and use methods that are academically robust. Examining issues with screencasts and multimedia instruction also had to be investigated and where possible best practices needed to be adopted. Initially search terms like "Packet Tracer" "Screencast computer program", "Cognitive load computer interface" and combinations of these terms provided a rich store of resources to support the project.

3.1 Packet Tracer

Initial research was conducted to validate the use of Packet Tracer as an instructional tool. Packet Tracer software is used in over nine thousand institutions worldwide and it is estimated that over one million students are currently actively using the program, [Mikroyannidis *et al*. 2015]. Many researchers, [Frezzo *et al*. 2009; Goldstein *et al*. 2005] have focused on the flexibility and affordances offered by using simulators for teaching networking. Frezzo et al. [2009] state that Packet Tracer can produce learning experiences comparable to working with real equipment and in some cases surpass them, for example eliminating the need to physically move, connect, and tear down equipment for practical labs. They also highlight the fact that the software allows for the construction of more complex network topologies and a level of administrative access which would not be possible with physical equipment.

Other research was carried out on instructing learners in the use of the Packet Tracer and [Mayrath *et al*. 2011] by using restricted interfaces and varying modes when teaching Packet Tracer. No papers were found that explicitly identified screencasts as a specific mode of instruction and although some refer to the use of instructional videos, these are considered less flexible and are perceived as impersonal. As Mayer [2014] wrote, "*People learn more deeply when the words in a multimedia presentation are in a conversational style rather than formal style*" which matches closely with the format of a screencast.

3.2 Screencasting

Screencasting has been identified by many as an effective tool for demonstrating the use of a computer or a computer program [Green *et al*. 2012; Oud 2009]. Screencasting is a term coined by Udell [2005] which combines the capture of actions on screen with an audio narrative. Much literature exists on the elements which constitute an effective screencast such as "bumpers", screen movement, and a natural audio narrative [Sugar *et al*. 2010; Green *et al*. 2011]. Aspects such as audio, length, and "depth" of instruction are also highlighted [Green *et al*. 2012; McLoughlin and Loch 2011]. There is a gap however, in research using screencasts for teaching Packet Tracer. "*The use of screencasts that supplement regular lectures, however, is still an active area of re-search*" as evinced by Lee *et al*. [2008] who developed screencasts to scaffold learning of object oriented programming in an introductory computer science class. That study revealed no statistical evidence to link the effect of screencasts to student learning, however in that project usage of the screencasts was not closely monitored.

3.3 Cognitive Load

Cognitive load is an area which has generated a lot of research but debate still continues on an appropriate method to measure it, Martin [2015] identifies many methods such as observation, surveys and even brain imaging. Much has been written on the intrinsic cognitive load, "*the mental demands or intellectual complexity of the task*" [Chandler and Sweller 1992], which should ideally be low for novice learner. Extrinsic cognitive load, i.e. "*poor materials or those that require a large amount of working memory to process will increase the load and leave little capacity for learning*" [Seery and Donnelly 2011], must be kept at a minimum to increase the chances of success. The understanding or awareness of cognitive load is important for this project, as according to Sweller [1994], a person learns better when learning objectives are stated clearly and instruction is without distraction.

3.4 Action Research

The methodology for this project was chosen for a number of reasons. Action research is suited to this project because it is carried out by the lecturer/researcher [Zuber-Skerritt 2002]. Many proponents recommend two cycles of change so that refinements can be made to enhance outcomes. To quote Norton [2001], the process of "*identifying the problem, thinking of ways to tackle it, doing it, evaluating it, and modifying your practice*" or ITDEM aligns with the design of this research. Action research can change the teacher as much as the student [Baum *et al*. 2006] and many have gone on to change their own practice as a result of using the methodology [Koulouri *et al*. 2014; Sela 2013].

