

The Effect of Graphical Representation on the Learner's Learning Interest and Achievement in Multimedia Learning

Sanghoon Park
Jung Lim
Florida State University

Abstract

The purpose of this paper was to investigate the effects of different types of visual illustrations on learner's learning interest, motivation and achievement, especially in multimedia learning. The participants were drawn from two classes of an "Introduction to Educational Technology" course and randomly assigned to one of the three treatments: one with cognitive interest illustrations which were designed to signal the structure of the explanation and another with emotional interest illustrations which are interesting but irrelevant illustration to understand the structure of text. The last one only contained text information. Result revealed that the post interest was different between learners in cognitive interest illustration group and text-only group, and also different between learners in emotional interest illustration group and text-only group. However, the types of illustration didn't have an effect on learner's achievement in terms of information recall and achievement test. There were also no significant differences between learner's motivations among three illustration groups. The features of the type of illustration that may have contributed to the findings are discussed.

Introduction

The effective use of graphical illustration in designing instructional material has been suggested as an important facet of instructional message design (Anglin, Towers, and Levis, 1996). Using illustration in instructional material is an effective method to support learning because it can be used as interest-getting device and it also helps learner interpret and remember the context of illustrated text. Since Spaulding (1955) reviewed sixteen research studies on the topic of using illustration in instruction conducted between 1930 and 1953, many researchers have studied the effects of illustration on knowledge acquisition in instructional setting (Samuels, 1970; Holiday, 1973; Concannon, 1975; Schallert, 1980; Levi & Lentz, 1982; Brody, 1984; Mayer, 1989; Levin & Mayer, 1993; Mayer, Steinhoff, Bower, & Mars, 1995; Harp & Mayer, 1997). After reviewing those studies, Anglin, Towers and Levis (1996) summarized that visual illustrations can facilitate the acquisition of knowledge when they are presented with text material concurrently.

However, it has been pointed out that the results of illustration related researches can not be integrated across all studies because of the lack of connections in terms of function of the illustration in the instructional treatment (Anglin, Towers, and Levis, 1996). It means that each illustration related study was focusing on the one function of illustration that might be different from the function of other illustration related research. In order to avoid the generalization of the results of illustration related researches, the functional framework has been suggested. The functional framework provides assistance in classifying visual illustrations into meaningful functional categories. Using this framework, the research results can be combined and generalized differently depending on the function of illustration. Therefore it is critical to determine the specific function of illustration before conducting actual research on the effect of visual illustration.

Regarding the function of illustration, Levie and Lantz (1982) suggested a functional framework that includes classifying illustrations in text based on how they impact a learner. According to them, framework contains four major functions which are attentional, affective, cognitive, and compensatory (Levie & Lentz, 1982). The attentional function attracts or directs attention to the material. The affective function enhances enjoyment or affects emotion and attitude. The cognitive function serves to facilitate learning text content through improving comprehension, increasing retention, or providing additional information. The last function, the compensatory function, is used to accommodate poor readers. Among those four functions, the previous researches usually were focusing on only the cognitive function of illustration. It has not been answered clearly what effect the visual illustration have on learner's emotion and attitude and how the illustration need to be designed to improve affective function of illustration.

In terms of affective function of illustration, Kintch (1980) insisted that the visual illustration has an effect on the learner's affective status in two different ways depending on the features of illustration. According

to his cognitive interest and emotional interest theory, visual illustration improves learner's cognitive interest and it promotes learner's emotional interest as well depending on the characteristic of it. The cognitive interest influences learner's cognition by promoting the reader's structural understanding of the explanation. On the other hand, emotional interest is explained by the addition of interesting but irrelevant material to a textbook lesson. It energizes learner's arousal so that they pay more attention and learn more overall. Therefore, cognitive interest illustration is defined as the illustration that signals the structure of the explanation. The emotional interest illustration is defined as the illustration which refers to interesting but irrelevant illustration to understand the structure of text. However, it plays an important role from the motivational aspect, because it increases emotional arousal and further influences the learner's cognitive process.

