AAEE 2012 CONFERENCE
Melbourne, Australia
www.aaee.com.au/conferences/2012/

Improving Engineering Students' Skills using a Digital Storage Oscilloscope using Multimedia Resources

Daniel Oswald[a], Desmond Baccini[a], Steven Hinckley[a] and Graham Wild[a,b].
[a]*School of Engineering, Edith Cowan University, Joondalup WA, Australia.*
[b]*School of Aerospace, Mechanical, and Manufacturing Engineering, RMIT University, Melbourne VIC., Australia.*
Corresponding Author Email: s.hinckley@ecu.edu.au

BACKGROUND

Currently, students at Edith Cowan University (ECU) studying engineering utilise a laboratory worksheet with written instructions to follow in all experiments. This can be restrictive as most laboratory sessions are limited by time and the written instructions can be misinterpreted by some students. To overcome this issue, a multimedia presentation was developed to reduce the workload of students during the pre-laboratory phase and the burden on the laboratory demonstrators during laboratory session. Our verbal feedback, from laboratory demonstrators, is that students have traditionally struggled with the basic usage of the Digital Storage Oscilloscope (DSO). A video tutorial has been created with the primary purpose for utilisation in first year engineering courses at ECU where students have the most difficulty, and reusability in later years when students need to review their knowledge and skills.

PURPOSE

The main reason for developing this project is to assist first year undergraduate engineering students in understanding the operation of electronic instrumentation that they will encounter in their laboratory activities. The conventional method of reading instructions from a manual can be time consuming and restrictive. With the multimedia presentation, the time constraints are reduced, allowing the student freedom and flexibility, thus removing unnecessary pressure which can manifest by not being prepared, or even confused.

DESIGN/METHOD

Over 75 students participated in this pilot study and were divided into two separate groups. The first group performed the experiment through the traditional method of the laboratory worksheet explaining how to complete the exercise. The second group was given the laboratory worksheet as well as developed multimedia explanation showing how to complete the same exercise. Both groups were given a questionnaire to complete pre- and post-laboratory. The questionnaire asks the student's questions based on the basic to setup the experiment. The data was analysed with an independent sample t-test to determine if there is a significant difference between the two groups at $\alpha=0.05$.

RESULTS

These results indicate that there is a greater variation in the scores in the no video pre-lab, and the highest score was achieved in the video pre-lab. Also, there is a significant difference between the two groups. More importantly, the results show that the video group all "pass" with a minimum score of 50%, while the majority of students failed in the no video group.

CONCLUSIONS

At a 95% significance level we are able demonstrate that there is a significant difference between the two pre-laboratory groups with the students who had accessed to the video tutorial performed significant higher, helped students complete the pre-laboratory exercise to a significantly higher standard. These results may indicate that the multimedia provides clear and concise instructions, which improves the student's understanding of the activities, as well as assisting the laboratory demonstrators.

KEYWORDS

Multimedia, digital storage oscilloscope (DSO), education.

Introduction

Currently, the School of Engineering at Edith Cowan University (ECU) is implementing a new learning strategy to help students in engineering laboratory classes with issues they have in effectively and efficiently utilising the Digital Storage Oscilloscope (DSO). The Agilent DSO3062A is currently used in most engineering and physics laboratory sessions at ECU. The current method of instruction for this instrument is a worksheet-based laboratory tutorial that involves a combination of written instructions and time-limited laboratory supervision. These sessions are time-limited, as each student in a session received, on average, up to ten minutes of individual instruction and supervision. As such, there is a perception among teaching staff that this process is not meeting the demands of students. Also, this process is repeated in subsequent laboratory-based units, where the retention of knowledge by students (and, in particular, the operation of the DSO) is poor. Mayer (1997, 2003a) suggest that a single medium explanation (i.e. verbal or written) of how a system works does not ensure that students understand what has been explained.

