Applying Redundancy and Animation in a Multimedia Learning Application on a Computer Science Domain

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ABSTRACT
This research aims to investigate the affects and advantages of the various media so that instructions and learning can be more effective. The principle of redundancy states that students learn better from animation and narration than from animation, narration, and text. This study applied the redundancy principle and investigated how students benefited from different types of animation and modes of instruction on the topic of memory management in the subject of Operating System concepts. In this study, learning effects of four multimedia-based learning applications (2:D Animation & Voice, 2:D Animation & Text & Voice, 3:D Animation & Voice, 3:D Animation & Text & Voice) were compared from a total of 72 students. The students who were identified as low prior knowledge (from a prior knowledge survey) on the subject were given a test on recall and transfer knowledge after viewing the learning applications. Early results demonstrated the superiority of the 3:D animation & Voice combination over the three other conditions in the recall test. No differences were found between the four experimental groups for the transfer test questions. This research may provide useful guidance for instructional designers specifically in the area of computer science.

Keywords: Memory Management Concepts, Multimedia Learning, Redundancy, Animation.

I. INTRODUCTION
One of the great promises of computer technology for education is the ability to combine text, sound and images to create multimedia learning environments. Researches from various domains demonstrate that students’ performance is enhanced with the use of multimedia (Markovic et al., 2012; Kisecek et al., 2012). Quality of Multimedia is the presentation of material using both words (printed or spoken text) and pictures (graphics, illustrations, graphics, photos, maps, animation, and video) (Clark & Paivio, 1991). Multimedia will make the learning experience for students more exciting as it triggers the different senses of a human such as hearing and seeing with the various media available.

Learning with multimedia, mostly visualization, with the use of animation has become a topic of major interest in recent years (Ariffin et al., 2011; Azman & Rozham, 2011). However, some multimedia designers and developers tend to get very adventurous and overload the learning materials with too many multimedia elements somehow harms learning instead of helping the learner. Instructional designers or web-based multimedia developers have to ‘form’ or develop multimedia interfaces ‘that best match all the resources of their target learners’ (Mayer, 2001) and understand how such interfaces assist in ‘forming’ or developing understanding in the user. Therefore, it is important for the designers of multimedia interfaces to have a clear understanding of how information that is presented in different digital media is stored, manipulated and recalled by learners (Large, 1996).

In this study, we attempt to investigate the redundancy and different animations (2-D & 3-D) effect on students’ achievement in recall and transfer tests in the topic of memory management.

II. THEORETICAL FRAMEWORKS
Mayer and his colleagues have done extensive experimental-based research on multimedia usage in learning. Mayer’s cognitive theory of multimedia learning (Mayer, 2001) has based his theories on an integration of Sweller’s cognitive load theory (Sweller, 1988; Chandler & Sweller, 1991), Pavio’s dual-coding theory (Clark & Paivio, 1991), and Baddeley’s working memory model (Baddeley, 1992). Mayer’s cognitive theory claims that information should be presented in such a way that the learner’s limited working memory resources are employed as efficiently as possible. This is especially the case with multimedia instruction, where learners have to integrate different information sources like text, pictures and spoken words, cognitive overload can be a serious threat to learning.
The theory provides useful insights into why different combinations of media can have different effects on comprehension and learning. Mayer focuses on the auditory/verbal channel and visual pictorial channel, and he defines multimedia as the presentation of material using both words and pictures, thus the definition of multimedia is narrowed down to two forms-verbal and pictorial because the research base in cognitive psychology is most relevant to this definition (Mayer, 2001).

A. Previous Work on Redundancy

The redundancy principle posits that animation and narration yield superior retention and transfer performance compared to animation, narration, and text as the redundant condition yielded stimulus overload on the visual path way as subjects had to simultaneously process animation and text (Mayer et al., 2001). There are many mixed results on the issue of redundancy, where there is less agreement about the use of related or completely redundant cues (Pastore, 2012; Mayer et al., 2001; Riaza & Halimah, 2010).

Although a number of studies support the presentation of related information through various combinations of audio, text, and/or visual images, an equal number of findings indicate no advantage, and a few report negative effects from the use of redundant cues. Chu (2006) studied the effects of redundant text on learners’ memory achievement and problem solving ability. The study replicated and extended prior research by using descriptive rather than cause-and-effect content information. No statistically significant differences were found between the redundant and non-redundant groups.

In addition, the study found that the impairment of redundant text was also affected by various learning characteristics, such as the structure of the instructional content and learners’ previous learning experiences. Many researches on redundancy in learning have given mixed results and have been rather inconclusive (Pastore, 2012; Pociask & Morrison, 2008; Moreno & Mayer, 1999). The issue of redundancy merits further examination. There are many mixed results on the issue of redundancy, where there is less agreement about the use of related or completely redundant cues. Although a number of studies support the presentation of related information through various combinations of audio, text, and/or visual images, an equal number of findings indicate no advantage, and a few report negative effects from the use of redundant cues. In a study, Schwartz (2005) studied how 10 to 12 year olds process a multimedia lesson about a fictional planet Zoldar. This study did not appear to have any negative effects for the use of text with redundant narration. This is in conflict with some past research findings that have advised instructional designers against this practice.

