

Comparing Two Forms of Spatial Contiguity Principle in Student Learning: 'Text Linked to Image' versus 'Text in Image Adjacency'

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ABSTRACT

Background: Using links to provide additional audio or video content can enhance learners' engagement with the learning content and keep them active in the learning process. This study aimed to compare the impacts of two different forms of multimedia presentation, namely 'text in image adjacency' and 'text linked to image', on learning and retention in a course entitled the Sciences.

Methods: This was a randomized trial research. Multi-stage cluster sampling was used to select 31 fourth grade elementary school students in Malayer (Iran) in the 2014-2015 academic year. They were randomly assigned to control (N=15) and intervention (N=16) groups. Three researcher-made achievement tests (pre-test, post-test, retention test) were used to collect data. The expert opinions of seven teachers were consulted to assess the validity of the questions and the CVR of their opinions was found to be 98%. The reliability was determined using Cronbach's alpha as well as the raters' opinions, and the coefficients stood at 73%, 85%, and 60%, respectively. Also, Multimedia software was used to prepare the content of chapter 12 (Circulatory System) for the experiment. It was presented to the students in two forms: text linked to image (hidden hyperlink) and text in image adjacency. The control group was provided with text in image adjacency and the intervention group with text linked to image (hidden hyperlink). Data were analyzed using Kolmogorov-Smirnov, repeated measures ANOVA, F, and ANCOVA tests in SPSS 19 software.

Results: The research findings showed that in the group in which multimedia content was presented with text linked to image, learning scores significantly increased from (5.28±3.74) in the pre-test to (11.36±3.98) in the post-test and (12.40±4.44) in the retention test (P=0.001). Also, in the control group receiving multimedia content in the form of text in image adjacency, learning values also significantly increased from (3.70±3.64) in the pre-test to (10.46±4.77) in the post-test and (12.60±3.62) in the retention test (P=0.001). However, there was no difference between the intervention and control groups in terms of learning gains ($F_{(1,27)}=0.014$, P=0.906). Similarly, no significant difference was found between the two groups in terms of learning retention ($F_{(1,24)}=0.292$, P=0.594).

Conclusion: The present study demonstrated that a new form of spatial contiguity (i.e., text linked to image via hyperlinks) is as effective in learning as presenting textual content in image adjacency. This is a new finding contributing to the development of spatial contiguity principle.

Keywords: Spatial contiguity, Multimedia content, Text in image adjacency, Text linked to image, Learning retention

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Introduction

Multimedia is at the core of e-learning, which is developed from a combination of visual and audio technologies such as text, audio, images, animations, and various simulations. The goal of multimedia content is to capitalize on the capacities of the learner's cognitive processing system and to help with facilitating the learning process. Using multimedia content by creating a processing model and helping to integrate the learner's prior knowledge with new content can result in meaningful learning (1). In addition, multimedia content facilitates the learning process by employing the senses, providing more practice opportunities to achieve mastery levels, facilitating learners' participation, and creating interaction between the user and the subject of education (2).

Clark and Mayer (3) presented the principles of designing and producing multimedia content in the cognitive theory of multimedia learning based on the three assumptions of dual channels, limited capacity and active processing. Given these assumptions, the stimuli and messages received through active memory are processed via both audio and visual channels, and the individual's cognitive processing system cannot receive and process two or more visual messages such as text and images or two or more audio messages at the same time. The second assumption is that capacity (-2 +7) and the permanence of information (30 seconds) in active memory is limited, and the information entered, if not repeated or reviewed mentally, can be quickly forgotten and lost (4); and the third assumption highlights the learner's active role in encoding and expanding the meaning of messages. Accordingly, the application of the principle of multimedia, spatial contiguity, temporal contiguity, quality of presentation, redundancy avoidance principle, coherence principle, and the personalization principle allow designers, multimedia producers, and teachers to capitalize on the present potentialities and tools in accordance with the capacities and limitations of the cognitive processing system, and contribute

to improving the quality of learning (5, 6).