There is a lack of multimedia instructional material on the operation of a DSO at a level appropriate for undergraduate students being exposed to this instrument for the first time. One reason for this could be that the potential for using technology to improve learning does not translate into reality, as studies suggest a failure to deliver on the expectations of educational administrators and practitioners, which then translates into scepticism (Muller, Eklund & Sharma, 2005). This means that students rely heavily on laboratory demonstrators, and other students who know how to use the DSO, to help them to complete their laboratory exercises. Muller (2008) offers an explanation to why there might not be these resources available for students to utilise, as one might expect that a video presentation would not be able to outperform a tutor, 'presuming the tutors are knowledgeable and readily available during laboratory'. This statement illustrates a misunderstanding of the pressure placed on laboratory demonstrators, because individuals may have the opinion that demonstrators are capable enough to help the students without the usage of multimedia tools. Also, this ignores the time constraints within the laboratory setting, and limited resources available in the current setting within tertiary institutions, where cost pressures are significant (Institute of Physics, 2010; Powell, Anderson, van der Spiegel, & Pope, 2003). Additionally, by allowing students to review the Video Tutorial at any time of their learning activities, this presents additional learning avenues that are not restricted to the laboratory setting.

To meet the demands of students, we have developed a new method of instruction that incorporates a multimedia presentation showing how to use the DSO and a function generator for basic measurements of waveform properties. This video tutorial has the added benefits to students, to be viewed on smart phones and devices, to help reinforce learning. This video presentation is intended to supplement the worksheet tutorial and laboratory supervision. This paper illustrates the usage of this Video Tutorial that significantly aids student understanding of DSO operation, compared to the Worksheet Tutorial currently employed. The audio-visual demonstration focuses primarily on the setup of a DSO and a function generator, as setting up is normally the hardest part of the laboratory exercise for an inexperienced student.

Design and Development

This study is divided into two parts; (i) the design and development of a rudimentary instructional audio-visual presentation for explaining the basic setup and use of a Digital Storage Oscilloscope (DSO) and a function generator for measuring the key properties of a sine wave signal, and (ii) the implementation of this audio-visual presentation into the learning activities of undergraduate students (mostly first year engineering students) and an analysis of the effect of this Video Tutorial on the student's understanding of DSO operation.

Video Design and Development

In developing this multimedia resource, the aim was to keep the video presentation as simple as possible, both for the developers creating it and the students who utilize it. Mayer and Moreno (2003) have shown that multimedia resources should be designed to minimize cognitive load, and that this represents a major challenge for instructional designers. To achieve our goals, we based the design and development of the video tutorial on Mayer's principles (Mayer, 2003b) for designing a multimedia resource. Table 1 presents different principles that we tried to incorporate when designing this multimedia tool, to make it more effective for students.

Table 1 - A summary of multimedia design principles (Mayer, 2003b).

Principle	Reason
Modality	Present the words in spoken form.
Contiguity	Present corresponding words and pictures at the same time
Multimedia	Use both words and pictures.
Personalisation	Present words in conversational style.
Coherence	Avoid extraneous video and audio.
Redundancy	When involving animation and narration, do not add redundant on-line text.
Pre-Training	Begin the presentation with concise descriptions of the components.
Signaling	Provide signalling for the narration.
Pacing	Allow the learner to have control over the pace of presentation.

Also, it is essential that the presentation be independent of the computer operating system, so that it could be viewed on the multitude of systems used by students. Creating a hands-on demonstration was too time-consuming, as well as too complicated to achieve. Hence, the study involves the creation of a resource using Microsoft PowerPoint, which allows users to create their own animation, and has the ability to synchronize with external audio files. The added benefit of using PowerPoint is that it is possible to use TechSmith's Camtasia Relay (TechSmith, 2012) to convert the presentation to a relatively small mp4 file. This can be posted on a teaching interface such as Blackboard without consuming large amounts of server memory. This also enables students who are studying on and off campus to view the video before, during and after a laboratory session.

High resolution images of the Agilent 3062A DSO and the Topward 8110 Function Generator were created using a Nikon D3S digital camera. The paint function was used to add animations to the images imported into PowerPoint. The audio was added using text-to-speech software (TextReader 1.2, Apple App Store (2012)), with a script acting as a road map. The TextReader software simplified the process, as we were able to make the voice as natural as possible, with no tangents or convoluted explanations. This also eliminated the major problem with the development of multimedia resources; timing the audio with the animations. For every slide, one audio file was created. If more than one point was raised on a slide, an audio file was created specifically for that point.

