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Developing an Educational Video for Utilising an Oscilloscope in First Year Physics

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Abstract Summary

We report the development of a multimedia resource designed to aid undergraduate engineering and physics students in learning the operation and functions of a Digital Storage Oscilloscope.

Keywords- DSO, education, multimedia.

I. INTRODUCTION

Currently, there is little work in the literature on educational multimedia to help students utilise Digital Storage Oscilloscopes (DSOs) effectively. Muller [1] suggests that in the past there have been high expectations for technology, but it has failed to rise to these expectations, prompting scepticism from educators in its use. This study focuses on developing an educational resource for use in laboratory programs utilizing DSOs at ECU, though procedures used to create this resource have the potential to be easily applied to other situations. This video is aimed at undergraduate first year students, though it also has use for retraining students in the operation of a DSO in later years. The main purpose of the study is to reduce the complexities of laboratory experiments and increase the retention of knowledge for students who study physics and engineering at ECU.

II. MULTIMEDIA THEORY

As mentioned in the previous section, little work has appeared in the literature on educational multimedia to help students utilising the DSO. Searching the literature, we have found studies on multimedia education and the elements a designer should consider when developing these resources. We first define multimedia learning as a medium where both audio and visual aspects are combined together in a single presentation. Mayer [2] indicates that single medium, such as verbal or written explanations, do not ensure that students understand the concepts being explained. He also demonstrates that a well structured multimedia presentation of audio and visual cues generates a better performance by students, than those who do not receive this type of treatment.

One of the most important ideas that Mayer postulates, when designing multimedia materials, is that it should be based on meaningful learning [2]. He defines this term as an understanding of the material being taught. This includes attending to the different aspects of the material, organising it in a coherent cognitive structure, and integrating this new information with existing knowledge [3]. Fig. 1 presents a summary of the cognitive requirements for meaningful learning. The model illustrates how the information is organised by integrating both verbal and visual aspects. Through this, the student will construct what is called a situation model – a coherent picture in which the knowledge is placed in a logical manner. There are issues with this type of learning such as the integration phase must take place in short-term memory, which is limited and strained by memory load.

For meaningful learning to take place, the student is required to utilise significant cognitive processing when learning is occurring, but the issue is that this cognitive processing is quite limited [3]. When designing and developing a multimedia resource, one major challenge is that a developer should minimise any and all unnecessary cognitive load placed on the student. When multimedia learning is occurring, there are five active cognitive processes happening, as illustrated by Fig. 2.

To reduce cognitive overload for a learner, Mayer [4] developed nine different principles (shown in Table I) that should be incorporated when designing your own multimedia resource. These principles are designed to reduce cognitive load placed on the learner.
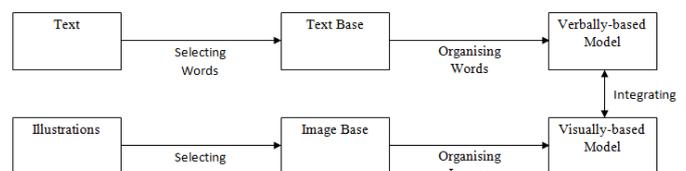

Figure 1.   Diagram representing the generative model; adapted from [2].
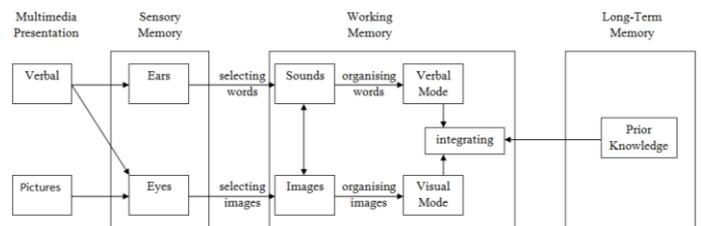

Figure 2.   A model of the cognitive processes that occur during multimedia learning; adapted from [4].

TABLE I.   DESIGN PRINCIPLES FOR MULTIMEDIA PRESENTATIONS [4].

Principle	Summary of the Principle
Modality	Present the words in narration spoken form.
Contiguity	Synchronise audio and the animation at the same time.
Multimedia	Design a presentation with both words and pictures.
Personalization	Narration of words should be design presented in conversation style not in a formal style.
Coherence	Avoid using extra and irrelevant information.
Redundancy	When using animation and narration in a multimedia explanation avoid using redundant on-line text.
Pre-Training	When designing multimedia explanation, begin with explanation of the components used in the explanation.
Signalling	Designing multimedia use signalling cues for the learner.
Pacing	Allow the learner to have control over the pace of the presentation.

III.   DESIGN AND DEVELOPMENT

In developing this multimedia resource, the aim was to keep it as simple as possible, both for the developers creating it and the students who utilize it, by following the design principles of Mayer [4]. Creating a hands-on demonstration was too time-consuming, as well as too complicated to achieve. One of the aims of this project was to make the multimedia development as cost effective as possible [5]. To meet these objectives, the multimedia project 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 [6] to convert the presentation to a relatively small mp4 file. This can be posted on teaching interfaces such as Blackboard without consuming large amounts of server memory. This enables students who are studying on and off campus to view the video before a laboratory session on both smart phones and other web capable devices.