To date there has not been a comprehensive review of the conflicting research results on the use of redundancy in multimedia. However, Moreno and Mayer (1999) endeavored to resolve the contradictory findings and clarify the relationship between redundant auditory, textual, and image information in multimedia presentations. They presented students with an explanation of lightning formation as: a) auditory narration; b) auditory narration accompanied by on-screen text; c) auditory narration preceded by an animation on the process of lightning; or d) auditory narration accompanied by on-screen text and proceeded by an animation on the process of lightning. They found that students performed better on tests of retention, matching, and transfer when words were presented as both narration and text than when words were presented only as narration, lending support to the benefits of verbal redundancy. They also found that the addition of animation (arguably a third redundant element) prior to the presentation of redundant narration and text provided “an extra code to be represented, associated and integrated with the verbal code” (Moreno & Mayer, 1999), resulting in better learning. In contrast, when animation was simultaneously presented with the redundant narration and text, learning suffered. Moreno and Mayer attributed this to the occurrence of a split-attention effect between the animation and on-screen text. Thus, although verbal redundancy as a combination of audio/visual elements was beneficial, the combination of audio/visual/visual redundant elements appeared to overload the processing system.

This study looks at the redundancy effect on students who study a computer science subject and this paper reports on the students’ performances.
after learning from a redundant and non-redundant treatment, in the form of knowledge recall and transfer.

B. Previous Work on Animation

In a series of studies, Mayer and Moreno (1999) have demonstrated the importance of simultaneous presentation of visual and verbal material in animated presentations and maintains that animation provides several important instructional roles (Bushro & Halimah, 2008; Riaza & Halimah, 2011). Animation helps to attract and direct attention, to represent domain knowledge involving movement and in explaining complex knowledge phenomena, such as, structural and functional relationships among system components.

Animation, like other instructional visuals, should facilitate recall and retention when it illustrates visually-based or spatially-based facts or concepts which are related with movements. Pavio’s dual coding theory Paivio (1986) stated that there are two separate information processing systems: a visual system which processes visual knowledge and a verbal system for processing verbal knowledge. Animated graphics are probably much better than static graphics at representing ideas which involve changes over time because of its ability to implement motion, therefore concretizing abstract temporal ideas (Rieber & Kini, 1991). If a learning task only requires learners to visualize fixed objects, then the use of static visuals would be sufficient. However, if the learning task requires the dynamic process, a situation in which an element is changing or evolving over time, it is better illustrated through animated visuals.

In the context of this research, we wondered if a 3-D animation is any better than 2-D animation. In a study conducted by Schanze (2003) which focused on students in the first two years of chemistry instruction (15 to 16-year-old students in German grammar schools) investigated whether the use of 3-D simulations lead to a better understanding of chemical structures than conventional 2-D figures. Schanze’s results indicate that chemistry beginners can profit from computer-based 3-D simulations which led to better understanding of chemical structures than 2-D figures (Schanze, 2003). In another study on comparing 2-D and 3-D display (Tavanti & Lind, 2001), this time on learning the place of an object, the results showed that a realistic 3-D display better supports a specific special memory task and an increase in performance compared to the 2D version.

Creating 3-D animation is intended to provide cues that are naturally cognition and action in contrast with its 2-D counterpart. There is however, a general lack of comparable experimental results on the superiority of 3-D in relation to 2-D animation. This study investigates if the use of 3-D animation is better than 2-D in student understanding in recall and transfer tests in a computer science domain.

III METHODOLOGY

This multimedia system was developed using Macromedia Flash MX 2004TM. The 3D animation was developed using 3D Max which is compatible to flash. The instructional design is self-paced and content was closely aligned with the textbook (Silberschatz & Gagne, 2008) used by the students.

Seventy two students participated in this study. All students were from the Faculty of Computer Science at University Technology MARA (UiTM). They had to take a prior knowledge survey before sitting for the treatment. This is to determine if the students had no prior knowledge in this subject. From the pool of students, one was detected as having high prior knowledge, therefore, the student was asked to leave the experiment. Some of the questions in the survey asked if students had taken the subject of OS prior to this survey. (Some first year students have already taken an introductory course in OS in their Diploma). Also some basic questions on memory management were asked and students were supposed to tick in the available boxes if they were familiar with certain terms. The experiment was conducted in a time span of two days in the computer lab at the Faculty of Computer Science.

The self-paced multimedia-based instruction explains on the memory management concepts which consist of background on memory management, swapping technique, contiguous allocation technique and paging technique. Then the students were asked to view the multimedia instructions which were installed in each computer in the computer lab. The animation was self-paced and interactive. Students could view the animation with the play button and they could rewind, pause or stop according to the needs. After the treatment, each participant had to take a test.