The contiguity principle is one of the multimedia principles considered as important by Clark and Meyer (3), according to whom, when textual or oral words and images are placed near each other on the screen, learners can create mental relationships between words and related images more easily. However, when text and image are placed away from each other spatially and temporally, the learner's limited cognitive capacity is occupied and thus this creates cognitive overloading (3).

Given the enormous impact of multimedia on improving learning and its widespread application in educational settings on the one hand, and the allocation of huge budgets by the large community of multimedia designers and developers on the other hand, it is essential that more research be carried out on the principles of multimedia content development. The spatial contiguity principle is one of such principles that refers to the coordination of words and images in a place and is in accordance with how people learn. Nonetheless, due to a number of issues such as its violation in e-learning environments, the need to observe the economics of web pages, engaging learners, and taking different learning styles into account, it is necessary to conduct research studies in this regard. Therefore, the purpose of this study was to compare the impact of two forms of multimedia presentation, 'text linked to image' and 'text in image adjacency' (spatial contiguity principle) on the level of learning and learning retention of fourth graders in elementary school. Researchers suggest placing images next to text or linking text to images by hiding them can improve students learning and their understanding (5, 6). The use of images and textual explanations in the multimedia production for science teaching can help to gain a deeper understanding of the concept.

In order to achieve the research objective, the Experimental Sciences subject was considered as the platform for the implementation of this research since it

involved concepts for which images could be created easily. In particular, the present study sought to determine students' level of learning and learning retention in the Experimental Sciences course via the presentation of the multimedia content using text in image adjacency (the spatial contiguity principle).

Methods

The method employed in the research was randomized trial with pre-test, post-test, and delayed post-test, which were applied on control and intervention groups. The intervention group was taught through "text linked to image" and the control group through content based on contiguity principle. The statistical population of the study included all fourth grade elementary school girls in Malayer in 2014-2015 academic year. More specifically, using the multi-stage cluster sampling method, one school was selected from among the 35 elementary schools for girls in district 1, Malayer. Then, out of six fourth grade classes of that school, one class with 31 students was randomly selected. Next, the selected students were randomly assigned to the intervention (N=16) and control (N=15) groups after observing several necessary criteria such as the academic achievement score in the Experimental Sciences course in the previous semester and the total grade point average (GPA) of the last academic year. Given that the prerequisite for learning new content, regardless of the type of learning method, is learning the information provided previously, an attempt was made to ensure that these prerequisites were met through examining the students' first semester scores in Experimental Sciences as well as their GPA of the previous year, which showed the extent to which they had learned the previous content. The students were randomly assigned to different groups in the following fashion. Students' names were written on separate pieces of paper and then were randomly drawn for each of the groups. They were also randomly assigned to each of the two groups. It should be noted that in order to comply with the ethical standards, the objectives

of the research were communicated to the individuals in both groups and their consent to participate in the research was obtained. They were also assured that their information would be kept confidential. Data collection tools were comprised of a researcher-made achievement test administered in three stages: pre-test, post-test, and delayed post-test (two months after the end of the instruction to measure learning retention). The academic achievement test was developed based on Bloom's classification as well as the content of the "Circulatory System" chapter, and the questions were randomly distributed among pre-test, post-test, and learning retention test. Pre-test, post-test, and retention test questions were prepared as per Bloom's six levels with equal difficulty. Accordingly, ten questions were included in the pre-test, ten questions in the post-test, and ten questions in the retention test. The scores on each test ranged between 0 and 20 in that two points were considered for each question without a negative score. The tests consisted of four-choice questions.

To determine the validity of the tests, the expert opinions of seven experienced elementary school teachers with at least five years of teaching experience were used, and the validity of the tests was confirmed after the necessary revisions. It is noteworthy that the CVR of teachers' opinions of the validity of the questions stood at 98%. The reliability of the multiple-choice questions was determined through Cronbach's alpha. The reliability coefficient of the pre-test, post-test, and learning retention test was found to be 73%, 85%, and 60%, respectively. As regards data analysis, the Kolmogorov-Smirnov, repeated measures ANOVA, F, and ANCOVA were employed to analyze the data.