The script was set out and written including main points such as the Introduction, Set up, DSO display screen, FG operation and Measurements. An example of the script is as follows: "The aim of this presentation is to show how to display a basic AC signal using the Digital Storage Oscilloscope (DSO) and the Function Generator (FG). The objective is to show which controls are used on both devices, the correct way of setting up, culminating in a display on the DSO. After a waveform is produced, we will show how to take key measurements."

Another example of the script for the set up component is as follows: "To begin we will connect the function generator to the D S O by using the B N C cable. The B N C cable input is placed into the output of the function generator. Looking at our generator front on, there are three outputs situated on the right hand side; the sync output, V C F and output. We want the output that is on the extreme right. Next we will connect the opposite end of the B N C cable to the D S O. To do this, connect the B N C cable to the input of Channel One which is situated directly under the number one on the control face.” This script was interlaced with the PowerPoint presentation, resulting in a step-by-step process highlighting the connection points and outputs, resulting in a final slide, as shown in Figure 1.

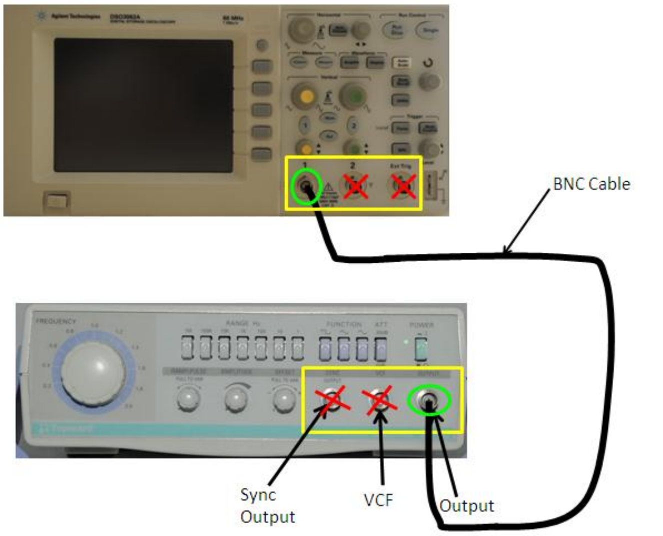


Figure 1: Slide showing the experimental setup of the DSO connected to the function generator using a coaxial cable.

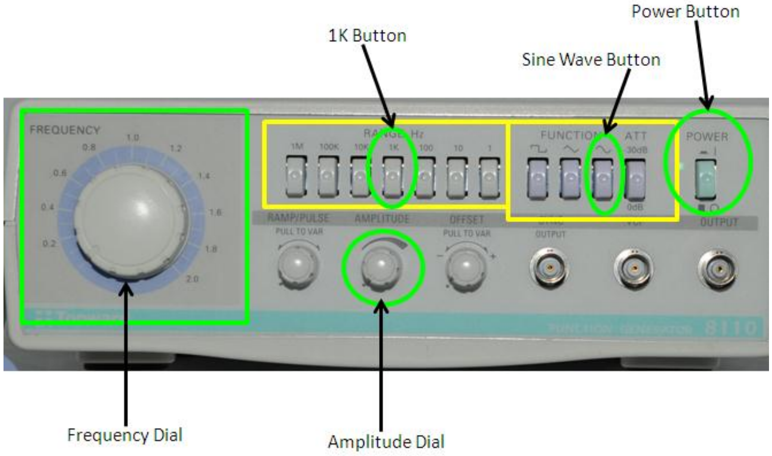


Figure 2: Image of function generator set up, highlighting specific button/dial functions.

For the function generator, the script was designed so that the student could follow the video to set up the function generator to produce a sinusoidal waveform displayed on the DSO screen. The script incorporated the buttons to push e.g., the sine wave button, frequency button, frequency dial and amplitude dial, as shown in Figure 2. All steps were interlaced throughout, culminating in a final display showing the sine wave and measurement display, as shown in Figure 3. The student could take measurements such as the peak to peak voltage, amplitude, frequency and period of the waveform.

