A STUDY OF VERBAL-VISUAL LEARNING PREFERENCES AND MULTIMEDIA LEARNING IN HIGHER LEARNING INSTITUTIONS

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Abstract

This paper describes how visual and verbal learning styles can be accommodated in multimedia learning environment. We investigated the effects and possible aptitude treatment interactions between verbal-visual learning styles and multimedia presentation strategy in higher learning institution. A multimedia courseware on C Programming was designed to allow two modes of presentation based on verbal-visual learning preferences – verbal presentation consists of text and audio while the visual presentation consists of text and animation. Students of Diploma in Business and Diploma in Business Information Systems at Multimedia University were randomly assigned to visual and verbal presentation mode and given a learning test to measure their learning achievement. Participants also took the Index of Learning Style Questionnaire to determine their visual/verbal scores. A one-way ANOVA was administered to investigate potential aptitude treatment interaction (ATI) between verbal-visual learning preferences, multimedia presentations and learning scores. Results from the experiment provided no support for significant ATI. Further exploratory analysis however, showed significant relationship between academic major differences (Business and Business Information Systems) and verbal-visual learning preferences. Results also suggested that scaffolding effects improve learners' performance within the multimedia learning environment.

Introduction

The success of a learning environment can be predicted by the level of achievement of learners (Meryem Yilmaz-soylu & Buket Akkoyunlu, 2002). In order to ensure the effectiveness of teaching environments, it is important to take account of characteristics, abilities and experience of learners as individuals or as a group when beginning to plan a learning environment (Kemp, Morrison, & Ross, 1998).

Learning styles can be referred to individuals' characteristics and preferred ways of gathering, organizing and thinking about information (Flemming, 2006). Learning styles characterize how a student prefers to learn about the subject being taught. When students understand their learning style preferences, research has shown they are more successful learners. Students reported that early knowledge of their learning style type affected how they adapted to and strengthened their strategies for learning, including how they developed their study habits (Gray, R. L., 2003).

The Aptitude Treatment Interaction hypothesis proposed by Lee J. Cronbach (1957) states that matching learning styles with instructional strategy will produce better learning performance. In the context of multimedia learning, multimedia can support preferences to learn from visual or verbal materials (Plass, Chun, Mayer, & Leutner, 1998). In the case of verbal-visual learning preferences, it was assumed that visual learners learn better when they receive visual rather than verbal methods of instruction, whereas verbal learners will perform better when they receive verbal rather than visual methods of instruction.

In another perspective of multimedia learning, the principle of multimedia effect states that text in combination with graphics leads to better learning success than using text alone (Mayer, 2001). The dual coding theory (Clark & Paivio, 1991) states that learners perform better when information is presented in both visual and verbal form. According to Moreno (2006), the effectiveness of combining pictorial and verbal information that varies with the learning content and individual differences in spatial ability, prior knowledge, and general learning ability, as well as the relationship of individual differences in visual/verbal constructs and learning from visual/verbal representations remain unclear.

In this study, we aim to contribute to multimedia theory and practice by examining the relationship and potential aptitude treatment interaction between students' visual and verbal preferences and multimedia presentation strategy. To achieve the objective of this study, we created two different modes of multimedia presentation based on multimedia principles. Student's verbal-visual dimensions were determined by the Felder-Silverman's Index of Learning Style Questionnaire. We tested for any potential relationships among learning preferences, multimedia instructional strategy and learning outcome.

Literature

Verbal-Visual Learning Style: Paivio (1971) first developed the verbal-visual cognitive style model and argued that the cognitive system is divided into two independent components: a verbal system which stores information as words and a visual system which stores information as pictures. Central to this model is the recognition that individuals differ in the degree to which they depend on language or on imagery to process information. The Ways of Thinking questionnaire (Paivio, 1971) which was later updated by Richardson (1977) as the Visualiser-Verbaliser Questionnaire (VVQ) are self-report measurements in which the respondents report on their habitual way of processing different types of materials.