In a same vein, Levie and Lentz (1982) reviewed previous researches comparing three separate research area concerning the role of illustration in learning. The first research area was concerning learning illustrated text information, the second was about learning nonillustrated text information, and the last was about learning using a combination of illustrated and nonillustrated text information. According to the cognitive interest theory, the illustrated text information is similar with the cognitive interest illustration. Also, the nonillustrated text information is comparable to the emotional interest illustration. They concluded that learning would be facilitated when the information in the written text is depicted in the illustrations and learning of text material would not be helped nor necessarily hindered with illustrations that are not related to the text. However, they didn't consider the affective function of illustration separately.

Harp and Mayer (1997) examined the effects of emotional interest adjunct and cognitive interest adjunct on information retention, learning transfer, and learning interest. They reported that learners in the base text group recalled the most, whereas learners who read passages containing the base text along with emotional interest text and illustrations recalled the least. This result was consistent with the prediction of cognitive interest theory and inconsistent with the prediction of emotional interest theory. However, the learners' achievement was measured based on the procedural information of scientific phenomenon, not based on the factual information. In addition, the instructional material was paper based material and the participants were not allowed to read the passage more than once.

Therefore, two important issues can be raised. The first issue is that it is doubtful if the instructional material is delivered through multimedia presentation. In the multimedia learning, courseware screens are consisted of text, graphic such as still illustration and/or animation, and video clip. The learners can navigate each screen through the navigation buttons. Thus learner can go back to previous contents text or go to next contents text. They are also allowed to read the text more than once. In other word, the learner has control over the process of learning in multimedia material setting rather than paper based material setting. The second issue is that the achievement result can be different depending on instructional material contents. If it contains factual information as well as procedural information, the learners in emotional interest illustration group may recall more concepts than that of the cognitive interest illustration group, because the learner in the cognitive interest illustration group will not be able to get any benefits from studying the instructional material containing the illustration representing the procedural information.

In order to answer those two questions, this study was designed with learner controlled multimedia material containing factual information as well as procedural information. Therefore the purpose of this paper was to investigate the effects of different types of visual illustrations on learner's learning interest, motivation and achievement.

One independent variable, "Visual illustration type" containing three types, was implemented for the research. Two different types of illustration were applied into designing instructional material from the perspective of cognitive interest and emotional interest. The first type was cognitive interest illustration and text. The second type was emotional interest illustration and text. The third type was text -only material without any illustrations, which was the control group. The experimental group and control group were formed as follows. (1) Group 1 contained text information and cognitive interest illustration, (2) Group 2 contained text information and emotional interest illustration, (3) Group 3 contained only text information.

Four dependent variables were examined. The first dependent variable was "Learning interest." The learning interest was measured by one question, which adopted from the research by Harp and Mayor (1997). The second variable, motivation was measured by IMMS (Instructional Material Motivational Survey) developed based on Keller's ARCS model. IMMS contains question items to measure the motivation status from four different aspects such as attention, relevance, confidence, and satisfaction. The third dependent variable was "Learner's concept recall" targeted to measure the number of factual information recalled in limited time. The last variable was "Learner's achievement" developed to measure the procedural information using achievement test on the topic of the instructional material contents.

Since the learner's prior topic interest and prior knowledge were assumed as important covariates that could affect on learning interest and learner's achievement, those prior topic interest and prior knowledge were also measured before conducting research and considered as two covariates in data analysis stage.

Given the characteristics derived from the definition of cognitive interest and emotional interest, the learners in the emotional interest illustration group were predicted to show higher learning interest and motivation than those of the learners in the cognitive interest group and text-only group because of the affective function of illustration. The first hypothesis is justified because, according to the definition, emotional interest is derived from the interesting illustration that boosts learner's arousal level. Therefore the learner pays more attention on the instructional material and is motivated overall as well. In addition, the learner in the cognitive interest illustration group no longer get benefits from using cognitive interest illustration, because the learners in all three groups have control over the learning material. In other words, learners can study the instructional material more than once as the instructional material allows learners to navigate the screens using buttons.