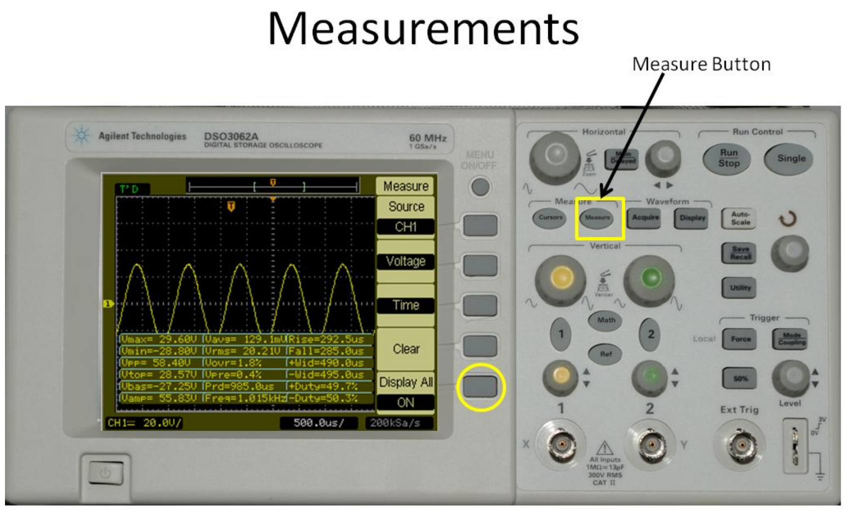


Figure 3: DSO Display for the Measurements function

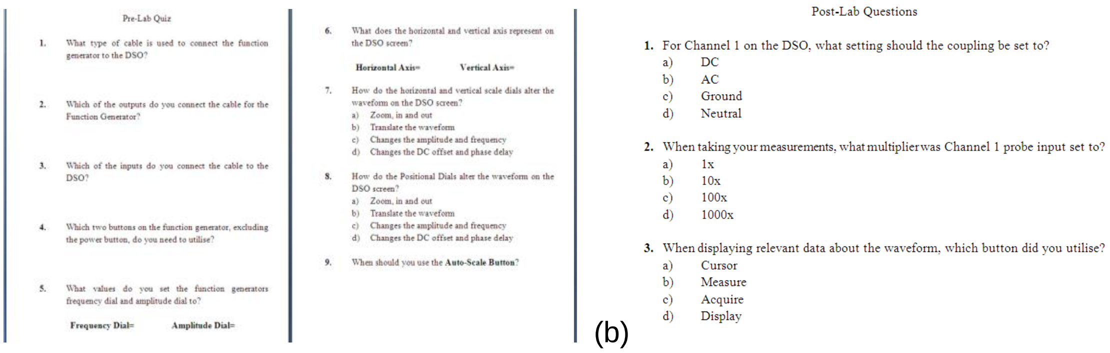
The simplified method we have used to develop the instructional video tutorial has additional advantages, particularly in terms of the resources required to modify the current tutorial, so that updated and further instructional multimedia presentations can be developed. The process developed is time efficient and the particular problem of synchronising the audio narration with the visual slides is solved.

Learning Activity Implementation and Evaluation

The participants were 75 first year students at ECU from the Introduction to Physics course. These were students who had not covered year 12 physics and required some form of knowledge of physics for their degrees. Most of the students attempting this unit are first year engineering students, although the cohort also includes students studying physics, education, aviation, and sports science. The experiment was conducted in scheduled laboratory classes. The participants were asked to sign a form acknowledging their approval to participate in this experiment, and to protect their anonymity during the study. The students had the option to withdraw at anytime from the study, without penalty to their academic achievement.

The focus of this study was to compare the instructions that are provided in the laboratory workbook to the instructions given from a video tutorial, explaining how to operate the DSO at the basic level. The main feature of this study was to analyse the participant’s results from pre-laboratory and post-laboratory quizzes that ask the students questions on how to setup a DSO with a Function Generator.

