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Effects of Lectures with PowerPoint or Prezi Presentations on Cognitive Load, Recall, and Conceptual Learning

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ABSTRACT

The purpose of this study is to investigate and compare the effects of two types of presentations as created by PowerPoint or Prezi, which are used during lectures at the higher education level, on the students' cognitive load, the level of recall of the learning and conceptual learning. Presentations prepared by PowerPoint have linear slides with a limited canvas, while Prezi allows for non-linear, multiple paths and unlimited canvas design. This study is of a quasi-experimental design. The participants were 50 university students enrolled in a Computer Programming program at a vocational school. Data were collected using the Cognitive Load Scale, achievement tests and concept maps. According to the results, students lectured by presentations created by Prezi had more conceptual learning and less cognitive load whilst teaching computer network systems' content. Recall the level of learning was measured by an achievement test which did not significantly differ across the groups. Prezi may be a better alternative for more conceptual learning and to reduce the cognitive load.

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Keywords:
Prezi, PowerPoint, cognitive load, conceptual understanding

Introduction

Although there are many strategies, methods, and techniques in the teaching-learning process, there is no "best solution" to fit every situation. In addition, the teaching materials used alongside the teaching method can also affect learning (Smaldino, Russell, Heinich & Molenda, 2005; Tennyson, 1994). Therefore, it is necessary to align teaching materials to the teaching method by utilizing instructional design principles. This solution also includes the learning environment, i.e. technology and instructional material as well as media. How instructional media and teaching methods affect learning is an important subject of debate in the field of educational technology (Clark, 1983; 1994; Kozma, 1991; 1994). The general consensus arising from this debate is that investigations on the effects of learning environments on learning should continue (Tennyson, 1994), although learning seems more related to the learner rather than the teaching process (Jonassen, Campbell & Davidson, 1994). Therefore, studies which investigate the impact of various learning technologies and materials used with specific teaching methods on variables related to teaching and learning are required (Parker, Bianchi & Cheah, 2008).

A widely used technology and teaching methods in higher education is projectors and lectures (Çağıltay et al., 2007; Sadi et al., 2008). University instructors most widely use presentations to facilitate the teaching and learning process. The software used to prepare these presentations is most often Microsoft's PowerPoint (Apperson, Laws & Scepansky, 2008; Gabriel, 2008; Gold, Swann & Chief, 2002; Parker, Bianchi & Cheah, 2008). PowerPoint allows the use of multimedia in the teaching-learning process and enriches the lecturing method with images, thus affecting pedagogy (Gabriel, 2008).

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Researchers previously reported that presentations prepared using PowerPoint improved student achievement (Jensen et al., 2002). In an experimental study conducted with 68 students, Akdağ and Tok (2008) found that the achievements of students who were taught using PowerPoint presentations were significantly higher. Between the experimental and the control group, students' post- test and achievement scores, significant differences were found in favor of the experimental group in which PowerPoint presentation supported instruction was used. Moreover, researchers demonstrated that PowerPoint presentations improved the students' attitudes toward the lecture (Apperson et al., 2008; Susskind, 2005) and their self-efficacy (Susskind, 2005; 2008). However, although PowerPoint is much preferred by lecturers, it has also been criticized. For example, a study conducted by Sugahara and Boland (2006), it was concluded that students taught using PowerPoint had lower grades in final examinations and less learning had occurred. The results of this study show a significant relationship between students' preferences regarding PowerPoint media and their academic performance as shown in their examination scores. In addition, researchers found that students downloaded lecture notes from the Internet, rather than attending the PowerPoint-assisted lectures. In a similar vein, Susskind (2005) taught a total of 51 university students using traditional teaching and PowerPoint. The results indicated that there was no statistically significant difference between the students' success and their motivation.