4. METHODOLOGY

The ontological view in this project is constructivist, which states that "*social phenomena and their meanings are continually being accomplished by social actors*" [Grix 2002] as illustrated by the daily interaction between lecturer, students, information, and technology. New research is published every day about students, how they learn, how they view the material, and even how they view the lecturer. There are different requirements for students who are progressing from first year learning (often by rote and only beginning their journey to understanding), to subsequent years in their academic careers.

The epistemological stance is aligned to post-positivist. This supports the belief that the effects of using screencasts are too complex to be simply quantifiable, there are human and other elements which will affect the impact and use of the screencasts. The goal is to gather as much relevant data as possible to gain some insight into the relationship between screencasts, studying new modules, and the effects on students and on teaching practice. Using action research, mixed methods and multiple lenses to view the project will aid the researcher in identifying and documenting the effects that the screencasts will have [Myers 1997].

4.1 Method Selection

For research methods a mixed method approach was adopted as this provides a holistic view of the projects and supplies different types of data to be analysed. This

included qualitative and quantitative methods. The view of the lecturer as a researcher was recorded albeit a subjective one, but there were a number of other sources of data to assist in providing a comprehensive and balanced view of the project. In observing the effects of the screencasts it was important to measure data such as tutorial times and assessment results, but also student impressions and opinions. It was also important that the feedback allow for suggestions for further improvement and to try to aid in identifying any factors which might discourage students from using the screencasts.

4.2 Using Action Research

Action Research can be described as the practitioner changing and reflecting on their own practice [Norton 2001], and observing the effect a change has on the lecturer/researcher and the students [Cohen *et al*. 2013] This is an initial investigation into the use of screencasts so the research was studying how they were created and used and how they will have an effect on teaching and learning going forward. They are part of the scaffolding that is done on this course to support learners. Once they have learned the elementary steps it should be possible to introduce more complex learning situations where they have to make their own judgement on settings within the simulation program.

4.3 Quantitative Methods

The quantifiable data included a number of aspects of the project and the associated tutorials. The most significant piece of data are the results of assessment linked to the content of the screencasts. The tutorials demonstrate how to use the software to select and connect computer network equipment, to apply network addresses where appropriate, and to then test the connectivity between the devices. At the end of the semester students must complete an assessment based on those skills. It must be noted that the content of the assessment does not exactly match the screencasts .i.e. Students cannot pass the assessment simply by following the steps in the screencast. However the screencasts contain all the actions required to be able to construct a network based on the assessment requirements. The Packet Tracer program is used for the assessment and through a facility called Variable Manager it is possible to randomise items within the assessment so that no two students receive exactly the same network to build. Once the student has saved and submitted the assessment the Packet Tracer program automatically produces a score based on criteria selected by the lecturer when creating the assessment file. This ensures consistency of marking and avoids any bias on the part of the lecturer. These scores were then compared against scores from a first year class from the previous year who studied the same subject with the same lecturer.

Another instrument was the surveys published after each set of screencasts. The Likert scale questions allow the researcher to identify trends or increase/decrease in satisfaction levels. The surveys also contained open questions to gather information not explicitly asked and for impressions which would contribute to the body of qualitative data.

4.4 Qualitative Methods

For qualitative analysis a number of instruments were used. The primary instrument was a set of survey questions created using a Google form. The survey

had a number of questions asking the students to rate different aspects of the screencast using a Likert scale with values set between 1 and 5. The rating for 1 was the lowest on the scale e.g. "Very poor" or "Too Slow", whilst the rating of 5 equated to the highest rating for a category e.g. "Too Fast" or "Very easy to follow". This was designed to provide consistency in ratings although in some circumstances a high rating may be equivalent to a poor result, for example, "*Please rate the length of the screencasts*" where a rating of 5 means "Too Long". These questions were included to identify basic numerical ratings. The surveys also contained some open comment boxes at the end to try to capture other information not directly covered by the multiple choice. These were included to prompt reflection on the screencasts by asking students for any advantages or disadvantages that they could see with the screencasts. In the final section of the survey respondents were asked a few demographic questions such as their usage of English as a first language, the device used to view the screencasts, and their preferred methods of study. See Online Appendix 1 for a full list of questions and answer choices.