To compare the instructional methods, the laboratory groups were separated into two different cohorts. This was straight forward as there were already laboratory groups that operated in alternating weeks. The first group who completed this study only had access to the written instructions from the laboratory workbook (the Worksheet Tutorial), whereas the second group had access to the Video Tutorial as well as the written instructions. Both groups were given supervisory instruction, although we ensured that the supervision provided to the two different cohorts was identical. At the end of the pre-laboratory, before the students started the laboratory workshop, both cohorts were required to complete the same quiz (see Figure 4 for examples of the Pre-Lab and Post-Lab Quiz sheets).



(a)

Pre-Lab Quiz

1. What type of cable is used to connect the function generator to the DSO?

2. Which of the outputs do you connect the cable for the Function Generator?

3. Which of the inputs do you connect the cable to the DSO?

4. Which two buttons on the function generator, excluding the power button, do you need to utilise?

5. What values do you set the function generators frequency dial and amplitude dial to?

Frequency Dial= **Amplitude Dial=**

6. What does the horizontal and vertical axis represent on the DSO screen?

Horizontal Axis= **Vertical Axis=**

7. How do the horizontal and vertical scale dials alter the waveform on the DSO screen?
   a) Zoom, in and out
   b) Translate the waveform
   c) Changes the amplitude and frequency
   d) Changes the DC offset and phase delay

8. How do the Positional Dials alter the waveform on the DSO screen?
   a) Zoom, in and out
   b) Translate the waveform
   c) Changes the amplitude and frequency
   d) Changes the DC offset and phase delay

9. When should you use the **Auto-Scale Button**?

(b)

Post-Lab Questions

1. For Channel 1 on the DSO, what setting should the coupling be set to?
   a) DC
   b) AC
   c) Ground
   d) Neutral

2. When taking your measurements, what multiplier was Channel 1 probe input set to?
   a) 1x
   b) 10x
   c) 100x
   d) 1000x

3. When displaying relevant data about the waveform, which button did you utilise?
   a) Cursor
   b) Measure
   c) Acquire
   d) Display

Figure 4: A screenshots of (a) the pre-laboratory quiz, and (b) the post-laboratory quiz.

Once testing was completed, the quiz sheets were marked (the maximum mark for the pre-lab quiz was 12 marks). As these cohorts are independent, we have chosen to conduct an independent samples t-test at a significance level of α=0.05. If we achieve a p-value that is less than α than we would conclude that the two groups means are significantly different. If the p-value, is greater than α, then our results will indicate that there is not enough statistical evidence to suggest that the two groups are different.

At the end of the laboratory exercise, the students then completed a second post-lab quiz, an example of which is shown in Figure 4(b). This data set was then analysed using the same methodology as the pre-lab results, except that the post-lab quiz maximum mark was 3 marks. Note that, due to the smaller sample of information collected for the post-lab quizzes, it is expected that the results will not be as clear as those of the pre-lab study.

Results

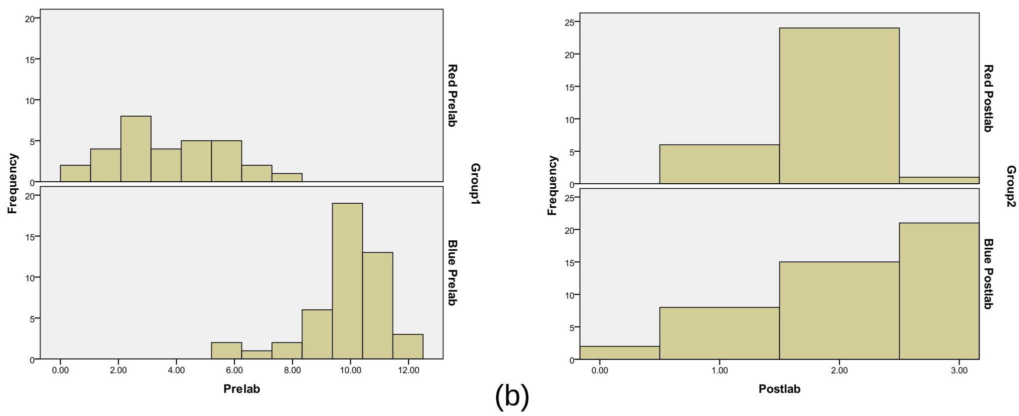
Table 2 displays the summary statistics for both cohorts for the pre-laboratory and post-laboratory quizzes. The Red group only had the worksheet instructions to guide them, whereas the Blue group had access to both the video tutorial and the worksheet instructions. These results clearly indicate that those students who had access to the video for the pre-laboratory performed significantly better than those students who did not have access to the video tutorial. This is illustrated in Table 2 where the mean for the Blue group (mean = 9.9565) is significantly higher compare to the Red group (mean = 4.065). There is also a greater variation in the scores in the no video pre-lab, and the highest score was achieved in the video pre-lab. The minimum for the video pre-lab is higher than the third quartile for the no video pre-lab, and the median and the mean are significantly higher in the video pre-lab group. These results indicate that there is a significant difference between the two groups. More importantly, the results show that the video group all “pass” with a minimum score of 50%, while the majority of students “failed” in the no video group.