According to some critics, static and monotonous presentations are prepared with PowerPoint (Craig & Amernic, 2006, p.147). Anderson (2002) argued that, although it is easy to organize presentations and create content-rich material using PowerPoint, the audience loses their motivation. Bartsch and Cobern (2003) found that images unrelated to the content added to the presentation negatively, affecting learning. In addition to these studies, Harris (2011) suggested that additional methods were needed to overcome the negative effects of PowerPoint's linear structure upon learning. PowerPoint has a design logic that is based upon sequential slides with a limited canvas. As a result, instructors often prepare presentations by dividing learning content into separate slides and set forth a linear progressive design by sorting these slides in succession (see Figure 1).

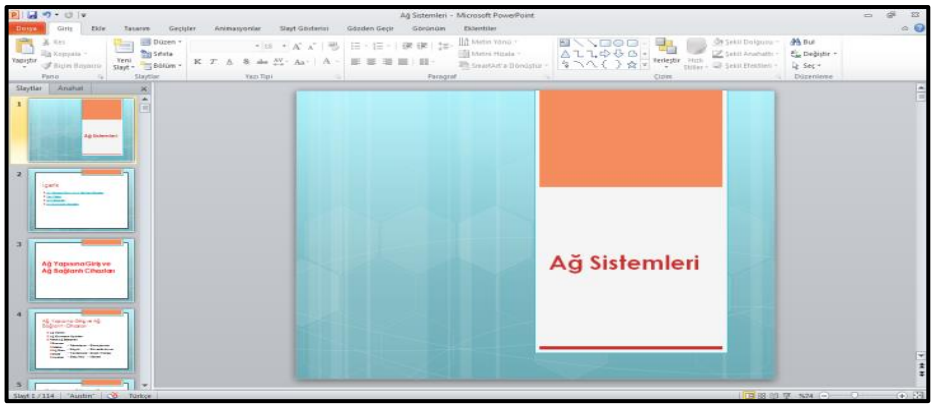


Figure 1. A Power point screenshot from a presentation used in this study

Although PowerPoint has a 'link' feature that allows branching, it may be difficult to clearly show relationships between information and concepts using sequential slides with separated slides, especially when instructors want to show holistically the interrelated content collectively in their presentations (Gabriel, 2008; Tufte, 2003).

Another presentation design tool, Prezi was developed in 2009 to address the perceived limitations of existing presentation tools. Presentations of Prezi are designed on an unlimited two-dimensional space without using a series of slides (see Figure 2). Visual or verbal elements placed on the canvas can be brought together or separated from each other and can be rotated around themselves at the desired angle depending on the user's design.