Aside from the surveys, the researcher kept a journal of observations and reflections on the creation of the screencasts, the running of the tutorials and any other observations relating to the class and the use of the software. Lecturer impressions on tutorial times were recorded but it must be acknowledged that there are a myriad of factors which can affect the smooth running of a tutorial and there may be no link between shorter tutorial times and the introduction of the screencasts. It should also be noted that this project was only designed during the current academic year and to properly measure the difference, times would need to have been measured on previous year's tutorials to provide an accurate comparison.

Finally, a focus group was held with a voluntary group of students from the class. The students were invited to participate, and once the purpose of the group had been explained to them and they had signed the consent forms the group was held. A group of five, considered by many the ideal number for a focus group [Oppenheim 2000] was randomly chosen from twelve volunteers. This group included a student who had not used the screencasts, which would provide insight into why screencasts were not used. The group was recorded (with their knowledge) and the recording was transcribed and analysed for insight into student's use and impressions of the screencasts. Opinion was also sought on further work in terms of screencasts for other subjects and with other lecturers.

5. RESEARCH DESIGN

The approach taken was to construct a series of screencasts replicating the steps that would be demonstrated during the in-class tutorials that are used to teach students how to use Packet Tracer. These were published on YouTube with a private link and students were shown how to access the videos in classes which were held over a week before the tutorials. The links to the screencasts were also available through the virtual learning environment (VLE) Moodle. The tutorials took place, replicating the steps followed in the screencasts, and the screencasts were again referred to for any student who wished to use them. Underneath the links to the screencasts in the VLE were links to an online form containing questions about different aspects of the screencasts, these were optional not mandatory. See online Appendix 1 for a copy of the questions asked.

The screencasts would be recorded as exact copies of the steps that are followed in class for the tutorials. Initially there were a series of five screencasts recorded including:

- *Downloading the software* – showing the student where to find the link on the VLE, what were the differences between the versions available, and where to save the file.
- *Installing the software* – Running the setup including location of the program files, which default and non-default options to choose and how to deal with any error messages or warnings that came up. This software requires access to external network connections and by default windows firewall presents a warning which could have led to students selecting the wrong option and cancelling the install.
- *The basics of the program interface* – Although the interface has a wide range of options novice users often only require a small subset of those options. This screencast showed students which options they would be using and how to use them, e.g. selecting devices and copying them or moving them.
- *Selecting devices* – This screencast showed the student which devices should be selected and used for any labs or tutorials as part of the course. In practice, five devices from three device categories needed to be used along with two different connection types. In total the program offers a range of eight device categories and three connection categories. In those categories students have a choice of forty-four different devices types quite a few of which look the same to the novice user.
- *Packet Tracer connections* - This introduces students to the different connection options between devices and how to tell if they are correct.

After the surveys were completed and submitted, responses were analysed for any feedback which could help the lecturer with any adjustments for the creation of a second set of screencasts.

The second set of screencasts would be produced in a similar method to the first with particular attention paid to audio quality and "natural" tone of voice. The second set of screencasts was published before the next tutorial. Again the student's attention was directed to the availability of the screencasts and a second online survey form with the same questions to gauge any changes in answers to the previous questionnaire. The results were checked and compared to the first questionnaire.

The second set of screencasts covered slightly more advanced topics which would help students with device configuration and saving their work. They were:

- *Configuring IP address using the config tab:* This shows students step-by-step instructions on configuring a network (IP) address using a graphical configuration tab which is available on all devices.
- *Configuring IP address using desktop tab:* this shows students how to configure some of the devices using a different, and easier method.
- *Pinging devices in Packet Tracer*: This shows students how to use a standard real-world application to test connectivity between devices in the simulated network.
- *Saving files in Packet Tracer:* This shows the student how to save their work and where it will be saved by default.