Felder Silverman (1988) proposed that learners can be categorized to visual and verbal learners. Felder & Solomon (2007) then explained that visual learners remember best what they see - pictures, diagrams, flow charts, time lines, films, and demonstrations. They tend to find diagrams, sketches, schematics, photographs, flow charts or any other visual representation of course material that is primarily verbal very useful to learn. They use concept maps listing key points, enclosing them in boxed or circles, and drawing line between concepts to show connections. They color code notes with highlighter so that everything relating to one topic is the same color. Felder & Solomon (2007) further explained that verbal learners get more out of words - written and spoken explanations. They write summaries or outlines of course material in their own words, work in groups to have more effective learning experience, gain understanding of material by hearing classmates' explanations and learn even more when they do the explaining.

Research using functional MRI (fMRI) imaging also distinguished visual from verbal cognitive styles that correlated with the Verbal-Visual dimension of the Visualizer-Verbalizer Questionnaire (David J.M. Kraemer, Lauren M. Rosenberg, & Sharon L. Thompson-Schill, 2009). Through the study, researchers found that people could reliably predict whether they are predominantly visual or verbal learners by answering the Visualizer-Verbalizer Cognitive Style questionnaire. When verbal learners remember pictures, they translate pictures into words (their preferred style of storing information); whereas visual learners will do the reverse - translating words in pictorial representations.

Mayer & Massa (2003) identified learning preference, cognitive style, and spatial ability as separate factors in Verbal-Visual Learning Style. In their studies conducted, a factor analysis was performed and distinguished between cognitive ability (i.e., possessing low or high spatial ability), cognitive style (i.e., thinking with words or images), and learning preference (i.e., preferring instruction with text or graphics). Based on the works of Mayer & Massa, it is noted that in our studies, we investigated the relationship between the verbal-visual preference aspect (preferring instruction with text or graphics) and multimedia presentation strategy.

Mutimedia Learning: According to Mayer (2001), multimedia is presentation of material using both words and pictures. Words encompass both written text and audio material and pictures include static formats (illustrations, photos, graphs, diagrams, charts and maps) and dynamic formats (e.g., animations and videos). There is a growing research base showing that students learn more deeply from well designed multimedia presentations than from traditional verbal-only messages, including improved performance on tests of problem-solving transfer (Mayer, 2001; Sweller, 1999; Van Merrienboer, 1997).

Cognitive science research suggested three assumptions crucial to multimedia learning - the dual channel assumption, the limited capacity assumption, and the active learning assumption. The dual coding theory (Paivio, 1991) states that learners perform better if information is presented in both visual and verbal form. In this context, learners have separate information processing systems for visual (diagrams and animation) and verbal (text and spoken words) representations. The limited capacity assumption is that the amount of processing that can take place within the information processing channels (visual and verbal) are extremely limited (Baddeley, 1998). The active learning assumption is that meaningful learning occurs when learners engage in active cognitive processing including paying attention to relevant incoming words and pictures, mentally organizing them into coherent verbal and pictorial representations, and mentally integrating verbal and pictorial representations with each other and with prior knowledge (Mayer, 1999a, 1999b, 2001; Wittrock, 1989). This process of active learning results in a meaningful learning outcome that can support problem-solving transfer. A framework for the cognitive theory of multimedia learning is presented in Figure 1.