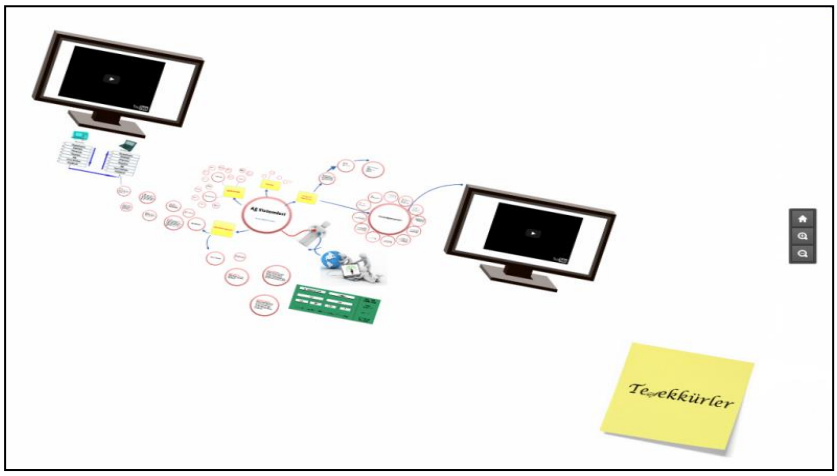


Figure 2. A Prezi screenshot from a presentation used in this study

In addition, Prezi elements are arranged in a specific order and the incoming information is zoomed in, comes to the forefront and is compared to the other elements on the screen (Graham, 2011). When the user opens a Prezi presentation, firstly, the user can see small pieces of text or pictures which are associated with each other as a whole. The Prezi's zoom feature provides more detailed information on the element when a user enlarges an element. In this way, the user can select any information and learn that information to a larger extent. Moreover, the relationship between this information and other information can also be displayed. Prezi lets show the whole picture of presentation. As with PowerPoint, Prezi can also integrate a variety of media. With these features, Prezi may give an opportunity for more effective teaching. It allows for grouping of the content and coding sequences so that Prezi Presentations can show more clearly the interconnections and relationships of content (Harris, 2011; Lorang, 2010; Manning et al., 2011; Prezi, 2012), giving an opportunity for teachers to design either induction or deduction strategies, based upon presentations which can make Prezi as effective design tool.

Previous studies showed that college students often preferred Prezi to PowerPoint and other technology tools. For example, Virtanen, Myllarniemi and Wallander (2012) created an instructional environment in which Prezi, Twitter and Socratic were used with 23 third and fourth year university students. The students' typical answer to the question “To what extent did learning with Prezi take place?” was "Very well". Accordingly, when students were asked with which tool they wanted teaching to be carried out, they preferred Prezi to other teaching tools. Some students stated that the best method would be to use a text tool along with Prezi. When the students were asked whether they wanted to use Prezi on their own in future, almost all of them stated that they wanted to use the tool. Prezi is among the technologies found “cool” by university students (Sundar, Tamul & Wu, 2014). In other words, students perceive Prezi as novel and motivating to use. Likewise, Conboy, Fletcher, Russell and Wilson (2012) found that students indicated that using Prezi makes the lectures more enjoyable than when using PowerPoint. Additionally, PowerPoint was practical in terms of usability and ease of access; however, Prezi provided more diverse opportunities and options during the lecture presentation.

The design features of PowerPoint and Prezi differ from one another. Considering the features; in some cases, Prezi implements more effective teaching techniques than PowerPoint (Harris, 2011; Lorang, 2010; Manning et al., 2011; Prezi, 2012). Therefore, investigating the effects of these two different tools on learning is an important issue that can contribute to the field of instructional design.

There are three variables to consider when investigating the effectiveness of PowerPoint and Prezi on academic achievement; (a) recall, (b) conceptual understanding and (c) cognitive load. The following sections will define and place these variables into the context of the current study.

Academic Achievement

Academic achievement can be briefly defined as to what extent learning has taken place. Learning can be said to have different types and levels. Recall can be given as an example of the basic level of learning, and conceptual learning as an example of a higher level of learning (Novak & Gowin, 1998). It was

considered to be more beneficial by the authors to include these basic and higher levels of learning, to determine the effects of PowerPoint and Prezi on academic achievement. A paper-and-pencil test that measures basic knowledge and memorization at lower levels of learning and a concept map will be used to measure academic achievement. The content map will reveal conceptual understanding as a product of a high level of learning (Novak, 2010).

Cognitive Load

Cognitive load is another variable to investigate the effects of PowerPoint and Prezi on learning. According to Sweller (1988), the level of cognitive load that occurs in the mind during the learning process is associated with the complexity of the problem of the learning task, subject area and teaching strategy used. Kirschner (2002) highlighted that cognitive load is related to working memory capacity and measures to be taken to support learning. Cognitive load is divided into three categories as extraneous, intrinsic and germane cognitive load (DeLeeuw & Mayer, 2008; Mayer, 2001; 2005). Extraneous cognitive load is related to the complexity of the learning material and is under the control of instructional designers, on how to present the information to the learner. Intrinsic cognitive load is related to the inherent level of difficulty associated with a specific instructional topic. For example, the need for extra information or the lack of knowledge should also be learned; to learn a topic constitutes a high intrinsic cognitive load on the working memory of learners. Germane cognitive load is related to the creation and modification of the schema. This type of cognitive load is indirectly influenced by instructional design. Lower extraneous load by instructional design allows for a more germane load in total working memory. Germane cognitive load positively affects learning, whereas extraneous cognitive load affects it negatively. It is not possible for the three types of cognitive load to overflow the total capacity of working memory. Therefore, better learning requires the avoidance of cognitive overload. This is achieved by keeping the cognitive loading level below cognitive capacity. Cognitive capacity may be increased by cognitive resources used during learning or performing a task. Cognitive resources and learning may be increased by motivation and learners' effort (Paas, Renkl, & Sweller, 2003: Renkl & Atkinson, 2003).