All students were given a class assessment which required the use of Packet Tracer software. This assessment had been issued the previous year to a cohort of students who did not have access the screencasts. This assessment requires the student to configure a basic network using the simulation software. The software randomises certain elements, machine names, IP addresses etc. to counter plagiarism. The software also provides an automatic correction and scoring system of each assignment, thus eliminating bias on the part of the researcher, a criticism often levelled at action research [Creswell 2013]. Marks from the previous year's cohort were compared to marks from the current cohort to identify any difference in grade averages on the assignment.

The Lecturer also maintained a journal of experience when creating the screencasts, running the tutorials and any comments made by students. The amount of time to complete the tutorials was compared to the time taken in previous years. This reflective exercise is a technique championed by Dewey [1997] and added to the views observed in the researcher's "panopticon".

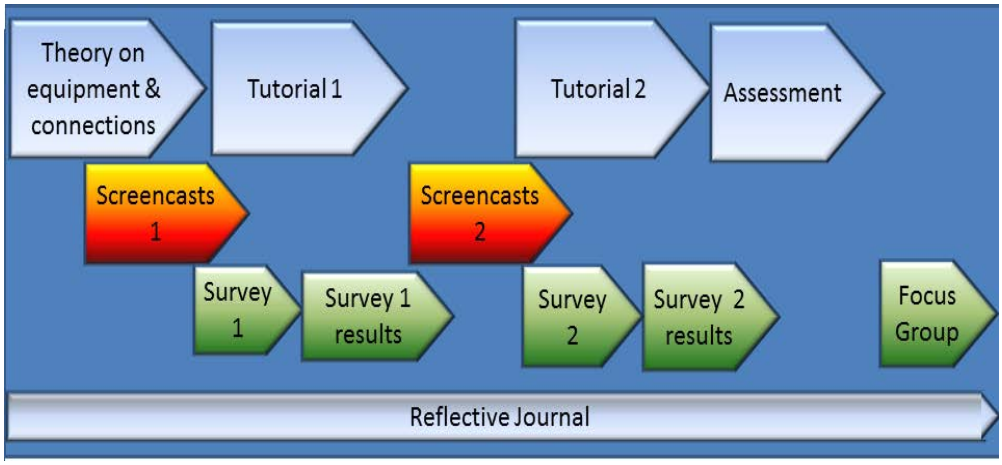

Fig. 2. Chronology of course and research methods.

6. DESCRIPTION OF THE EXPERIMENT

The students were instructed on use of the software using live in-class tutorials conducted by the Lecturer. This involved two separate tutorials of approximately two hours duration during which steps were demonstrated on screen and students were prompted to repeat the steps on their own computers. If a student had difficulty following the steps they were encouraged to seek help from the Lecturer in the form of repeating the instructions or going to the student and helping them out on their own computer.

The two tutorials covered a number of topics all covering basic tasks such as downloading, installing the software and the program interface. These tutorials are important because as already discussed students need to be familiar with the simulation software in order to understand the theory being taught on the course.

The students were also informed of the optional availability of the screencasts before each tutorial, during the tutorial and at the end of each tutorial. The purpose of this was to reinforce student awareness of their availability. The videos were recorded using a screen recording software program called ActivePresenter, which

allows screen actions to be captured and saved in a variety of formats including HTML5, WMV, and MP4. The software can record narration whilst recording the video or a separate audio track can be added subsequently.

For the initial videos the live narration was recorded and used for the soundtrack. The videos were then encoded as MP4 as this is a non-proprietary format which can be played on a number of devices and platforms. This format also uses advanced compression techniques to produce high quality video with relatively low file size. The size of the files was considered important because if they were too big they might take too much time to download which would possibly discourage students from accessing them.