The learners in the emotional interest illustration group were also expected to show higher score in both of the recall test and achievement test, because of the same reason. The learner will pay more attention to the instructional material than the two other groups so that the learners would be able to recall more concepts and achieve higher score than those of the two other groups.

Method

Participants

The participants in the study were 36 college level students who were attending a four-year university in southeastern area in United States. The study took place during the "Introduction to Educational Technology" course which designed to teach how to apply the technology into learning and teaching. Hyperstudio, one of the multimedia authoring tools, was used in this experiment because it was the required software learners need to study in the class. Four of the learners were male and thirty two of the learners were female. All of the learners were sophomore and junior level learners who were willing to apply to the college of education. The participants were drawn from two classes of "Introduction to Educational Technology" and randomly assigned to one of the three treatments. Total number of participants was thirty six excluding four learners who decided not to attend in this research.

Materials

The multimedia instructional material was developed using Hyperstudio to teach the "Life cycle of hurricane." The material consisted of 10 screens containing 6 different concepts covering (1) Unit overview, (2) Origin of Hurricane, (3) Life Cycle of hurricane development, (4) Eye and Eyewall, (5) Hurricane rotation, and (6) Hurricane's demise. Even though the material was designed using multimedia authoring tool 'Hyperstudio', only graphic and text information were applied in order to prevent learner from learning contents with other variables such as sound or animation. The applied illustrations were all colored graphics describing the hurricane development process. The three types of instructional material were developed separately according to the differences among three independent variable types.

Independent variables

The independent variable used for this study included the type of visual illustration used to deliver learners the concept of the life cycle of hurricane. The first level of the independent variable was cognitive interest illustration. The second level of the independent variable was emotional interest illustration. The third level of the independent variable was text-only information without illustration.

The instructional material containing cognitive interest illustration consisted of a screen-based presentation on the topic of the life cycle of hurricane. The design of the cognitive interest illustration was centered on the Kintch (1980)'s cognitive interest theory, According to Kintch, the cognitive interest influences learner's cognition by promoting the reader's structural understanding of the text explanation. Therefore the cognitive interest illustrations need to be designed to signal the structure of the explanation. For example, Harp and Mayer (1997) used an illustrations with explanative summary designed to promote cognitive interest on lightning process. In present research, cognitive interest illustrations were designed to improve the understanding of the four development stage of Hurricane, the required ingredients for a hurricane, and the location of eye and eyewall as shown in [Appendix A]. The illustrations were positioned right after text information. Therefore the participants were able to read the text first and look at the illustration next. Total number of the cognitive interest illustration was six; each illustration was placed on the screen #3, #4, #5, #6,

#7, and #8 with corresponding text.

The instructional material including emotional interest illustration was also consisted of the screens on the topic of the life cycle of hurricane. The design of the emotional interest illustration was based on emotional interest theory insisted by Kintch (1980). According to the theory, the emotional interest energizes learner's arousal so that they pay more attention on the instructional material. Therefore the emotional interest illustrations are interesting but irrelevant illustration to understand the structure of text. Harp and Mayer (1997) used emotional interest illustrations to compare the effect of it with the cognitive interest illustration. In present research, emotional interest illustrations were designed to improve the learner's arousal of the four development stage of Hurricane, the required ingredients for a hurricane, and the location of eye and eyewall as shown in [Appendix B]. As the case of cognitive interest, emotional interest illustrations were positioned right after text information. The position and the number of emotional interest illustrations were same as those of cognitive interest illustrations.

The instructional material containing only text information consisted of a screen-based presentation on the same topic as cognitive/emotional interest illustration material. However, it didn't include any illustrations. Learners had a full control over the navigation using buttons throughout the instructional material.

Dependent variables

Four dependent variables for the study included a learner's post-interest, motivation, the number of recalled concepts, and achievement.

One post-interest question item was used to measure learners' post interest level. This post-interest item was used in previous research designed to see how much the learners feel interest on the contents (Harp & Mayor, 1997). Participants were asked to respond their interest level about instructional material by selecting one of five choices ranging from "Not at all true" through "Very true".