These differences between the means can also be illustrated from Figures 5, where the overall scores achieved by the Blue group students were significantly higher than the scores achieved by students in the Red group. The results also indicated that there is a larger spread of scores in the Red group compared to the Blue group. Standard deviation measure by how much a particular score deviates from the mean. The Red group recorded a standard deviation of 1.89623 and the Blue group 1.33261, indicating that the scores in the Red group varied more than those in the Blue group. This can also be indentified from Figure 5 where the spread of the scores is larger in the red group than those compared the blue group. Table 2 indicates that the Red group’s histogram in Figure 5 is slightly positively skewed and the Blue group’s is negatively skewed.

Table 2: The summary statistics for the Red (no video) and Blue (with video) groups for the pre-laboratory and post-laboratory quizzes.

	Pre-Laboratory		Post-Laboratory	
Statistics	**Red Group**	**Blue Group**	**Red Group**	**Blue Group**
Mean	4.0645	9.9565	1.8387	2.1613
Median	4	10	2	2
Min	0	6	1	0
Max	8	12	3	3
Standard Deviation	1.89623	1.33261	0.45437	0.96943
Skewness	0.058	-1.272	1.265	-0.467

These results do not clearly indicate that those students who had access to the video for the post-laboratory performed significantly higher than those students who did not have access to the video tutorial. This is illustrated in Table 2 when the mean for the Blue group is slightly higher compare to the Red group mean. The mean for the Red group was 1.8387, compared to the Blue group mean of 2.1613. These results indicate there is a greater variation in the scores in the video post-lab, and the highest score was achieved in both groups. Figure 8 illustrates a histogram plots for both groups.



(a) (b)

Figure 5: A histogram displaying the spread of all the scores from (a) the pre-laboratory quiz, and (b) the post-laboratory quiz.

To confirm this opening statement, a hypothesis t-test was conducted to investigate if there was a significant difference between the two means at a 95% confidence interval. From Table 2, for the pre-laboratory results, the lower boundary was -6.68189 and the upper boundary was -5.10212. As zero is not included between the upper and lower boundaries then the results indicate at a 95% confidence interval that there is a significant difference between the two means of both laboratory groups.

For the post-laboratory results (Table 3), a hypothesis t-test indicates the lower boundary was -0.66381 and the upper boundary was -0.05007. As zero is not included between the upper and lower boundaries then the results indicate at a 95% confidence interval there is a significant difference between the two means of both laboratory groups.

Table 3: The independent sample t-tests comparing the means for the two laboratory groups.

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Pre-laboratory	-14.985	49.628	0.000	-5.89201	0.39319	-6.68189	-5.10212
Post-laboratory	2.319	70.834	0.023	-0.35694	0.15389	-0.66381	-0.05007