Cognitive load is an important variable that should be taken into consideration, due to its importance on learning from multi-media. Mayer (2001; 2005) emphasized the importance of cognitive load within the Cognitive Theory of Multimedia Learning. Since PowerPoint and Prezi are two multi-media design tools, cognitive load is an important variable in the current study. There are different methods to measure cognitive load. Within the limitations of this study, we measured cognitive load by using subjective cognitive load measure (SCL).

Investigating the effects of lectures with differently designed presentations (Prezi and PowerPoint), on recall, conceptual learning and cognitive load constituted the problem of this research. In the context of this problem, answers were sought to the following questions with regard to the two independent treatment groups; one group taught by presentations prepared using PowerPoint and the second group taught using Prezi. Is there a statistically significant difference between these?

- The groups' pre-test achievement test scores
- The groups' post-test achievement test scores
- The students' concept map scores
- The students' perceived (subjective) cognitive load scores.

At this point, it is expected to this work provide contribute to the literature about effects of using Prezi or Power Point.in education.

Method

In the present study, we used a quasi-experimental design. In a quasi-experimental design, random assignment is not possible in the process of assigning each participant to experimental conditions (Shadish, Cook & Campbell, 2002). Instead of a random assignment, the group assignment is determined based upon some criteria (Cohen, Manion & Morrison, 2007). In this study, the assignment in experimental conditions was made from existing classes. The intact group of participants (classes) was randomly selected from the classes where the students were currently taught. In both groups, teaching was delivered using lecture-

format presentations. Whilst using the same teaching method, Prezi was used in the Treatment1 group and PowerPoint in the Treatment 2 group. There was no control group.

Participants

A total of 50 first-year students in the department of computer programming from Amasya University, a post-secondary vocational school of technical sciences, participated in the study. The purposive sample consisted of 21 female (42%) and 29 male (58%) students.

Table 1. Student distribution by gender and group

Groups	Prezi (Treatment1)	Power Point (Treatment2)
Female	11	10
Male	12	17
Total	23	27

The reason for selecting these participants was that they were graduates from a department related to computing from secondary education, and they took a network systems' course for the first time. Participants (Table 1) were also familiar with PowerPoint and Prezi presentations, minimizing possible novelty effects. Moreover, the participants had similar prior knowledge and skills about using computers, and the content of computer network systems.

Instruments

A paper-and-pencil achievement test, cognitive load scale and concept map were used to collect data. The paper-and-pencil achievement test was prepared by taking into account the learning outcomes identified in the Modules of Strengthening Vocational Education Project (in Turkish, *Mesleki Egitim ve Öğretim Sistemini Geliştirme Projesi, (MEGEP*)), which constitutes vocational education standards in Turkey, and "remembering domain" in Bloom's revised taxonomy (Anderson, Krathwohl & Bloom, 2002). The test consists of open-ended questions. Senior faculty members and senior teachers reviewed the first version, consisting of twenty-five questions, to examine content validity and face validity. The final version consisted of twenty questions. Reliability analysis of the instrument revealed that the Cronbach-Alpha coefficient was (.87). The test was scored using a scoring key containing the correct answer to each question. The highest score from the test was 100 and the lowest score was 0.