Initially, we analyzed the introductory laboratory sessions that Physics and Engineering students are required to complete [7]. From this analysis, we developed a script, describing how the presentation would play out on screen for the students. The script is similar to a storyboard that film and television creators develop describing how the story will play out in a logical manner. Next, high-resolution images of the Agilent 3062A DSO and the Topward 8110 Function Generator were created using a Nikon D3s digital camera. These images could be cropped and resized to fit a Powerpoint slide, without losing any detail.

The audio was added using text-to-speech software (TextReader1.2 [8]) with a script acting as a road map. Following Mayer's "personalization" principle [4], when reading the script we were editing the document, as you would proofread this paper and making the script formal, but this does not benefit the students. His studies have indicated that students perform to higher standards if the narration is in a conversational style. 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 was the case because we were able to import sections from a Word document into the software and play the voice repeatedly until the narration sounded as natural as a computer-generated voice can be. The voice we chose for this project was 'Karen', an Australian computer-generated voice, as it was the closest to the most natural voice the software had on the software's list of English computer speaking voices. The next challenge was to set the speed of the audio, and we settled on 180 words per minute. While we would like to use a normal voice in place of a computer-generated voice, this would have been too complicated. It would be necessary to repeat the recorded performance many times in order to obtain the correct pitch and pace of the voice, and would have been too time-consuming for us to achieve. Hence, the computer-generated voice was selected.

One of the unseen benefits of using a computer-generated voice is that the script can be translated into different languages. Most tertiary institutions have students from a wide range of cultural backgrounds, many with English as a second language. Hence, the ability to be able to develop identical presentations in different languages will aid the learning of these students as this will have the potential to bridge the language gap for foreign students who undertake physics and engineering degrees.

Another benefit of using this software is that it also eliminated the major problem with the development of multimedia resources; timing the audio with the animations. Synchronizing the animation with the narration is important because it does not place too much pressure on the cognitive processes of the learner [4, 9]. 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. We did this because it helped with the pacing of the presentation, so students do not feel they are rushed in an explanation, as there are pauses or gaps between the points that are illustrated to help students understand what has been explained.

To create all the animations, the inbuilt animation functionality of Microsoft PowerPoint was used. The animations that were used were as simple as possible to reduce any distractions to, or confusion by, the learner.

Review of the multimedia resource was performed at all stages of development by individuals within the Photonics Research Group of the Centre for Communications Engineering Research (CCER) at ECU. This group consisted of experienced senior academics, postdoctoral researchers, laboratory tutors, postgraduate research students, third year undergraduate Physics students, and fourth year Engineering project students. This diverse group was able to provide different perspectives to help improve the effectiveness of the multimedia presentation. Table II provides a summary of the feedback that the members of the Photonic Research Group. This was important as not all members were involved with the creation of the presentation and were able to offer feedback to oversights that were omitted before the final version was created.

TABLE II.   SUMMARY OF IMPROVEMENTS TO BE MADE TO A PREVIOUS
VERSION OF THE POWERPOINT PRESENTATION.

Improvements
• Explaining what the screen is displaying such as the x-axis is time and the y-axis is voltage.
• Tidy up the squares that show which button is being talked about.
• Red/Green highlights stop/go.
• Highlighting everything at once, might be an issue.
• Adding – Period, peak and peak-to-peak values, and zero level.
• What the DSO is showing, voltage-y and time-x, zero level.
• The colouring and box sizes weren't totally consistent.
• Audio Rushed.
• Needs work timing pauses.

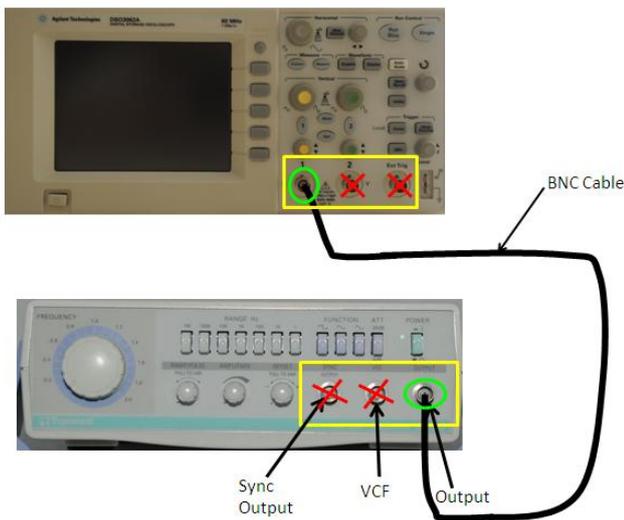Fig. 3 and 4 show images taken from the current version of this multimedia resource.

