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Different Multimedia Presentation Types and Students' Interpretation Achievement

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***Abstract*—**The main purpose of the study was to determine whether students' interpretation achievement differed with the use of various multimedia presentation types. Four groups of students, text only (T), audio only (A), text and audio (TA), text and image (TI), were arranged and they were presented the same story via different types of multimedia presentations. Inference achievement was measured by a critical thinking inference test.

Higher mean scores for the TA group compared to the other three groups were found. Also when compared pairwise, interpretation achievement of the TA group differed significantly from scores of the T and TI groups. These differences were interpreted with the increased cognitive load. Increased cognitive load for the TA group may have invited students to put more effort into comprehending the text, thus resulting in better test scores.

Findings of the study can be seen as a sign of the importance of learning situations and learning outcomes in multimedia-supported learning environments and may have practical benefits for instructional designers.

***Keywords*—**Multimedia, Cognitive Multimedia, Dual Coding, Cognitive Load, Critical Thinking

I. Introduction

MULTIMEDIA may be defined as the presentation of content in various forms such as voice, graphics, animation, music etc. [19]. As computers have become more powerful and less expensive, multimedia presentations have been produced and employed in education more than in the past. Nonetheless, the question of whether multimedia has any effect on learning still remains. And we still ask the question "if multimedia has any effect on learning, which format is the most effective – text only, text with graphics, audio with graphics, or text and audio with graphics?" [1].

One of the best known theories related to multimedia presentation forms is Paivio's dual coding theory. The dual coding theory tries to explain how the mind processes information [20]. According to Paivio, two types of information (verbal and non-verbal) are encoded simultaneously in human memory by two subsystems. The verbal subsystem processes and stores linguistic or language information, whereas the visual subsystem processes and stores images and pictorial information [18].

The verbal and nonverbal subsystems are independent of each other. They can operate independently or parallel to each other. Despite this, the two subsystems are interconnected, so that a concept represented as an image can be converted to the verbal system, or vice versa, allowing the dual coding of information [1]. Dual coding occurs when both verbal and nonverbal systems are activated at the same time. In other words, when an imagen (picture) and visual logonen (written text) or an imagen (picture) and auditory logonen (aural text) are activated simultaneously [19].

Another multimedia related model belongs to Baddeley. According to this model working memory has two subsystems which are visual and auditory. The main difference between Baddeley's model and dual coding theory is classification of verbal and non-verbal information. Dual coding theory omits the medium which information is presented through. For example it accepts both auditory verbal and visual verbal information as verbal and claims they are both processed through the same channel. On the other hand, Baddeley's model accepts auditory-verbal as auditory and visual-verbal as visual type of information [14].

Mayer's cognitive multimedia learning theory [13] is based on a multiple channel communication model and dual coding theory. Mayer stated in his theory that human information processing systems consist of visual-pictorial and auditory-verbal channels. Each channel has limited capacity in information processing. Active learning occurs when learners pay attention, organize incoming information, and integrate new knowledge with prior knowledge from other channel. According to the theory, information can be processed more deeply when it is presented through both visual and auditory channels. When more than one information types are presented through one channel, learners may experience the difficulty called split attention effect [12]. Presentation of visual and auditory information types together yields better information processing than presentation of visual-verbal and pictorial information together [3].

Finally cognitive load theory is an important theory that deserves to be considered during multimedia related studies. Cognitive load theory focuses on working memory, which has a limited capacity and long term memory, which is assumed to have an unlimited capacity. Working memory mainly deals with organization and comparison of information while long term memory acts as a storage medium for knowledge and skills [10].

Cognitive load theory states that human working memory is limited and that only two or three elements can be dealt simultaneously. Cognitive load partially derives from difficulty of the contents and partially derives from instructional materials that are used to present information. High cognitive load may occur when the instructional material is poorly designed. Changing instructional materials to

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facilitate learning is one way to reduce cognitive load [1]. When cognitive load is high working memory will be overloaded. Cognitive overload may be defined as learner confusion because of too many options, components, and ways [16]. Cognitive load can be reduced effectively by using the limited capacities of visual and verbal-auditory channels [12].

The amount of information presented to learners and the limitation of the human information processing system are also concerns to a model called multiple channel communications. Hsia [9] concluded from the review of many single channel and multiple channel communications studies that learning from multiple modalities will be superior to single modalities when the amount of information received is not greater than the subject's information processing capacity.

Another topic that should be mentioned within the scope of this study is critical thinking. Despite many various definitions of critical thinking the following elements have been identified with it. These elements are divergent thinking, evaluation and decision making, intrinsic motivation to think critically, and reflective thinking [8]. As a consequence of a Delphi study Facione [7] defined basic skills under critical thinking as interpretation, analysis, evaluation, inference, explanation, and self regulation. Within the scope of this research only the interpretation skill was studied. Interpretation may be defined as comprehending and expressing meanings and importance of situations, experiences, claims, beliefs, rules and procedures. It contains sub-skills such as categorizing, decoding significance, and clarifying meaning.