Learner's motivation was measured using IMMS developed by Keller. The survey included 36 items intended to be a situational measure of learners' motivational reactions to instructional material. The response scale ranges from 1 to 5 with 12 Attention related questions, 9 Relevance related questions, 9 Confidence related questions, and 6 Satisfaction related questions. The reliability based on Cronbach's alpha for each subscale and the total scale was Attention: .89, Relevance: .81, Confidence: .90, Satisfaction: .92, and Total: .96.

The recall test was designed to assess the learner's ability to remember hurricane related terms. The recall sheet had the following instruction typed at the top of the page: "Please write down everything you can remember from the passage." Participants were allowed to write down as many as concepts they can recall from the instructional material in 5 minutes limitation.

The achievement was measured using post achievement test. The achievement test was designed to assess the learner's ability to solve the given problems using what they have learnt from the instructional material. Total number of item was ten including five short answer items and five multiple choice items. Items were designed to ask following topics; (a) Four development process of hurricane, (b) Meteorological factors necessary for forming hurricane, (c) Identification of hurricane from real weather pictures, and (d) The structure of hurricane.

Procedures

The instructional material was presented in a computer laboratory with 24 individual personal computers. Participants were drawn from two sections of introduction to educational technology course and randomly assigned to one of three treatments groups: the cognitive interest illustration group, and the emotional interest illustration group, and the text-only group. Participants were asked to fill out the prior knowledge and pre interest survey before processing instructional material. Then they were informed that they would be studying multimedia instructional material on the life cycle of hurricane and that, after they finished reading, they would be asked a series of questions about what they have read. They were instructed to read the material carefully in their normal reading rates. Instructor was present at all times to ensure that they were studying only the multimedia material. Each participant was given the material corresponding to his/her treatment group and told to start studying. They were not allowed to take notes or refer to other resource. As each participant finished studying after 10minutes, the experimenter handed the post interest survey inventory to fill out at his or her own rate. After completing the post interest inventory, participants were given the recall test. The experimenter collected the recall sheet after six minutes had passed. Next, participants were given achievement test sheets and allowed 10 minute to work on test. After final sheet had been collected, the participants were given IMMS to measure motivational level. After this, the participants were thanked for their participation.

The scoring procedure for the recall test and achievement test were administrated as follows. Recall test was scored based on prepared criteria. Since only differences among three treatments was the type of illustration on 6 slides out of 10 slides, the information recalled from only those 6 slides were considered in scoring procedure. When learner described all of development stages (1st stage through final 4th stage) of hurricane on recall sheet, each stage was considered as 1 point. The score for necessary five ingredients for hurricane also scored 1 point each. Lastly, description regarding eye and eyewall was computed 1 point each. Therefore total score ranged from 0 through 11.

Achievement test was graded based on pre determined answer sheet. Total number of questions was 10, but each question had different weight depending on the difficulty of question. Since there are correct answers for all of questions, answer sheet was prepared based on the information from hurricane learning material. Total score ranged from 0 through 19.

Results

Table 1. Means (Adjusted means) and standard deviations of dependent variables across groups.

DVs	Maximum Score	Treatment groups					
		Cognitive interest Illustration (n=12)		Emotional interest illustration (n=12)		Text-only (n=12)	
		M (Adj. M)	SD	M (Adj. M)	SD	M (Adj. M)	SD
Post interest*	5	3.75 (3.87)	.96	3.83 (3.87)	.83	3.33 (3.05)	1.15
Motivation							
Attention	60	40.83	8.56	44.58	7.25	37.58	10.59
Relevance	45	27.92	5.43	30.42	5.68	25.25	6.98
Confidence	45	37.00	4.84	37.17	5.22	34.75	6.74
Satisfaction	30	19.08	5.20	19.25	4.58	15.92	5.43
Total	180	124.83	21.44	131.42	19.29	113.50	25.07
Recall score	11	5.67 (5.64)	1.15	4.75 (4.71)	1.05	4.83 (4.90)	1.59
Achievement score	19	12.67 (12.78)	2.77	11.83 (12.00)	3.16	13.17 (12.88)	1.90