Once encoded, the files were uploaded to YouTube, a publicly accessible site which hosts online videos (see Figure 3 below) and is configured to be accessible on multiple devices and operating systems. The site also provides the option to leave the videos unlisted so they could not be publicly searched, only accessed by a custom link. This feature was selected so as to measure the number of views and duration viewed by the students first. The videos were publicly listed for others to use once the data gathering was complete. It should be mentioned that no registration or username was necessary to view the videos which contributes to the anonymity of the viewers.

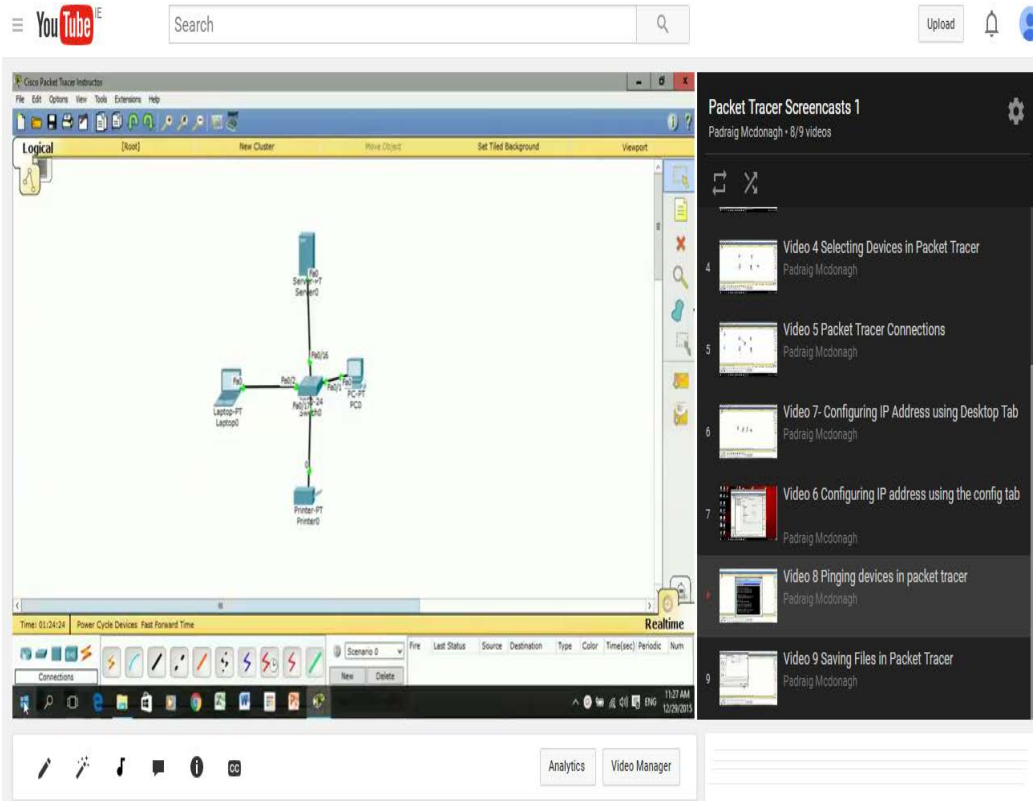

Fig. 3 Screencast in YouTube with playlist.

After the first set of screencasts were published and the links shared, the tutorial took place. As in previous years the tutorial was conducted using Powerpoint slides with screenshots of the application. Students were advised to install the software program on their own laptops in advance of the tutorial. As each new function was introduced the Lecturer would talk about it, then swap to the program running on a

laptop and perform the steps just discussed. Some time was left for students to repeat the steps themselves and they were then asked if they had been able to complete them. In some cases there were issues, either with students missing part of the instruction or had not understood the instructions. These were rectified by the lecturer either verbally or by going to the student laptop and taking them through the steps on their own machine.

This method is employed to teach the students the basic facilities of the program, which is required for use in the semester and for subsequent semesters in later years of the course. The technique of display, explain, repeat is considered effective [Felder and Silverman 1988] but it can be quite time-consuming, especially when individual students require attention, which can leave the rest of the class waiting.

