Animation of complex data communications concepts may not always yield improved learning outcomes.

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Abstract

The field of data and computer communications networking uses an array of abstract concepts such as encapsulation, protocol data units, virtual circuits etc. to describe and explain the underlying processes. Various studies, together with our own observations, strongly indicate that students often find these concepts difficult to learn, as they cannot easily be demonstrated.

A number of academics have described the animation tools they have developed to illustrate such concepts and almost invariably they comment on the favourable reactions their efforts receive from their students. However, it is difficult to find examples that anchor the design of their animation offerings in the principles of good instructional design and few conduct rigorous evaluations to see if there has been a genuine and measurable improvement in student understanding of the basic concepts being illustrated.

Our work does both. We have designed an animation tool on virtual circuits which takes cognizance of contemporary work on instructional design, particularly the work of Mayer (2003). Two versions of the animation were produced, one with narration and the other with narration and additional on-screen text. We randomly assigned 110 first year undergraduate students to view a version of the animation. A pre and post test was used to determine if, in fact, improved learning actually occurred and which version of the animation produced the better outcome. Initial analysis of results indicates no statistical difference between the scores for the two versions and suggests that animations, by themselves, do not necessarily improve student understanding.

Keywords: multimedia, animation, evaluation, data communications, redundancy principle, instructional design.

1 Introduction

Information Technology teaching at Universities in data communications theory is heavily dependent on abstractions. For example, first year students are faced with a number of abstract concepts including: network layers, encapsulation, connectionless data transfers, Protocol Data Units (PDUs), Virtual Connections (VCs), and Virtual Private Networks (VPNs).

Academic staff involved in introductory Data Communications units are faced with the challenge of ensuring that students develop a deep understanding of these abstract concepts that are assumed knowledge for second and third year data communications' units. However, it is widely recognised by University academics that students experience difficulty with these concepts: **'**Data communications is renowned for its overuse of acronyms, the wide range of fundamental and highly technical concepts students have to grapple with, many of which need to be learned by rote. Coupled with these, there are a wide range of complex and abstract concepts that need to be understood' (Leung and Pilgrim, 1995:1). The challenge of teaching these abstract concepts is also widely recognised by University academics: 'It is difficult to teach data communications because it involves complex, dynamic processes which are not visible to students and are hard for them to conceptualise' (Dixon and Koziniec, 2002:349).

Academic textbooks are including animations on CDs in book jackets, and literature (Hercog, 2003: White, 2001) has described animation tools to illustrate abstract data communication concepts which received favourable reactions from students. However, it is difficult to find examples that include rigorous evaluations of genuine and measurable improvement in student understanding of the basic concepts illustrated in the animation. Carbone and Kaasbøll, (1998) comment that 'the teacher's own impression of the teaching, and the students impressions, is the most common way of evaluating novel approaches in teaching.'

Evaluation of an improvement in student understanding of a complex data communications concept was therefore a primary goal of this current study. An approach that integrated evaluation into the design of the multimedia resource to ensure improved learning outcomes has been encouraged by the literature (Harvey, Oliver, and Smith, 2002; Naps, Rößling et al., 2002).

The essentials of good design of multi-media materials demand consideration of motivational factors, such as, user friendliness, attractiveness, and content factors. However, literature has also identified that there are definite instructional design issues in using multimedia animations for teaching science concepts (Mayer, Heiser and Lonn, 2001). Studies of instructional design of multiple mode presentation of technical information have found that 'the elimination, rather than integration, of redundant sources of information is beneficial for learning.' (Kalyuga, Chandler and Sweller 1999: 368). Since data communication explanations use both science and engineering concepts, a research study was developed to determine if these issues are visible in an Information Technology environment.

2 Our study

Our aim was to produce a multi-media animation that would complement existing lecture and textbook materials (Stallings, 2004), and improve student understanding, of a complex data communications concept. Since differentiating between circuit switching and packet switching is ranked by both academics and practitioners as one of the ten most important data communications concepts for senior-level undergraduates (Johnson, Stallard and Tanner, 1999), we chose to create an animation to illustrate these concepts.