Although many educators believe multimedia is a tool that can enhance learning, studies on its impact on learners' retention have yielded varying results. Clark and Craig [5] conducted meta-analyses and found that multiple media were not the factors that influenced learning. They stated that if there was evidence for unique learning benefits from any medium, then additive learning from combining media would be possible. This is called the additive assumption. The most common sources of confounding in additive media research are from uncontrolled effects of instructional method or content differences between treatments being compared and a novelty effect of newer media [4]. A similar inference is reprted by Najjar [17]. After reviewing numerous studies related to multimedia from different fields of studies, he concluded that learning does not always improve when comparing redundant multimedia to a single medium.

These mixed results regarding use of multimedia for educational purposes remind us of the importance of cognitive learning outcomes where multimedia presentations have been employed to obtain them. As is known, cognitive learning outcomes have various forms such as knowledge, comprehension, critical thinking, decision making, problem solving, reflective thinking, or creative thinking. Although a majority of the studies related to cognitive multimedia have focused just on simple recall, a few studies have focused on comprehension, critical thinking, and problem solving. Because human learning is a complex process or a number of complex processes, different multimedia presentation forms may have different effects on different learning outcomes. In other words, the principles of multimedia-related theory and models such as dual coding, cognitive multimedia, and cognitive load may not fit completely for all learning outcomes.

II. Method

The main aim of this study was to determine whether students' interpretation achievement differed with different multimedia presentation types. In order to reach this aim an experimental study was designed and conducted with 4 groups. There were 22 students in each group making 88 students in total. All fourth and fifth graders of a primary school were randomly assigned to the experimental groups. All students were at a moderate socio-economic level. A little more than half of the students (56.82%) were girls while 43.18% of them were boys. Groups were identical in terms of gender distribution, age distribution, computer usage skills and general academic achievement.

As is known, the novelty effect is one of the main disturbing effects on the results of computer based/assisted instruction studies. Although within the content of this study, computer aided/based environments were not compared with classroom environments, a primary school which had regular ICT lessons was selected in order to control the novelty effect. All students who contributed to this study had previous ICT lessons in their education and they were computer literate. Students were also accustomed to the use of multimedia presentations for educational purposes.

The experimental study lasted for 4 lessons. Because there was only one IT classroom in the school, each lesson one group (22 students) participated to the experimental study. The backbone of the experimental study was a short story about one day in the life of a primary school child. The same content was presented to all groups in different formats. Afterwards the students took an interpretation test.

The first group was the text only (T) group. They read the whole story without any accompanying voice or animation. The second group was audio only (A) group. They just listened to the story. The content was presented through multiple channels for the third and fourth groups. While the third group listened and read the content (TA), the fourth group listened and watched related images (TI). There were enough number of computers for each student, and the students were provided headphones where necessary. All the groups received necessary explanations and guidance before and during the experimental studies in order to minimize disturbing effects.

The story and the critical thinking interpretation sub-scale had been developed for 4th and 5th graders by Demir [6] after an intensive literature review. The story contained 333 words while the interpretation subscale consisted of 10 multiple choice questions. Difficulty indexes of the items were found

to be moderate, and internal validity of the scale was calculated as 0.76 by Demir.

III. Findings

Averages of the interpretation test results (maximum 10 points) were calculated for each group and given in Table I. According to the test results it can be seen that average points for the students who listened and read the story are slightly higher than the other three groups' average points.

TABLE I
INTERPRETATION TEST RESULTS

Group	n	$\overline{X}$
T (Text Only)	22	5.23
A (Audio Only)	22	5.50
TA (Text and Audio)	22	6.27
TI (Text and Image)	22	5.23

Afterwards the significance of the differences between groups (pairwise) was tested (Table II). Because the number of students in each group was not sufficient to employ a parametric test, a non-parametric test, Mann-Whitney U test, was used.

TABLE II
PAIRWISE COMPARISONS BETWEEN GROUPS

	Mann-Whitney U	p
T – A	217.00	0.55
T - TI	239.00	0.94
TI - A	220.50	0.61
TA - T	159.00	0.04
TA - A	183.50	0.16
TA - TI	164.50	0.06

Table II contains results of the Mann-Whitney U comparisons. From the table it can be seen that two differences, TA – T and TA – TI, were found significant ($p<0,1$). In other words the students who read and listened to the text performed better than the students who only read the text and who read the text and watched related images.