After the first tutorial, the first online survey was published and students were asked to complete them if they had watched the screencasts voluntarily. The first five screencasts were watched over 200 times, the second four were watched over 280 times.

This process was repeated over two weeks. As the material got more complex further screencasts were introduced. This cycle of refinement aligns with action research [Somekh and Zeichner 2009], and allowed the lecturer to use feedback from students and journal entries to make changes where appropriate and with a view to improving the effectiveness of the screencasts.

7. RESULTS

As stated earlier, mixed methods were used to try to capture a number of aspects of the project. The results from quantitative methods were compared using results from previous years attempting the same assessment. The results of qualitative methods such as the survey were tabulated and the focus group was transcribed and then categorised using a number of themes where possible.

7.1 Quantitative Results

The data gathered from the Likert scale questions on the surveys provided good data and contributed to changes made for the second set of screencasts and subsequent screencasts created for other courses. Factors such as speed of instruction and ability to remember content received favourable ratings. Survey results showed an improvement in ratings for clarity of instruction and ease of understanding, while there was a slight decrease for audio quality.

The length of the screencasts was considered appropriate (on average, each screencast was under 2:20). Figure 5 below shows a sample of some of the data gathered and some initial analysis of it.

Rating		1	2	3	4	5
Audio Quality		Very Poor				Very Good
Q1	Survey 1	3.7	11.1	25.9	29.6	29.6
Q1	Survey 2	9.1	18.2	9.1	27.3	36.6
Difference		-5.4	-7.1	+16.8	+2.3	+7
Rating		1	2	3	4	5
Video Quality		Very Poor				Very good
Q2	Survey 1	0	3.7	7.4	44.4	44.4
Q2	Survey 2	0	9.1	9.1	18.2	63.6
Difference		0	+5.4	+1.7	-26.2	+19.2
Rating		1	2	3	4	5
Length of Screencasts		Too Short				Too Long
Q3	Survey 1	0	12	36	32	20
Q3	Survey 2	0	0	81.8	9.1	9.1
Difference			-12	45.8	-22.9	-10.9
Rating		1	2	3	4	5
Speed of Instruction		Too Fast				Too Slow
Q4	Survey 1	0	4	44	36	16
Q4	Survey 2	0	0	63.6	27.3	9.1
Difference		0	-4	+19.6	-8.7	-6.9
Rating		1	2	3	4	5
Clarity of Instruction		Very Hard				Very Easy
Q5	Survey 1	0	0	20	24	56
Q5	Survey 2	0	0	0	40	60
Difference		0	0	-20	+16	+4
Rating		1	2	3	4	5
Ability to Remember Instruction		Very Hard				Very Easy
Q6	Survey 1	0	4	16	32	48
Q6	Survey 2	0	0	0	50	50
Difference		0	0	-16	+18	+2

Fig. 5 Sample Survey Results

One of the most significant findings was the comparison of results in assessments to the previous year's cohort. Overall an improvement in marks of 28.5% was recorded. In the previous year 89 students attempted the assessment (figure 4). In this year's cohort a total of 95 students took the assessment (figure 5). The number of students achieving a score of 20/20 went from 0 in 2014 to 44 in 2015. Scores of 17, 18, and 19 (out of 20) also increased. The class average mark increased from 11.6 to 17.3 between the two years. It must be acknowledged that there are other possible factors which could have influenced this improvement such as previous exposure to networking, student aptitude, and other external factors.