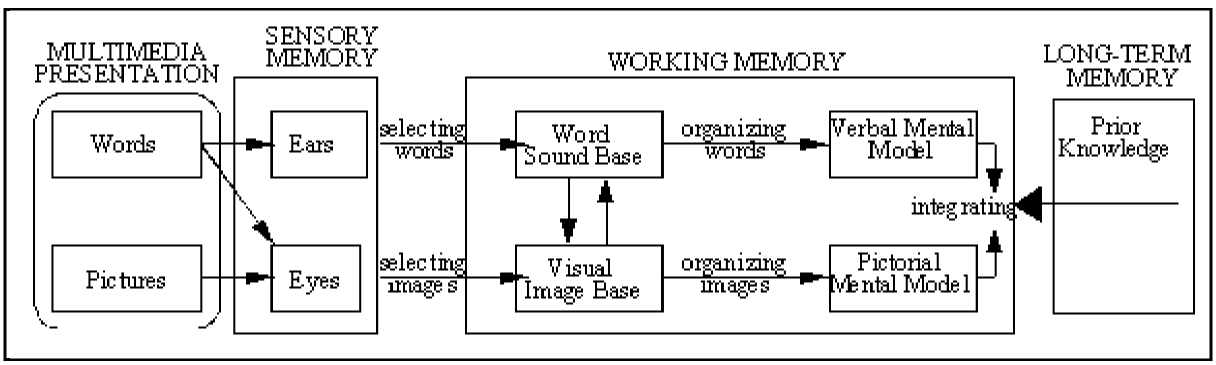


Figure 1: A Framework for the Cognitive Theory of Multimedia Learning

According to Fadel (2008), there is a research base which signifies that the brain has three types of memory – sensory, working and long-term. Sensory memory is the ability to retain impressions of sensory information after the original stimulus has ceased. The two types of sensory memory that have been most explored are iconic memory (visual) and echoic memory (auditory). According to Fadel (2008), sensory memory degrades relatively quickly. It is only when the person pays attention to elements of sensory memory that those experiences get introduced into working memory. Working memory (where thinking is done) is dual coded with a buffer for storage of verbal/text elements, and a second buffer for visual/spatial (Clark & Paivio, 1991). A short-term memory is thought to be limited to approximately four objects that can be simultaneously stored in visual/spatial memory and approximately seven objects that can be simultaneously stored in verbal short-term memory. Within working memory, verbal/text memory and visual/spatial memory work together, without interference, to augment understanding. The long-term memory consists of two types - episodic and semantic. Episodic is sourced directly from sensory input and is involuntary. Semantic memory stores memory traces from working memory, including ideas, thoughts, schema, and processes that result from the thinking accomplished in working memory. Figure 2 illustrates the summary of memory types

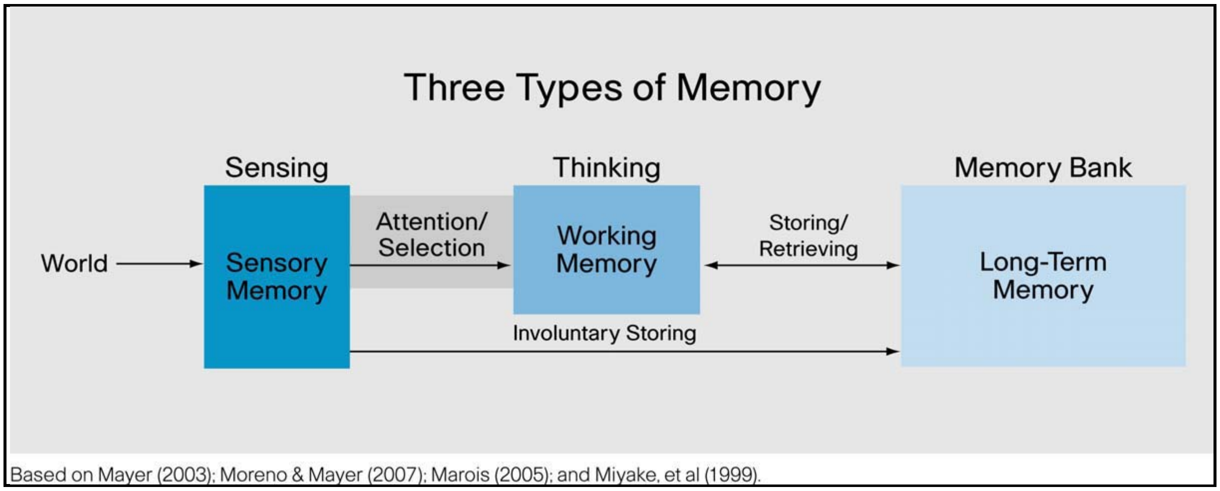


Figure 2: Three Types of Memory

A set of principles related to multimedia learning are listed below. They are based on the work of Moreno & Mayer (2007), and other prominent researchers.