Finally crosstab comparisons between groups (Table III) were made. For crosstabs students were categorized as low achievers (0-3.33), moderate achievers (3.34-6.66), and high achievers (6.67-10) according to their interpretation test scores. Crosstab results showed that while T, A, and TI groups had low achieving students, the TA group had no low achieving students.

TABLE III
CROSSTAB COMPARISONS

	Low	Moderate	High
T	5.7%	13.6%	16.7%
A	3.4%	12.5%	9.1%
TA	0%	12.5%	12.5%
TI	3.4%	14.8%	6.8%

IV. Discussion

Throughout this research we tried to find an answer to the question: Does students' interpretation achievement differ with different multimedia presentation types? With this four groups of students were arranged text only (T), audio only (A), text and audio (TA), text and image (TI). The groups were presented the same story via different types of multimedia presentations and their inference achievement was measured using a critical thinking inference test.

According to the results, higher mean scores for the TA group compared to the other three groups were observed. When compared pairwise using a non-parametric test, interpretation achievement of the TA group differed significantly from scores of T and TI groups.

We accepted our findings as one of the varying results on the impact of multimedia presentations. In fact at the beginning of the study we were expecting text and image (TI) group to produce the highest score. As stated earlier, dual coding theory categorizes learning channels as verbal and non-verbal. According to the theory using both channels (TI group for this study) makes operation of working memory more efficient. In literature support for the dual coding theory can be found. For example in Severin's study six groups of conditions were compared: Audio only, text only, audio with text, audio with related pictures, audio with related pictures of the same category, and audio with unrelated pictures of the same category. The subjects were seventh grade students. The results from Severin's study showed that the audio with related pictures group was significantly better than audio with text group in the recall test. Besides audio with text group was not significantly better than the text only group. He concluded that multiple channel communications appear to be superior to single channel communications when relevant cues are summated across channels [1]. Another related study was carried out by Arlin, Scott, and Webster [2]. They examined the use of auditory versus visual logonens. They showed that students who saw a picture and read a word (imagen and visual logonen) learned 44% faster than students who saw a picture and heard a word (imagen and auditory logonen). This suggests that seeing a word with the picture may form a link between the word and the picture. Finally, according to the results on a research conducted on adult learners, Kalyuga, Chandler, and Sweller [11] suggested two principles for instructional designers which are "it is better to present verbal information in auditory form than in written form" and

"presentation of verbal information in written and auditory forms together should be avoided".

Clearly our study results contradict the results stated above, but it should be noted that generally the main interest of the studies mentioned above is knowledge recalling not high order thinking. In addition, there are some other results that may be interpreted as a parallel to our findings. For example, in her study, Adulseranee [1], compared seventh graders' comprehension of social studies text using four multimedia formats: written text only (W), written text with graphics (WG), audio with graphics (AG), and written text with audio and graphics (WAG). Results of the study showed that W group scored significantly better on posttest, while the WAG group performed better on delayed posttest. Adulseranee concluded pattern recognition and cognitive load may have contributed the higher posttest scores for the W group.

Findings of this study make sense if they are considered in the light of two theories: dual coding theory and cognitive load theory. Dual coding theory focuses on two channels of the memory: verbal and non-verbal. According to the theory both visual and auditory forms of verbal information are processed in the verbal channel. So there is no difference between these two types of presentations.

On the other hand cognitive load theory focuses on effective use of working memory capacity. According to the theory, working memory is limited, and when cognitive load is high working memory will be overloaded, resulting in a decrease in learning performance.

The redundancy effect is one of the principles of cognitive load theory. Presentation of the same information through the same channel using different formats is overly repetitious and is called as the redundancy effect. It occurs when additional information, rather than having a positive or neutral effect, interferes with learning. There are many different forms of redundancy such as diagram-text redundancy, mental-physical activity redundancy, and auditory-visual redundancy. The last form of redundancy occurs when the same material, presented simultaneously in written and spoken form, results in a learning decrement compared to the material presented in written or auditory form alone [11], [15].

The TA group in this study learned by both verbal reading and verbal listening. In fact using these two presentation types simultaneously is redundant. It can be assumed that the the TA group in our study had the highest cognitive load compared with other three groups. The increased cognitive load for the TA group may have invited students to put more effort on comprehension, thus resulting better test scores. But unfortunately during the study cognitive loads for the different multimedia presentations were not measured, which is a weakness of the study. This situation is preventing us to make clear connections between the interpretation test results and cognitive load.

In the conclusion, the findings of our study did not give very clear answers to the research question. We are aware that our findings cannot be interpreted as strong and clear clues. Nonetheless we think that they can be seen as a sign pointing to the importance of learning situations and learning outcomes in multimedia-supported learning environments. Human learning is complex. It may be incorrect or inadequate to formulate and generalize multimedia design principles for all learners, for all situations, and for all learning outcomes. Clearly more in depth studies are needed.

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