We collaborated with professional instructional designers who, over a period of months, applied best practice design principles to create two, three minute animations using commercially available software. This was achieved through a number of consultations with subject matter experts on the storyboard, design implementation and development of the animation. Our methodology was adopted from the study by Mayer, Heiser and Lonn (2001) which examined suggestions for possibly improving multimedia scientific explanations such as the formation of lightning. One suggestion from their study was to make the explanation more accommodating by adding on-screen text that summarized or duplicated the narration. Their study found that the redundant information provided by the on-screen text inhibited, rather than promoted learning, and that, in some situations, people learn better from animation and narration than from animation, narration and on-screen text.

This finding conflicts with the general view that presenting information in multiple formats should better support learning. Our study sought to test these interpretations in an Information Technology environment. A between-subjects design was used, with the variable factor being presence or absence of on-screen text that duplicated the narration in the multimedia presentation. Version 1 of the animation included narration, but with no additional on-screen text. Version 2 of the animation included narration with on-screen text that duplicated the narration.

Teaching of circuit switching and packet switching usually occurs in week 10 of our introductory Data Communications unit in the Bachelor of Information Technology Undergraduate course. The study was conducted during the practical classes that followed the lecture on the topic. A large number of students (n=110) participated in the evaluation, which was conducted in our IT computer laboratories, and students were requested to use their own earphones or the desktop speakers. Pre-animation and post animation tests were conducted using on-line web-pages and consisted of a questionnaire and a combined Retention & Transfer test.

The questionnaire asked students to indicate their age, gender, language most used with their family, number of years experience with data networking, and to answer four questions related to data networking concepts. The Retention & Transfer test consisted of a multi-choice on-line quiz to determine differences between circuit switched and packet switched networks and included the four questions related to data networking concepts from the questionnaire. The transfer test questions were designed to encourage students to use knowledge gained from the animation and their own problem solving techniques to answer questions on sources of packet switched network delays. Although this was not directly explained in the animation, correct responses were considered to demonstrate deeper learning. Students were randomly assigned to versions of the animation as they logged on, completed the questionnaire within a ten minute timeframe, and then viewed the multimedia animation. Students then linked to the multi-choice Retention & Transfer test for completion within fifteen minutes. Students were able to study both versions of the animation on completion of the data collection study.

3 Results and Analysis

The results of the Questionnaire revealed that greater than fifty percent of students scored correct responses to the four questions relating to differences between circuit switching and packet switching, prior to viewing a version of the animation. Responses to the same four questions in a different order on the Retention & Transfer test revealed an improvement in correct responses of only one percent, or less. For one question on the generic concept of packetization the scores in the Retention & Transfer test were ten percent worse.

The results of the Retention & Transfer test, taken after students viewed just one version of the animation, are shown in Figure 1. and Figure 2. It appears at first glance, that more correct answers were achieved by the no-additional on-screen text (Version 1) group.

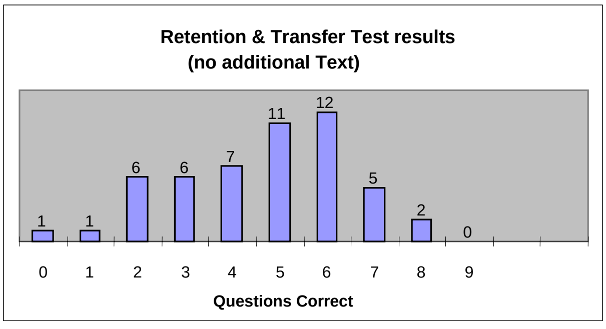

Figure 1. Histogram of correct scores from the no-additional text version.

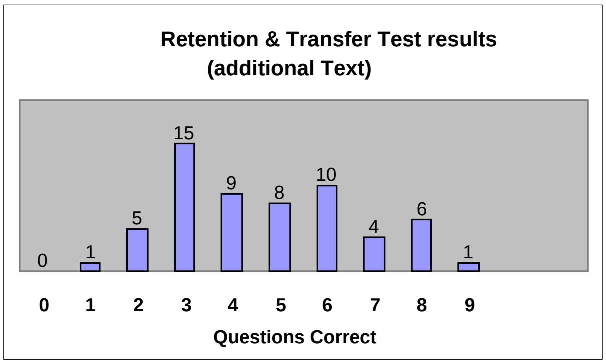

Figure 2. Histogram of the correct scores from the additional text version.

However, the F test results in Table 1, reveal no significant difference in the results between the students who received the no additional text version of the animation (Version 1) and the students who received the additional text version of the animation (Version 2).