1. **Multimedia Principle:** Retention is improved through words and pictures rather than through words alone.

2. **Spatial Contiguity Principle:** Students learn better when corresponding words and pictures are presented near each other rather than far from each other on the page or screen.

3. **Temporal Contiguity Principle:** Students learn better when corresponding words and pictures are presented simultaneously rather than successively.

4. **Coherence Principle:** Students learn better when extraneous words, pictures, and sounds are excluded rather than included.

5. **Modality Principle:** Students learn better from animation and narration than from animation and on-screen text.

6. **Redundancy Principle:** Students learn better when information is not represented in more than one modality – redundancy interferes with learning.

Fadel (2008) noted that there is still research gap between specificity of the type of multimedia intervention such as specific combinations of modalities, formats within modalities, learner characteristics, scaffolding of learners, learner age, complexity and type of learning goals addressed. In this context of study, we hope to contribute to multimedia learning research base by investigating the elements of verbal-visual learning preferences (sensory memory and working memory) and the formats of multimedia presentation.

Methodology

Sample: Participants in this study were 60 Diploma students, majoring in Business and Business Information Systems at Multimedia University, Malacca campus. 30 students were randomly assigned to the visual presentation mode (text + animation) and 30 students were assigned to the verbal presentation mode (text + audio).

Design: A sample multimedia courseware was designed to explore how verbal and visual learners respond to the multimedia instructions. The courseware consists of sub-chapters of C programming, focusing on conditional statements and repetition structures. Verbal presentations include text, coding and accompanying audio explanations. The visual presentations include text and animation. It is worth noting that multimedia principles such as spatial contiguity principle (words and animations are presented near each other) and temporal contiguity principle (words and pictures are presented simultaneously) were observed in our design.

The total number of students was divided equally and students were randomly assigned to two different computer labs. The first computer lab features the multimedia courseware with verbal presentation mode (text + audio) and the second computer lab features the multimedia courseware with visual presentation mode (text + animation). Students from both groups were first asked to answer the Index of Learning Style Questionnaire. The updated instrument developed by Felder & Soloman (2007) has four dimensions: Processing (Active/Reflective), Perception (Sensing/Intuitive), Input (Visual/Verbal), and Understanding (Sequential/Global). The instrument scales are bipolar, with mutually exclusive answers to items, i.e. either (a) or (b) and the items are scored as +1 and –1. The total score on a scale from –11 to +11 shows an emerging preference for the given modality. For the purpose of our study, only 11 questions from the Visual–Verbal dimension were used.

Students from both groups were given 30 minutes to use the multimedia courseware - the first group used the verbal multimedia presentation mode and the second group used the visual multimedia presentation mode. During this period of time, students were not allowed to interact with each other. The next procedure was to administer a learning test to the students. The learning test consisting of ten questions required students to write down the output based on the C-programming code. Students from both groups were given 15 minutes to complete the test. Similarly, during this period of time, students were not allowed to interact with each other.

Data analysis: Two levels of attribute (verbal learners and visual learners) were created using the median split from the Index of Learning Styles questionnaire's scores. A 2×2 analysis of variance (ANOVA) was conducted with attribute (verbal learners vs. visual learners) and treatment group (verbal multimedia presentation vs. visual multimedia presentation) served as the between subject factors, and learning score as the dependant measure. We conducted a T-Test to measure potential significant difference of learning scores between students of Diploma in Business and Diploma in Business Information Systems. For further exploratory analysis, we conducted a chi-square analysis to determine the significance between academic major (Business and Business Information Systems) and verbal-visual learning preferences.