Procedure

Following obtaining permission from the Education Organization of Malayer, the necessary coordination was made with two fourth grade elementary school teachers for two days so that the instruction of chapter 12 of the book (Circulatory System) could be done through multimedia software. After

performing the required processes such as matching the students and dividing them into two groups, the pre-test was administered to both groups. In order to start the instruction, the content of chapter 12 (Circulatory System) was prepared using multimedia software in two forms: text linked to image (hidden hyperlink) and text in image adjacency. The control group was provided with text in image adjacency and the experimental group with text linked to image (hidden hyperlink). In doing so, 15 important points of the chapter were identified and their multimedia files were prepared in the two formats and finally presented to the experimental and control groups. Both groups received a total of 90 minutes of instruction in eight sessions. After completing the teaching course, a post-test (academic achievement test) was administered to the students in both groups. Finally, in order to investigate the effect of the two forms of multimedia presentation on student learning retention, the learning retention test was given to the groups after two months.

Results

In this research 31 fourth grade primary school girls were assigned to control and experimental groups. Before hypothesis testing, the Kolmogorov-Smirnov test was employed to ensure that the variables were normal in a statistical distribution (Table 1).

According to Table 1, the significance level

of the obtained Z values in the distribution of achievement scores across groups and tests was more than 0.05 ($P > 0.05$). This indicates that the dependent variables of the study have a normal distribution and it is possible to use parametric tests to check the objectives. Therefore, due to the normality of data distribution and also to determine the level of students' learning and learning retention using the mode of presenting multimedia content through text in image adjacency (the principle of spatial contiguity) in the Experimental Sciences course, the repeated measures ANOVA test was used (Table 2). In order to run repeated measures ANOVA, a spherical Machely test was first employed. Based on the results of this test, the significance level of spherical statistic is higher than 0.05. Therefore, the assumption of equality of variances was confirmed and the F test was used to examine the significance of the differences between the means.

According to Table 2, in the group in which presentation of multimedia content with text linked to image was implemented, the mean score on the achievement test has increased from 5.28 in the pre-test to 11.36 in the post-test and 12.48 in the delayed post-test. Also, the results of repeated measures ANOVA show that the significance level of the obtained F value is less than 0.05 ($P = 0.001$, $F_{(2,24)} = 23.397$). Consequently, the difference between the mean scores is significant. In fact, it can be concluded that presentation

Table 1: Kolmogorov-Smirnov Test to Check Normality of Data

Group	Test	Most Extreme Differences			Z	Sig	Normality
		Positive	Negative	Absolute			
Text Linked to Image	Pre-test	0.174	-0.104	0.174	0.695	0.719	Normal
	Post-test	0.140	-0.102	0.140	0.558	0.914	Normal
	Delayed Post-test	0.107	-0.142	0.142	0.511	0.956	Normal
Text in Image Adjacency	Pre-test	0.280	-0.155	0.280	1.084	0.191	Normal
	Post-test	0.139	-0.102	0.139	0.950	0.950	Normal
	Delayed Post-test	0.166	-0.101	0.166	0.804	0.804	Normal

Table 2: Results of Repeated Measures ANOVA for Text Linked to Image

Pre-test	Post-test	Delayed Post-test	F	df	Sig.	η^2
Mean±SD	Mean±SD	Mean±SD				
5.28±3.74	11.36±3.98	12.40±4.44	23.397	2,24	0.001	0.661

of the multimedia content with text linked to image has a significant positive effect on learning gains in the Experimental Sciences course, with the effect size being 66%.

Further, in order to determine the extent of students' learning and learning retention using text linked to image (with the help of hyperlinks) as a form of multimedia content presentation in the Experimental Sciences course, repeated measures ANOVA was employed once again (Table 3).