F-Test

Two-Sample for Variances

Retention & Transfer Test results	*No Add. Text*	*Add. Text*
Mean	4.6	4.7
Variance	3.4	3.8
Observations	51.0	59.0
df	50.0	58.0
F (1,108)	0.9	
P(F<=f) one-tail	0.3	
F Critical one-tail	0.6	

Table 1. F test of Scores for the Retention & Transfer tests from the no-additional text and additional text groups.

The mean scores and standard deviations of the Retention & Transfer test results are almost identical for the two groups and the small difference in sample size is not considered to have influenced the conclusion that no significant statistical variation exists between total scores of the two groups.

4 Discussion

The lack of improvement in correct responses to the four questions relating to differences between circuit switching and packet switching, which were in both the Questionnaire and the Retention & Transfer test, shows an increase in our student's understanding of these fundamental concepts was not detected. This supports the view that 'continuous animation offers no real advantage' to achieve more effective student understanding of complex computer concepts (Naps, Rößling et al., 2002:140). It is therefore considered possible that CD animations included with textbooks, or on-line links to multi-media resources, will not necessarily improve student understanding above that expected from a static diagram.

The analysis revealed that the group of students that viewed the version with the additional on-screen text showed no statistical difference in Retention & Transfer test scores over the group of students that viewed the version without additional on-screen text. Since the animation did not improve the students' understanding of the topic this was to be expected. The version with additional on-screen text could not impede learning when no learning occurred.

This study therefore shows that the animation in question requires more development and quantitative evaluation to determine if an improvement in learning can be achieved over a static diagram, before consideration can be given to the theoretical interpretations of the redundancy experiment in the Mayer, Heiser and Lonn (2001) study.

We certainly empathise with other academics who have devoted time and effort to improving the visual appeal of fundamental topics and only seeing a slight improvement in students understanding (Tyler, cited in Biggs 2003:215). In looking for some positive outcomes, we draw strength from 'recognising the need to develop an evaluation strategy' (Harvey, Oliver and Smith, 2002:6) which provides the motivation to continue.

5 Limitations of the study

Limitations of this study relate to (a) timing considerations between the narration and the appearance of the additional on-screen text, (b) viewing of the animation in a noisy laboratory environment, and (c) the availability and use of headsets by the participants. This may have resulted in some of the participants, who viewed the additional on-screen text, not being subjected to an ideal redundant information environment.

6 Conclusions

This study was motivated by a desire to improve student understanding of a complex data communications concept by complementing a textbook diagram with a multi-media animation. The results suggest that further development of a more effective resource, built around the animation, is required to achieve this objective.

This result supports the view that quantitative 'practitioner evaluation' (Harvey, Oliver and Smith, 2002) of the use of animations to improve student understanding should be included within the resource. By including a pre-animation Questionnaire and a post animation Retention and Transfer test, an analysis of our approach has revealed a more effective strategy is required.

While the analysis of the effect of additional on-screen text does not support the findings of Mayer, Heiser and Lonn (2001), our future instructional design methods will still pay particular attention to the mix of animation, narration and additional on-screen text. Since data communication explanations use both science and engineering concepts, the above issues are considered to be relevant in an Information Technology environment.

This experience has developed a better understanding of the relationship between student experience levels and instructional design methods as suggested by Sweller (1999). Allowing students a choice between additional on-screen text, narration, or both, will be a feature of our future continuous technical animations. The experience has also convinced us to follow closely the recommendations of Naps et al (2002) when developing animations as an interactive resource for initial presentation of complex technical computing concepts.

7 Future Direction

The future direction will be to incorporate the animation into a lecture presentation, or other practical learning modes, where active engagement with the students can be better controlled (Plass, cited in Mayer et al., 2001). This will require the inclusion of a play, stop forward or rewind facility and summative assessment tasks for rapid feedback to ensure improved learning outcomes are actually taking place (Chickering and Ehrmann,1996).

Another area of interest, for further data mining of the results, lies in clarifying if the problem solving questions were answered better by a select band of individuals. Further analysis of the relationship between total scores and student demographics, particularly language, gender and previous experience will allow comparisons with studies of engineering students such as those discussed by Sweller (1999). Analysis of the demographics may initiate further research into the relationship between current IT student and staff learning styles, as discussed in the study by Stewart and Stark (2002), where an almost opposite distribution of MBTI type was revealed.

More focus will be applied to the issue of evaluation of instructional design techniques for multimedia resources in an attempt to quantify techniques that explicitly demonstrate improved learning outcomes.

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