These results indicate that the video tutorial significantly helped the students to complete the pre-laboratory quiz, with a greater understanding of the operation of the DSO than if they did not view the video. We would classify the video tutorial as “direct instruction” and the worksheet handout as more “self discovery”, as the instructions were vague and required the students to think how to accomplish the goals themselves. ‘Direct instruction is capable of producing a significant level of correct performance’ (Dean & Kuhn, 2006), suggests that informing the students from a video tutorial that is more direct than indirect is an efficient method in helping students learn in this case. Following Mayer’s principles, all non-essential information was eliminated in the design of the video tutorial, which ensured that more of the students cognitive resources could be used to learn the material in a laboratory setting, as it has been empirically verified in controlled laboratory studies with learners who have little prior knowledge and limited interest in the instruction (Muller, 2007.) One reason for this is that it can reduce the level of frustration that students experience, when the instructions are not as clear as they would like. A video tutorial can also ensure better consistency, as the video will always provide the same instructions and explanation in the same manner. Mayer (1997) found that students receiving coordinated explanations in both verbal and visual form performed 75% better on transfer tests than those with only a verbal explanation. Therefore, as long as the video contains appropriate instructions, it will achieve better consistency than a live demonstration, which may vary from session to session. The effect of clear and consistent instructions is that it reduces burdens placed on lab demonstrators, as they can help students with other issues and not worry about constantly explaining the same issue multiple times, reducing their level of frustration.

Future Work

A weakness with this pilot study is that we did not able to examine the student’s ability to retain the knowledge in post-test analyses, as the focus of this study was to see if there was a difference in the student’s performance using the worksheet tutorial versus the video and the worksheet tutorial. Though we were able to see a significant difference, future investigations will need to analyse the student’s ability to retain the knowledge. Hence, future developments with this study will involve post-test analyse, looking at the student’s ability to retain the knowledge that they have gathered from previous weeks, and how effective it is in affecting their retention of knowledge in later years and semesters of their study, where they are required to use the DSO for more difficult experimental activities. Another weakness was that we were not able to do more of a qualitative study with the students, to see if they felt more confident with the video tutorial compared to the worksheet tutorial.

We also intend to continue the development of these videos tutorials to more complicated functions of the DSO, especially as students are required to use the DSO for more complex and difficult experiments. Finally, we intend to investigate studies comparing the different methods of measuring data on the DSO using this multimedia learning tool.

Conclusion

In conclusion, this paper illustrates that a significant improvement is obtained to students understanding of DSO operation by the utilisation of a video tutorial in a laboratory exercise. We believe this to be the case as the video tutorial offers clear and consistent instructions if the students chose to replay the video. Added benefits in the use of a video tutorial of this kind is that it reduces strains placed on the laboratory demonstrator, as students are more capable on completing parts of the laboratory exercise by themselves without the aid of the demonstrator.

References

Apple App Store (2012). Available from the Apple App Store.

Dean, D., & Kuhn, D. (2007). Direct instruction vs. discovery: The long view. *Science Education*, 91(3), 384-397.

Institute of Physics (2010). *Independent Review of Higher Education and Student Finance*. Institute of Physics, 28 January 2010, page 8.

Mayer, R. E. (1997), Multimedia learning: Are we asking the right questions? *Educational Psychologist,* 32(1), 1–19.

Mayer, R. E. & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, 38(1), 43-52.

Mayer, R. E. (2003a). The promise of multimedia learning: Using the same instructional design methods across different media. *Learning and Instruction,* 13(2), 125–139.

Mayer, R. E. (2003b): Elements of a science of e-learning. *Journal of Educational Computing Research*, 29(3), 297-313.

Muller, D. A., Eklund, J. & Sharma, M. D. (2006). *The future of multimedia learning: Essential issues for research*. Australian Association for Research in Education (AARE) 2005 International Education Research Conference, UWS, Parramatta, Sydney, NSW.

Muller, D. A., Lee, K. J. & Sharma, M. D. (2008), Coherence or interest: Which is most important in online multimedia learning? *Australasian Journal of Educational Technology,* 24(2), 211-221

Muller, D. A. (2008). *Designing Effective Multimedia for Physics Education.* PhD Thesis, School of Physics, University of Sydney.

Powell, M., Anderson, H., van der Spiegel, J., & Pope, D. P. (2002). Using web-based technology in laboratory instruction to reduce costs. *Computer Applications in Engineering Education*, 10(4), 204-214.

Techsmith (2012). Available from www.techsmith.com/camtasia-relay.html.

Copyright statement