* p < .05

Table 2. The analysis of covariance summary

Source	Sum of Squares	df	Mean Square	F Value
Preinterest	18.565	1	18.565	42.381*
GROUP	4.340	2	2.170	4.954*
Error	14.018	32	.438	

*p<.05

Post interest

Post interest score was collected using one interest survey question item. An analysis of covariance (ANCOVA) was conducted to determine whether the post interest scores for the three groups differed after adjustments were made for pre interest differences. Pre interest was served as a covariate. Table 1 presents the mean as well as the adjusted mean, and standard deviation for post interest scores across all three treatment conditions. With alpha set at .05, and a sample size of 36 (12 per cell), it was determined that the power for determining moderate effects was .54. A review of scatterplot for post interest scores revealed no serious violation of the normality assumptions required for linear regression analysis. Testing for the assumption of homogeneity of variance, a Levene's test revealed appropriate homogeneity of the post interest scores, $F(2,33) = 1.63$, $p=.211$. The assumption of equal regression slopes was tested and found tenable, $F(2,30)=2.09$, $p>.05$.

The ANCOVA indicated at least one pair of means was significantly different, $F(2,32)=4.95$, $p<.05$. A post hoc analysis using a bonferroni multiple comparison, with alpha at .05, showed that the post interest score for the cognitive interest illustration group ($M=3.87$) was significantly higher than the post interest score for the

text-only group ($M=3.05$). Also the the post interest score for the emotional interest illustration group ($M=3.87$) was significantly higher than the post interest score for the text-only group ($M=3.05$). However, there was no score difference between cognitive interest illustration group ($M=3.87$) and emotional interest illustration group ($M=3.87$). Table 2 presents the analysis of covariance summary.

Motivation

Motivation data was collected using IMMS developed by Keller (1993). An analysis of variance was conducted on the participant's ratings of motivation level in terms of attention, relevance, confidence, and satisfaction. Table 1 presents the mean and standard deviation for motivation scores across all three treatment conditions. With alpha set at .05, and a sample size of 36 (12 per cell), it was determined that the power for determining moderate effects was .54. A review of scatterplot for post interest scores revealed no serious violation of the normality assumption. Testing for the assumption of homogeneity of variance, a Levene's test revealed appropriate homogeneity of the post interest scores, Attention, $F(2,33) = .439$, $p=.648$; Relevance, $F(2,33)=.181$, $p=.836$; Confidence, $F(2,33)=2.217$, $p=.125$; Satisfaction, $F(2,23)=.151$, $p=.861$; Total, $F(2,33)=.287$, $p=.752$).

The results of the ANOVA revealed that none of the mean score difference was significant. The each sub scale of motivation score did not differ across the type of illustration group. Sub scale means (with standard deviations in parentheses) for group 1 through group3 were, 40.83 (8.56), 44.58 (7.25), 37.58 (10.59) for attention, 27.92(5.43), 30.42(5.68), 25.25(6.98) for relevance, 37.00(4.84), 37.17(5.22), 34.75(6.74) for confidence, and 19.08(5.20), 19.25(4.58), 15.92(5.43) for satisfaction, respectively.

Recall test

Recall test data was collected by grading the number of hurricane related terms the learner wrote down in limited time. An analysis of covariance (ANCOVA) was conducted to determine whether the recall test scores for the three groups differed after adjustments were made for prior knowledge differences. Prior knowledge was served as a covariate. Table 1 presents the mean as well as the adjusted mean, and standard deviation for recall test score across all three treatment conditions. With alpha set at .05, and a sample size of 36 (12 per cell), it was determined that the power for determining moderate effects was .54. A review of scatterplot for post interest scores revealed no serious violation of the normality assumptions required for linear regression analysis. Testing for the assumption of homogeneity of variance, a Levene's test revealed appropriate homogeneity of the recall test scores, $F(2,33) = .899$, $p=.417$. The assumption of equal regression slopes was tested and found tenable, $F(2,30)=.622$, $p>.05$. The recall test score did not differ across the type of illustration groups, $F(2,32)=1.724$, $p>.05$. According to the second hypothesis, emotion interest group was expected to show higher recall score than those of cognitive interest group and text-only group. However, the result revealed that there were no significant differences among different types of illustration groups.