Results

Table 1 presents the mean learning scores, standard deviations and ANOVA test details for the Attribute Treatment Interaction for verbal learners and visual learners in verbal multimedia presentation mode and visual multimedia presentation mode. For verbal multimedia presentation mode (text + audio), verbal learners achieved a mean score of 42.5 while the visual learners achieved a mean score of 48.75. For visual multimedia presentation mode (text + animation), verbal learners achieved a mean score of 46.6 while the visual learners achieved a mean score of 44.66. The ANOVA analysis showed a result of $F=0.116$ with $p=0.95$ and this failed to indicate any support for significant interactions between attribute and treatment.

VERBAL TREATMENT			
	N	MEAN	STD DEV
VERBAL LEARNERS	14	42.5	31.7
VISUAL LEARNERS	16	48.75	30.9

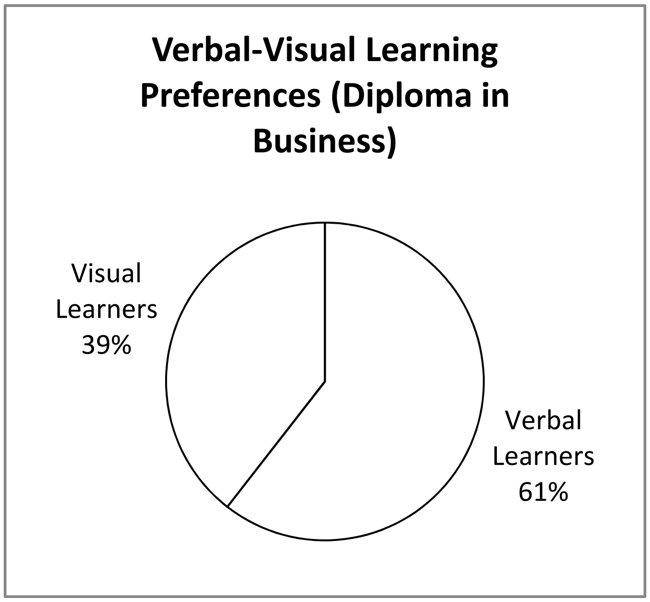
VISUAL TREATMENT			
	N	MEAN	STD DEV
VERBAL LEARNERS	15	46.66	31
VISUAL LEARNERS	15	44.66	27.9

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	322.0833	3	107.3611111	0.116023	0.950353	2.769431
Within Groups	51819.17	56	925.3422619			
Total	52141.25	59				

Table 1: Mean Learning Scores, Standard Deviations and ANOVA Test for the Attribute Treatment Interaction for Verbal Learners and Visual Learners

Figure 3 shows the percentage of verbal-visual learning preferences of Diploma in Business students and Diploma in Business Information Systems students. For Diploma in Business, 61% of the students were categorized as verbal learners while 39% of the students were categorized as visual learners. For Diploma in Business Information Systems, 21% of students were categorized as verbal learners while 79% of the students were categorized as visual learners. A contingency table (Table 2) was used to determine the significance between both groups (Business and Business Information Systems) and verbal-visual learning preferences; and the chi-square analysis showed a result of $p=0.00156$, which indicates that there was a very significant difference between academic majors (Business and Business Information Systems) and verbal-visual learning preferences.

Table 3 presents the mean learning scores, standard deviations and T-Test details between students of Diploma in Business and Diploma in Business Information Systems. The learning score mean for students of Diploma in Business Students and students of Diploma in Business Information Systems were 40.00 and 55.68 respectively. T-Test analysis yielded differences of mean with $p=0.056$.