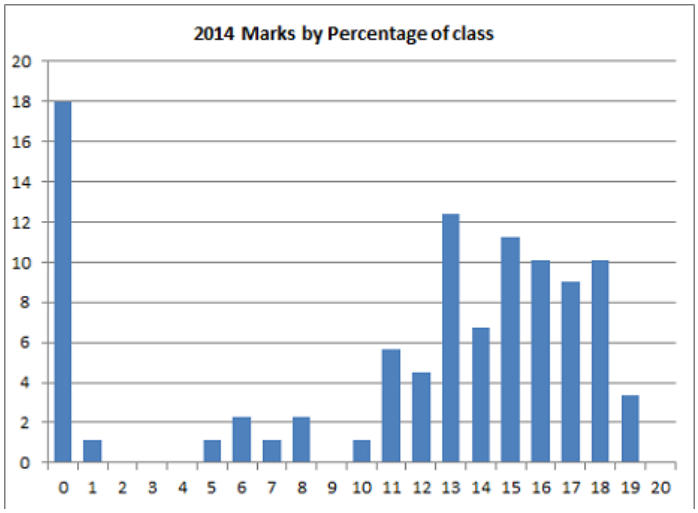

Fig 4. Marks achieved 2014 by percentage of class.

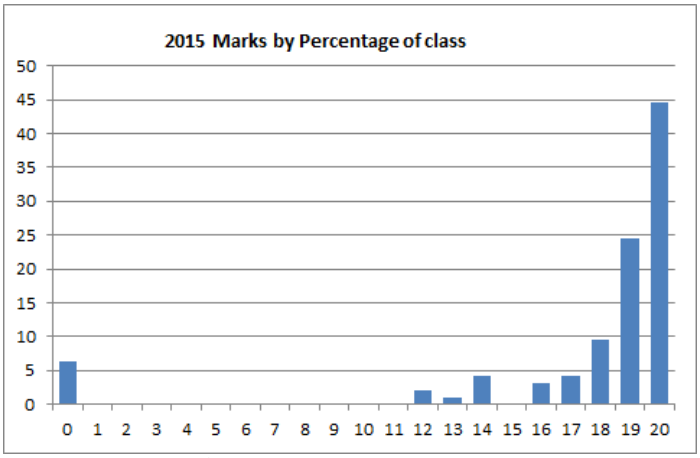

Fig 5. Marks achieved 2015 by percentage of class.

7.2 Qualitative Results

Qualitative methods included a researcher journal with observations, two surveys with open questions, and a focus group of volunteers from the student cohort. The main finding from the Lecturer journal was the change in practice of the lecturer and the use of screencasts to support learners. When preparing to use Packet Tracer or other software for other modules (Oracle Virtualbox for example) a short introductory screencast is prepared detailing the elementary steps required to install the software, use the interface, and some brief configuration examples. Tutorial times also seemed to be reduced from previous years but unfortunately there were no documented times to back this up. As recorded in the research journal *"Second set of tutorials seemed faster, finished approx. 15 mins ahead of end of tutorial, would need to check attendance figures against previous year but numbers seemed as high if not higher. Thought attendance might fall because of online screencasts but no!"*

The surveys conducted after the first and second sets of screencasts received positive feedback in the comments and open question sections and again highlighted

the importance of production values, especially where audio was concerned. A significant number of respondents mentioned low audio quality and efforts were made to correct this using the software and equipment at hand.

The focus group confirmed this with descriptions of headphones being used a lot when listening to screencasts. Questions querying speed and clarity of instruction also helped confirm appropriate pace of the screencasts and a brief poll on likelihood of using screencasts going forward also polled positively.

The focus group produced a valuable insight into student attitude to screencasts, most of which was positive, and also into learning and study habits. YouTube appears to be a popular source of study material although this was not specifically measured and would require further research to confirm. Students noted the wide range of material available online to supplement study but felt that "in-house" videos carried a higher reputation for reliability and were more likely to be course-specific. When the student who didn't use the screencasts was questioned it turned out that lack of study time outside of school had prevented them from viewing the screencasts but that student said they would be looking at any future videos. Students also espoused the use of screencasts because of their ability to stop and try tasks, as one participant said *"your screencast for me was extremely helpful because I was following you and then it let me pause it, and I could I cannot pause you in the class"*. When questioned on the unidirectional nature of the instruction some participants said they could simply email questions that came up. Students were wary of screencasts being used to substitute face-to-face time with lecturers, a sentiment borne out by research [Rose 2009], but were reassured that this is not planned for this course.