According to Table 3, in the group in which presentation of multimedia content with text in image adjacency was used, the mean of achievement scores improved from 3.70 in the pre-test to 10.46 in the post-test and 12.60 in the delayed post-test. In addition, the results of repeated measures ANOVA show that the significance level of the obtained F value is less than 0.05 ($P=0.001$, $F_{(2,24)}=57.616$), hence the difference in the mean scores is statistically significant and the effect size is as high as 82%.

To compare the effect of the form of presentation of the multimedia content with text linked to image and the form of presentation of multimedia content with text in image adjacency in learning the Sciences course, ANCOVA was deployed. Prior to this analysis, however, its assumptions were examined. There was a linear relationship between the pre-test and post-test scores in each group and the homogeneity of the slope of the regression lines in the achievement scores of the groups was observed. Then, ANCOVA was run, the results of which are presented in Table 4.

The results of ANCOVA in Table 4 show that the value of F obtained for the difference between the mean scores between the two groups is 0.014 and the significance level of this value with degrees of freedom of 1 and 27 is higher than 0.05 ($P=0.906$, $F_{(1,27)}=0.014$). Therefore, the difference between the mean scores is not statistically significant, and it can be argued that there is no significant difference between the form of presentation of multimedia via "text linked to image" and "text in image adjacency" in learning the Experimental Sciences course of the fourth grade in elementary school.

Moreover, to compare the effect of the form of presentation of the multimedia content with text linked to image (with the help of hyperlinks), with the presentation of multimedia content with text in image adjacency (spatial contiguity principle), in the learning retention of the Experimental Sciences course, ANCOVA was used to control for the post-test scores (Table 5).

Table 5 indicates that the moderated mean of achievement scores of the group in which the form of the presentation of the multimedia content with text linked to image (with the help of hyperlinks) was used is 12.18, which is lower than that of the control group (12.85). The results of ANCOVA are presented in Table 6.

The results of ANCOVA in Table 6 demonstrate that the F value obtained for the difference in the mean of learning retention scores between the two groups is 0.292 and the significance level of this value with degrees of freedom of 1 and 24 is higher than 0.05.

Table 3: Results of Repeated Measures ANOVA for Text in Image Adjacency

Pre-test	Post-test	Delayed Post-test	F	df	Sig.	η^2
Mean \pm SD	Mean \pm SD	Mean \pm SD				
3.70 \pm 3.64	10.46 \pm 4.77	12.60 \pm 3.62	57.616	2,26	0.001	0.816

Table 4: Results of ANCOVA for Post-test Scores of Text Linked to Image and Text in Image Adjacency Controlling for Pre-test Scores

Source of Effects	SS	df	MS	F	P
Methods of Multimedia Presentation	0.176	1	0.176	0.014	0.906
Error	338.34	27	12.531		
Total	4131.06	30			

Table 5: Moderated Mean and Standard Error of Learning Retention Scores in Text Linked to Image and Text in Image Adjacency

Text Linked to Image	Text in Image Adjacency
Mean±SE	Mean±SE
12.18±0.88	12.85±0.85

Table 6: Results of ANCOVA for Learning Retention Scores of Text Linked to Image and Text in Image Adjacency Controlling for Post-test Scores

Source of Effects	SS	df	MS	F	P
Methods of Multimedia Presentation	2.948	1	2.948	0.292	0.594
Error	242.08	24	10.087		
Total	4658.06	27			

Therefore, the difference between the mean learning scores of the two groups is not statistically significant ($P=0.594$, $F_{(1,24)}=0.292$), and thus it can be stated that there is no significant difference between the presentation of the multimedia content with text linked to image (with the aid of hyperlinks) and the form of presentation of multimedia content (text in image adjacency - spatial contiguity principle) in terms of learning retention of the Experimental Sciences course of the fourth grade elementary students in Malayer.