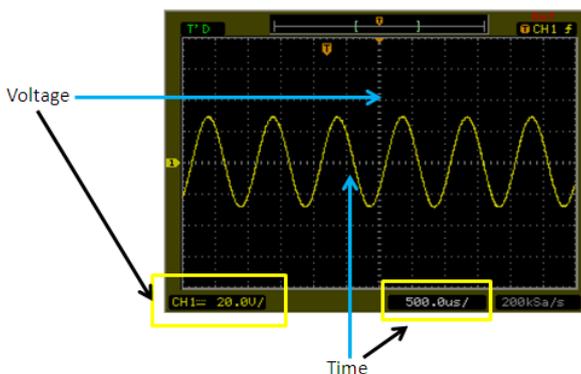Figure 3.   An image explaining how to connect a DSO to a Function Generator.

Figure 4.   An image explaining the layout of the DSO screen.

IV. RESULTS

The video tutorial is an explanation of the basic functionality of the DSO and the function generator. The presentation is broken into different sections focusing on the different aspects of the laboratory worksheet that all students traditionally use. The first section is an introduction explaining to the students; the outline, goals, and the equipment to be used in the current laboratory session, and runs for a total time of 42 seconds.

The next section is an animation on how to connect the function generator to the DSO. The second half of this section explains the function generator and how to utilize it to display a sinusoidal waveform on the DSO screen. We then move onto explaining how to use the oscilloscope, with the key focus of avoiding using the Auto-Scale button, as this can set the DSO to incorrect default settings, and ingrain poor habits in students. The combined explanation of both the DSO and the function generator runs a total time of 4 minutes and seven seconds.

The third section involves how to measure different features of the waveform on the oscilloscope, and runs for one minute and ten seconds. The final section is a summary of the video tutorial and has a run time of 30 seconds. As a whole, the video runs for a total of 6 minutes and 30 seconds.

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 entire cohort was broken into two approximately equal groups; Red and Blue groups running in alternative weeks. The red group just received the traditional laboratory worksheet explaining how to complete the laboratory exercise. The blue group received the video as well as the traditional handout to help them to complete the laboratory exercise. Both groups' 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 evaluate the effectiveness of this multimedia presentation, we conducted a pre and post activity analysis comparing this method to the traditional method of explaining how to use the DSO [10]. Our results indicated that there was

a significant difference between the two groups for both the pre and post test scores in favour of the multimedia presentation. Table III provides a summary of the effect size for both the pre and post test analysis. The results indicated that there is a large difference between the two groups.

TABLE III.   SUMMARY OF THE EFFECT SIZE FOR BOTH THE PRE AND POST TEST ANALYSIS.

Test	Effect Size
Pre-Test	1.56
Post-Test	0.73

V.   BENEFITS

The benefits of designing a multimedia presentation of this type are wide-ranging. One of the first benefits is that making a video of this type is low cost. Much of the software and technology that is used was either already owned or licensed by the University for use by staff members and students. This project used readily available equipment and technology found at any University to a positive effect on student learning [10]. It is also possible to quickly and simply modify a presentation, and create new presentations.

A secondary advantage is that the narration of the presentation can easily be converted into different languages to aid those students where English is not their first language. This allows the multimedia resource to significantly aid their learning process, as they can view the video in both English and their native language.

A third benefit is that the presentation is targeted specifically at students studying at ECU, and demonstrates the specific test equipment that students will be exposed to in Physics and Engineering Lab sessions in the School of Engineering. Many amateur (and some professional) video presentations are available on sites such as YouTube [11]. However, these are often quite generic in nature and often do not cover the activities that we wish our students to attempt and understand. As such, they are not necessarily relevant to the learning activities that we require our students to perform at ECU. Also, experience has shown that students want instruction on the specific instruments they will use in the laboratory program, not a general presentation on an instrument that does not have the same controls (located in the same positions) as those used in the lab. The purpose of our project is to design a presentation for the students that relate to equipment that is utilized at ECU.

Finally, the availability of relevant instructional videos allows students to easily access these learning tools online, both during and outside scheduled classes. This is useful, not only for initial instruction in the use and operations of a DSO (and function generator), but can also aid knowledge retention for future units of study, where it is assumed that students have already mastered the operation of a DSO. Experience has shown that student retention of this knowledge is poor for current teaching methods. This is an issue that we will examine in future studies.

VI.   FUTURE WORK

In the next stage of development, we intend to examine the following issues: (1) To conduct a survey asking students for their input (as the presentation is designed for students) on what they do and do not like about this current version of the presentation, and what should and should not be included in future presentations. This will give us a guide to how we can better help the students understand how to utilize the DSO. The results of this study will be published in future. (2) The affect of these multimedia resources on students' retention of knowledge in future units of study. The ability to understand and operate a DSO is considered to be pre-requisite knowledge for students progressing to later units of study. However, experience has shown that students struggle with the retention of this knowledge for these later units, and then start to fall behind in their knowledge of more advanced concepts.

VII.   CONCLUSIONS

We have designed and developed an educational audio-video resource on how to utilise the basic functions of the DSO. This resource is currently targeted at undergraduate first year students, although it is also useful as a review tool for students in second and third years. The resource was simple to develop, and its introduction has resulted in a significant improvement in student's understanding of how to setup and operate a digital storage oscilloscope and a function generator.

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