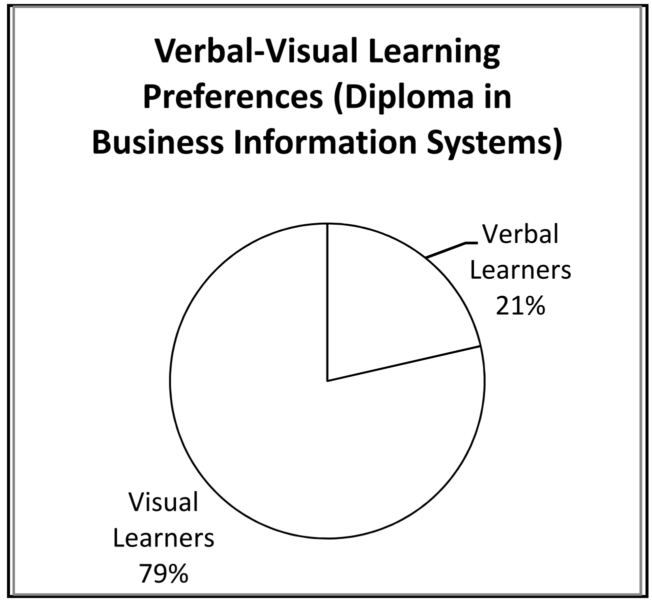


Figure 3: Verbal-Visual Learning Preferences of Students of Diploma in Business and Diploma in Business Information Systems

	DB	DBIS	Total
Verbal Learners	23	6	29
Visual Learners	15	22	37
Total	38	28	66

Table 2: Contingency Table for Performing Chi-Square Analysis

	Diploma in Business	Diploma in Business Information Systems
Mean	40	55.68182
Variance	756.7568	986.4177
Observations	38	22
Hypothesized Mean Difference	0	
df	39	
t Stat	-1.94881	
P(T<=t) one-tail	0.029269	
t Critical one-tail	1.684875	
P(T<=t) two-tail	0.058537	
t Critical two-tail	2.022691	

Table 3: Mean Learning Scores, Standard Deviations and T-Test Details for Students of Diploma in Business and Diploma in Business Information Systems

Discussion

Summary of findings: The Aptitude Treatment Interaction (ATI) hypothesis states that verbal learners should receive verbal methods of instruction and visual learners should receive visual methods of instruction. In order to test for potential ATI, we designed a multimedia courseware with two different multimedia modes – the visual presentation (text + animation) and verbal presentation (text + audio). Two levels of attribute- verbal learners and visual learners were determined from the Index of Learning Styles questionnaire's scores. The ANOVA results in our experiment did not show any significant differences in mean learning scores between verbal-visual learning preferences and multimedia presentation mode. Therefore, our study did not provide support for the ATI hypothesis. This finding is consistent with the works of other similar research that failed to show interactions between learning styles and multimedia learning. One such experiment (Yuli Yeh, Chai-wei Wang, 2003) indicated that perceptual learning styles did not seem to have a significant influence on the effectiveness of multimedia. Mayer & Massa (2006) introduced text vs. static pictorial multimedia elements and measure for any potential ATI with verbal and visual learners. Results from their studies showed no significant ATI. According to Les Howles (2007), researchers have not been able to consistently replicate and validate interaction between learning styles and instructional methods. Howles suggested that the failure is due to other variables within learners and/or instructional environments that are difficult to control.

In our study, we did not find any multimedia effect that showed students learned better from words and pictures than from words alone. According to Mayer (2001), words include written and spoken text, and pictures include static graphic images, animation and video. In this context, our results did not show that students using visual multimedia presentation (text + animation) have higher learning score than students using verbal multimedia presentation (text + audio). A possible justification for this result is that the students using verbal multimedia presentation (text + audio) benefits from dual coding (Paivio, 1986). Both benefits may have offset each other.