The Subjective Cognitive Load Scale, developed by Paas and van Merriënboer (1993) and adapted to Turkish by Kılıç and Karadeniz (2006), was used to measure cognitive load. The Cronbach's alpha of the scale was .78, and Spearman Brown's split-half correlation is .79. The CLS has a single item, with a 9-point Likert type scale. The highest score that could be obtained from the scale was 9 and the lowest score was 1. The mid-point of scoring on the scale was 5. Scores under 5 indicated that the student did not experience cognitive overload and scores above 5 indicated that the student did experience cognitive overload, relatively.

To assess to what extent the students had learned concepts, they were taught how to draw a concept map before the data collection processes. A concept map is a schematic representation of ideas and knowledge. By the courtesy of concept maps, the students not only have an opportunity to see the accuracy of their knowledge, but also of their misunderstandings or misconceptions (Novak & Gowin, 1998). Concept maps are effectively used in order to assess and evaluate the students' level of conceptual understanding (Wallace & Mintzes, 1990). The students were asked to show the concepts, and the relationships between concepts in the subject they have learned, by creating a concept map. Novak and Gowin's (1998) scoring method was used to score the participants' concept maps. Accordingly, the concept maps were scored using a total score obtained by multiplying 'proposition' by a coefficient of 1, 'hierarchy' by a coefficient of 5, 'cross-link' by a coefficient of 10 and 'example' by a coefficient of 1. The lowest score from a concept map is 0. There is no upper limit for the score.

Experimental Procedures and Data Collection

Experimental procedures were designed, based upon the computer network systems' course curriculum and content module, which describes objectives, outcomes, methods and whole content, developed within the scope of the Strengthening Vocational Education Project (MEGEP) by the Ministry of

National Education in 2007. For the same content, two separate sets of presentations were prepared using PowerPoint and Prezi. The presentations were used for lectures over a period of six weeks. To prevent interaction between them, experimental groups were selected from among classes that were taught on different schedules. Both experimental groups were taught using the same presentation teaching strategy. Before and after the experimental procedures, a paper-and-pencil achievement test was applied. During each week of the experimental process, the cognitive load levels of the participants were measured. The meanings of these measurements were used in the analysis, as in the case of Kılıc's (2006) study. Hands-on training on how to draw a concept map was given to students before the experimental procedures. Before and after the experimental procedures, they were asked to create a concept map using their knowledge.

Data Analysis

The data were analysed by t-test using SPSS. Preliminary analysis showed that the data met the assumptions to conduct the t-test. We intended to conduct an ANCOVA, which allows us to test the differences between post-test scores by covariation of pre-test scores; however, the data did not meet the assumption of equality of the regression coefficients. Statistical significance was set as 0.05. Eta square coefficients and Cohen's d coefficients were calculated to present the effective size of statistically significant values.

Results

The groups' pre-test test scores were analysed using t-test (see Table 2). There was no statistically significant difference between the two groups' pre-test scores ($t_{(48)} = 1.40$, p= .166). In other words, the levels of knowledge before the experiment were similar. Additionally, the concept maps of the participants before the experimental procedures were almost incomplete; thus, all of the students' scores were very near to the minimum score. As a result, the participants' pre-test achievement scores could be said to be statistically the same.

Table 2. Equalty of groups paper nad pencil achievement

	Groups	N	$\overline{X}$	S	df	t	p
Pre-test	Prezi	23	16.91	8.62	48	1.40	16*
	PowerPoint	27	13.48	8.55			

*p>0.05

In order to examine the students' mean scores after the experimental procedures, their post-test achievement test scores were analysed by t-test (see Table 3). The t-test indicates that there is no statistically significant difference between the Prezi group and the PowerPoint group ($t_{(38.78)}$= -.965, p= .326). This result indicates that lecturing with PowerPoint or Prezi did not significantly differentiate the students' multiple-choice achievement test scores. On the other hand, lectures have significantly increased the students' achievement in both groups. One of the questions of the study was to determine which of the multimedia presentations was more effective (e.g. between-groups effect). As a result, it was understood that lectures created by PowerPoint or Prezi did not significantly differentiate the students' level of recall of the learning.