Discussion

This study involved comparing two groups of students who were instructed in the multimedia content style of “text linked to image” and “text in image adjacency”. The findings are discussed in what follows:

First, the presentation of the multimedia content with text linked to image (with the aid of hyperlinks) significantly increased the mean of achievement scores in the Experimental Sciences in the post-test, but the difference between the mean score of the post-test and delayed post-test was not significant ($P>0.05$). In previous studies such as Moreno (7), Shi and Chen (8), Holsanova, Holmberg and Holmqvist (9) and Davis and Keremik (10), it was shown that the use of text adjacent to the image, or vice versa, improves learning which is in line with the results of the present study. Moreno (7) has demonstrated that providing guiding cues in the proximity of text helps teachers to access, analyze and apply the guiding material easily.

Shi and Chen (8), reporting the results of several studies, emphasize the inclusion of text in the proximity of the image. Holsanova, Holmberg and Holmqvist (9) also showed that providing guiding cues and secondary material adjacent to the text, in the form of text or image, helps reduce the cognitive load and facilitates learning. Therefore, the results of these studies are consistent with those of the present study in that these studies also place emphasis on the use of the principle of spatial contiguity in the same way as Clark and Meyer have suggested.

Second, the presentation of multimedia content with text in image adjacency significantly increased the mean of achievement scores in the Experimental Sciences in the post-test, while the difference between the mean score in the post-test and the delayed post-test was not significant ($P>0.05$). Findings from researchers such as Wouters, Paas and Van Merriënboer (11), Ayers and Paas (12), and Paas and Sweller (13) indicate that the use of text close to the image or vice versa reduces learners’ motivation, makes them passive, and plenty of pages will be needed to deliver content which runs counter to the results of the present study. Mayer and Moreno (14) also showed that when text is placed on the screen in close proximity of the corresponding image in terms of location and physical position, individuals learn more deeply and effectively compared with when the text and image are far apart from each other, which is in line with the present study.

The third dimension of the findings in this

study indicated that there is no significant difference between the two groups. Likewise, no significant difference was observed between the form of presentation of the multimedia content with text linked to image (with the help of hyperlinks) and the form of presenting it with text in image adjacency (the principle of contiguity) in the learning retention test (delayed post-test) of the Experimental Sciences course delivered to fourth graders. In fact, it can be stated that in the method of presenting text in image adjacency, the connection between the content and the concepts are simplified and presented in a concrete way to the learners. In this way, the learners do not experience excessive cognitive load, but their freedom with regard to the activity is limited. As for the method of hyperlinks, the learners have the power to modify the links and study the material in accordance with their learning style and the extent to which they tend to be active, but in this way the relationship between concepts might not be as simple and concrete as it is in the method of text in image adjacency.

In general, it can be argued that text in image adjacency is one of the principles that complies with the spatial contiguity principle. Despite the effectiveness of the design in accordance with this principle, its violation in e-learning courses (web-based), the need to observe the economics of web pages, consideration of learners' motivation and their varying learning styles requires due attention. In this regard, the "hyperlink method" offers another form of the spatial contiguity principle, and taking the three assumptions into consideration, it tries to take heed of learners' learning styles, keep learners active in the learning process, and help content producers economize on the cost of web pages. Accordingly, developers of multimedia and electronic content are recommended to use different forms of spatial contiguity in order to tailor to the needs of different learners and engage them in the learning process. This will result in motivating learners, adapting to different

learning styles, and keeping the web pages economical. This form of presentation can also be deployed in the effort to prevent the violation of the principle of spatial contiguity in e-learning environments.

Limitations

- Not considering the gender variable in comparing the impact of two different forms of multimedia content presentation on student learning and learning retention.
- Lack of support for randomized trial designs by the Education Organization and, consequently, by schools and teachers.

Ethical Considerations

This research was conducted with the consent of the participants. They were also assured that all information collected will remain confidential.

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Conflict of interests

The author declares that they have no conflict of interests.

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