The chi square analysis result indicated a very significant difference between academic majors (Business and Business Information Systems) and verbal-visual learning preferences. Our results showed that majority of students of Diploma in Business Information Systems were visual learners (79%). It is worth noting that the course structures in Multimedia University for Diploma Business Information Systems emphasized on computer sciences study with technical and theoretical aspects of hard sciences. Interestingly, this result seemed to consolidate with similar report by Reid (1995) that suggested students from hard sciences tend to favor visual learning. McEwan & S. Reynolds (2007) in their studies showed that visual learners tend to choose to enroll in technological majors as compared to verbal learners. Another study on 854 participants in an academic institution and an Information Technology (IT) company by Md. Tanwir Uddin Haider, Aditya K Sinha, & Banshi Dhar Chaudhary (2010), also showed that the percentage of visual learners is higher than verbal learners in technology-based major or industry.

Our studies showed that the average learning score for students of Diploma in Business Information Systems is higher than students of Diploma in Business. Although not statistically significant ($p=0.056$), this result suggests a relationship between scaffolding effect and learning performance within the multimedia learning environment. It is worth noting that all students participating in this experiment have no prior knowledge and lesson of any programming language. However, in this context, the scaffolding effect is present for students of Business Information Systems who were exposed to basic programming terms such as "*variables*", "*source code*" and "*output*". Fadel (2008) defined scaffolding as "the act of providing learners with assistance or support to perform task beyond their own reach if pursued independently when 'unassisted'". Clay & Cazden (1992) pointed out scaffolding strategies in teaching reading: a teacher suspects the child does not have the ideas or words needed for a particular text, he/she may explain some part of the story or contrast a feature presented with something he/she knows the child understands from another reading. The justification of results is in agreement with research by Roth & Bowen (2001) which suggested learners need to understand graphing specifics to the topic they are learning. Fadel (2008) in his paper noted that scaffolding effect is required to prepare learners to effectively use multimedia. Fadel argued that the scaffolding practice can reduce extraneous diversions so that learners can focus on elements aligned to the topic in multimedia learning.

Further research: Some suggestions to further enhance the knowledge of learning styles and multimedia learning research include: 1) investigating the significance between verbal-visual learning preferences and multimedia learning of students with different education levels and in other fields 2) investigating the significance between verbal-visual learning preferences and different modes of multimedia presentations, and 3) examining additional learners' verbal-visual characteristics such spatial ability with multimedia learning.

Conclusion

This study aims to find potential aptitude treatment interaction between verbal-visual learning preferences and multimedia learning presentation. To achieve this objective, we investigated the relationship between verbal-visual learning preferences and the effectiveness of two types of multimedia presentation: text + audio and text + animation. The findings and results of this study did not provide support for the Aptitude Treatment Interaction hypothesis that states that verbal learners should receive verbal multimedia presentation of instruction and visual learners should receive visual multimedia presentation. These results are generally consistent with previous studies (Yuli Yeh, Chai-wei Wang, 2003; Mayer & Massa, 1999). Results from our study showed no multimedia effect (Mayer, 2001) that indicated students using visual presentation mode learned better than students using verbal presentation mode. A possible justification for this result is that the multimedia effect has been offset by the benefits from dual coding (Paivio, 1986) achieved in verbal presentation mode. Our studies showed that majority of students from computer science discipline (Diploma in Business Information Systems) are categorized as visual learners. The results of this study provide support that there is a significant difference between verbal-visual learning preferences across different academic majors. Furthermore, similar reports (Reid, 1995; McEwan & S. Reynolds, 2007; Md. Tanwir Uddin Haider, Aditya K Sinha, & Banshi Dhar Chaudhary, 2010) indicated that visual learners tend to be in science courses such as engineering, technology and computer science. Based on results, this study also suggests that scaffolding effect has a positive impact on the effectiveness of multimedia learning in higher learning institution. Through scaffolding practice, learners can reduce extraneous diversions and thus focus on elements aligned to the topic in multimedia learning.

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