The system with 2-D animation and voice version (G1) had animation designed using Macromedia Flash and concepts of swapping, contiguous memory allocation and paging techniques were explained using animated form in 2-D. For example, the use of geometric shapes and arrows to
show movements of data from memory to backing store as shown in Figure 4. The same concept is shown in 3-D animation using two different trucks to represent movement of data in Figure 5.

The system with 3-D animation and text and voice version (G4) had animation designed using 3D Max and the concepts of memory management were explained using animated form in a 3-D realistic version. For example, the concept of contiguous memory allocation was explained using a forklift to carry large chunks of data to be put into empty spaces in the memory as shown in Figure 3.

Table 1. The groups, number of participants and type of instructions

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>N</th>
<th>MODES OF INSTRUCTION</th>
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<tbody>
<tr>
<td>GROUP1(G1)</td>
<td>18</td>
<td>2-D ANIMATION &amp; VOICE</td>
</tr>
<tr>
<td>GROUP2(G2)</td>
<td>18</td>
<td>2-D ANIMATION &amp; TEXT &amp; VOICE</td>
</tr>
<tr>
<td>GROUP3(G3)</td>
<td>17</td>
<td>3-D ANIMATION &amp; VOICE</td>
</tr>
<tr>
<td>GROUP4(G4)</td>
<td>18</td>
<td>3-D ANIMATION &amp; TEXT &amp; VOICE</td>
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IV  RESULT

Below are the hypotheses and results for the redundancy effects of the prototypes on the participants.

Hypothesis 1: There is a significant difference in recall score in the redundancy principle for the 2-D group.

Hypothesis 2: There is a significant difference in transfer score in the redundancy principle for the 2-D group.

Hypothesis 3: There is a significant difference in recall score in the redundancy principle for the 3-D group.

Hypothesis 4: There is a significant difference in transfer score in the redundancy principle for the 3-D group.
The Redundancy principle states that students learn better from animation and narration than from animation, narration and text. The theoretical rationale is that when pictures and words are both presented visually, (as animation and text), the visual channel can become overloaded (Mayer, 2009). Mayer, in his string of research had concluded that the redundancy principle applied to both the retention/recall and transfer scores.

Findings from this research found that, there was a significant difference in recall tests for students who were using both 2-D and 3-D animation versions for students. However, there was no significant difference for students using both the prototype versions in the transfer test. These results indicated that for the 2-D animation category, students who were using the 2-D animation + Voice version, who were considered as the non-redundant group gave a better result on recall scores compared with students using 2-D + Text + Voice version, who were considered as the redundant group. The same results were found for the 3-D animation category where 3-D + Voice version gave better results compared to 3-D + Text + Voice version of the prototype. These results were consistent with the existing literature on the redundancy effect on multimedia learning.

However, no significant difference was found in the transfer test scores for students using both 2-D and 3-D animation. In other words, there was no difference in transfer test scores between samples who received redundant effect (Animation + Voice) and non-redundant effect (Animation + Voice).

Students generally did better in recall test when non-redundant effects were displayed. Mayer [16], calls this the redundancy effect for retention because adding on-screen text that is identical to the narration tends to jeopardise students’ learning. The redundancy effect for retention means that students perform poorly on verbal retention when they learn with animation, narration, and text than when they learn with just animation and narration.

Students showed no significant difference in the transfer test undertaken. Transfer test requires understanding, and the ability to use presented material in a novel situation. These students had never learnt the subject on operating systems before and were novices in understanding on memory management. For recall or retention, these students
performed well because recall test only required them to memorise or the ability to reproduce or recognize presented materials. Similar results were achieved in a study by (Chu, 2006; Riaz & Halimah, 2010; Lee & Kalguya, 2011), who investigated the effectiveness of redundant text and animation in a multimedia learning environment. A possible reason for this is because the content was difficult for students with low prior knowledge to comprehend in a 2 hour lab period.

Another possible reason on why no significant effects were found based on the students for the transfer test could be that most Malaysian students are accustomed to having television and movie subtitles while concentrating on the respective programmes. This is perhaps why they may not be distracted from the on-screen text when viewing redundant materials.

In an informal interview session conducted after the experiments, some students mentioned that the multimedia lesson alone was not enough. They felt that the presence of a lecturer to get further information on some difficult sub-topics, such as “Paging” was necessary. According to Baharuddin (2006), students would still require the presence of a facilitator. This is especially the case when students need to get further guidance and clarity on a challenging topic, such as “Paging”.

Mayer (2001) stated in his studies that the redundancy effect is not so harmful in some situations, such as, when the rate of presentation is slow or when no pictorial material is concurrently presented. For example, it might be useful to present summary slides (or to write key ideas on the board) in the course of a verbal presentation or lecture. This is an area that would need further research.

ACKNOWLEDGMENT

The authors would like to thank the RIF Grant by the Research Management Institute (RMI) at Universiti Teknologi MARA (UiTM) for supporting a part of this study.

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