8. DISCUSSION

The project was undertaken in an attempt to scaffold novice learners in using a complex computer program as well as to improve teaching practice. From feedback in the surveys, comments made during focus groups, and comparing assessment results to previous years, these goals appear to have been met.

Packet Tracer is recognised as valuable teaching tool [Goldstein *et al.* 2005; Janitor *et al*. 2010; Elias and Ali 2013] and it is important that students can use the tool properly in order to extract maximum value from it. Using the software to supplement the instruction on network equipment and media means that students can expand their options for network size, topology, and complexity.

The use of screencasts to support learners was well received by the students with feedback including sentiments such as: "[I] *just loved it! Maybe more of this in the future"* and *"I feel like I learn much better this way because if I don't understand the content, I will able to repeat the video again and over again"*. The creation of the screencasts is technically easy to do and there are a wide range of free tools available for their creation. When the time taken to create a screencast is weighed against the time saved in repeating steps and instructions during tutorials the net effect was a perceived time gain. Inclusion of the recommended elements such as buffers, main content, [Sugar *et al*. 2007] and using natural speaking voice were straightforward to incorporate and produced easy-to-follow instructions.

The use of action research and mixed methods produced a balanced view of the project [Baskerville and Wood-Harper 1996], and revealed issues such as some student's use of online videos for study, the preference for reliable online resources, and a possible correlation between screencast use and improved academic performance. Qualitative methods provided guidance on screencast production and student attitudes, while quantitative methods provided indication that academic

performance could be improved. The practice of the Lecturer was also positively affected by the methodology, and reflecting on the learning by keeping a journal and analysing non-technical tasks offered insights which have proven beneficial to programme development [Zuber-Skerritt 2002].

Student assessment results improved compared to the previous year although further study would be required to definitively link the two together. Feedback from the surveys and anecdotal evidence also point to the screencasts reducing the mental effort expended by the students to learn Packet Tracer. The Lecturer's attitude to the importance of support materials, using technology, and the concept of producing videos to supplement face to face tutorials has also been affected with more screencasts on this and other courses being produced.

In any research project there will be refinements and alternative views that could have been used but with the time available, the resources at hand, and the optional nature of participation in surveys and focus groups, much has been achieved.

9. CONCLUSION AND FURTHER WORK

The field of Information Technology can be a daunting one to study [Martin-Michiellot and Mendelsohn 2007] and supporting students with technology is an ever developing and shifting paradigm. Introducing small, targeted, appropriate changes to teaching methods can have a ripple effect among students and staff. The Lecturer/researcher on the networking course has expanded the portfolio of screencasts to cover other more advanced tasks using Packet Tracer, other screencasts which introduce theoretical concepts in networking, and other software programs such as those covering virtualization and network sniffing (Wireshark). Colleagues at the same institution have been presented with the findings of the study and a short series of workshops have been prepared. These are intended to help other staff create screencasts for their modules, such as computer programming using Java, and operating systems using Windows and Linux virtual machines.

A possibility for further research also exists by producing screencasts based on the "muddiest point" [Mosteller 1989] where in-class online polls would highlight areas which students find difficult so that screencasts targeting those issues could be produced. Screencasts have alleviated some of the pressure on the lecturer and student to learn a specific task or concept at a moment in time, and have allowed them to concentrate on the important theories being taught as part of the course. In the words of one focus group participant *"A lot of things we get in classes especially in computers, they can't be said in notes, so having these videos actually showing them almost like a tutorial, it's just invaluable"*.

ELECTRONIC APPENDIX

The electronic appendix for this article can be accessed in the ACM Digital Library.

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Online Appendix to:
Observing the Effects of Instructional Screencasts to Support Students Learning Computer Networks Using Packet Tracer.

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Copy of online survey.

See attached Document.

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