Achievement test

Achievement test data was collected by grading the number of correct answer for the achievement test. An analysis of covariance (ANCOVA) was conducted to determine whether the achievement test scores for the three groups differed after adjustments were made for prior knowledge differences. Prior knowledge was served as a covariate. Table 1 presents the mean as well as the adjusted mean, and standard deviation for recall test score across all three treatment conditions. With alpha set at .05, and a sample size of 36 (12 per cell), it was determined that the power for determining moderate effects was .54. A review of scatterplot for post interest scores revealed no serious violation of the normality assumptions required for linear regression analysis. Testing for the assumption of homogeneity of variance, a Levene's test revealed appropriate homogeneity of the recall test scores, $F(2,33) = 1.152$, $p=.328$. The assumption of equal regression slopes was tested and found tenable, $F(2,30)=.330$, $p>.05$. The achievement test score did not differ across the type of illustration groups, $F(2,32)=.394$, $p>.05$. It was also predicted that the score of the emotional illustration group will be higher than those of cognitive illustration group and text only group. However, the result showed that there were no significant differences among different types of illustration groups.

Discussion

Supporting the primary hypothesis of the study, the mean score of post interest of learners in the emotional interest illustration group was significantly higher than the text-only group. In addition, the mean score of post interest of learners in the cognitive interest illustration group was significantly higher than the text-only group. This result indicates that learners who were given illustrations feel much interest than the

learners who were given only-text information. However, there was no significant difference between the mean score of cognitive interest illustration group and the mean score of emotional interest illustration group. This finding affirms that when learner is given either cognitive interest illustration or emotional interest illustration, he/she is aroused and feels positive emotion, interest, in the instructional material. This result is consistent with the findings of Harp and Mayer (1997). They pointed out that the failure to find differences in students' ratings of interestingness raises the possibility that the distinction between emotional interest and cognitive interest based on learner's evaluation of how the material was entertaining

The hypothesis predicting a motivational effect for the type of illustration was not supported by data. As shown in Table 1, there was mean differences among three groups, but those differences were not significant. The possible explanation for the type of illustration failing to predict motivation involves the effect of multimedia program. All learners receive the same instruction using same multimedia program. This program was the topic of the "Educational technology" class on experiment day. Therefore it is possible that they are all motivated to the instructional material regardless of the type of illustration, because the material was developed by a new program which learners are motivated.

The failure of type of illustration to affect recall and achievement test can also be explained in the same grounds. Unlike the findings of Harp and Mayer (1997), learners are allowed to navigate the instructional screens with free in this multimedia instructional material. Therefore they could go back to the information screen to confirm that they understand the information correctly and illustration did not play a strong role to emphasize the information.

There were several limitations to the findings of this study. First, learner's individual characteristic regarding the preference to the illustration was not considered. Because learner did not have a control over the illustration type, he/she had to have illustrations along with the text information. Second, the effect of multimedia authoring program was not considered. Since the program was totally new to participants in this research, all participants could be motivated on the same level no matter what illustrations they were given.

Additional research is needed to fill the gaps in our understanding of the interaction between learner's characteristic and the type of illustration in multimedia setting. Future research should also attempt to determine different functions of illustration in terms of cognitive function as well as affective function. Hence it will be possible to compare the different research results on the same topic based on the function of illustration.

The implication of this study involves the importance of visual illustration on learner's affect in multimedia learning, even though this study didn't prove that positive effect of visual illustration on learner's achievement. However, it is clear that using illustration in multimedia instructional material increases the learning interest of learner. Learner' interest is very complex psychological construct (Krapp, Hidi & Renninger, 1992). Instructional designer or educator need to consider the potential benefits of using different types of illustration when they develop multimedia based instructional material.

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