Table 3. Equalty of groups paper-and-pencil achievement

	Groups	N	$\overline{X}$	S	df	t	p
Post-test	Prezi	23	67.26	22.34	38.78	-.97	.33*
	PowerPoint	27	72.63	15.80			

*p>0.05

Table 4 presents the results of the t-test conducted to compare the students' concept map scores. The results indicated that there was a statistically significant difference ($t_{(48)}$= 4.24, p= .001) between the groups. The mean scores of the Prezi group ($\overline{X}$=29.83, S=14.56) were significantly higher than PowerPoint group ($\overline{X}$ =12.00, S=15.00). The effect size values are η^2 = .273, and Cohen's d= 1.21 large, according to Green and Salkind (2008) and Cohen (1988). The results suggest that teaching using Prezi allows students to conceptualize the relationships between concepts.

Table 4. Post-test concept map

Group	N	$\overline{X}$	S	sd	t	p	η^2	Cohen's d
Prezi	23	29.83	14.56	48	4.24	.00*	.27	1.21
PowerPoint	27	12.00	15.00					

*p<0.05

Table 5 presents the results of t-test for students' cognitive load scores. The cognitive load of the PowerPoint group ($\overline{X}$ = 5.19, S= .96) was statistically significantly higher than the Prezi group ($\overline{X}$ = 4.53, S= .88) ($t_{(48)}$= -2,499, p < .05, η^2=.12, Cohen's d= 0.71). According to Green and Salkind (2008), when the effect size is in the range between .06 and .14 for eta square, it is moderate. According to Cohen, it is moderate when .50 and big at .80. Therefore, considering both, the size of the effect can be interpreted as moderate but near to big (large) according to Cohen. Presentations prepared using PowerPoint to teach the subject of computer network systems increased cognitive load, compared to those prepared using Prezi.

Table 5. Cognitive loadings

Group	N	$\overline{X}$	S	sd	t	p	η^2	Cohen's d
Prezi	23	4.53	0.88	48	-2.49	.02*	.12	0.71
PowerPoint	27	5.19	0.96					

*p<0.05

Discussion

Student recall of the content on the academic achievement test remained the same whether using Prezi or PowerPoint presentations. However, Prezi presentations resulted in a lower cognitive load, compared to PowerPoint presentations. Moreover, Prezi presentations improved the conceptual understanding of the content of computer networks. Previous studies suggested cognitive load is directly proportional to cognitive effort in learning (de Jong, 2010). Accordingly, the present study suggests using Prezi presentations reduces the subjective cognitive load, rather than linear PowerPoint presentations.

From an instructional design perspective, three major applications of cognitive load theory include reducing intrinsic load by taking into account the students' prior knowledge, reducing extraneous load by avoiding unnecessary and confusing elements, and increasing germane cognitive load by designing processes that will ensure a rich and in-depth understanding (de Jong, 2010). The contents with a dimension that can affect the intrinsic load of the presentations are the same, so the presentations prepared using two different presentation tools can be said to directly affect the extraneous load and, indirectly, the germane cognitive load, to a different extent.

In particular, the impact on the formation of mental structure, namely the determination of the germane cognitive load, is important for the expansion of cognitive load theory (van Merriënboer & Sweller, 2005). However, considering that the same content was presented to both experimental groups and the Prezi group had a lower cognitive load, it is plausible that Prezi decreased extraneous load (van Merriënboer & Sweller, 2005). Thus, presentations prepared using Prezi may result in less extraneous load, as compared to presentations prepared using PowerPoint. Prezi presentations may lower cognitive load because of being easier to navigate and view concepts and the relationships between concepts at the same time. Whereas PowerPoint consists of individual slides, so pieces of information are divided into different slides, which may increase extraneous loading. For more robust interpretations, instruments that can measure the different types of cognitive load and more accurate tests are required.

The results of paper-pencil test scores showed that there was no statistically significant difference between the effects of Prezi and PowerPoint in the recall and it means that no difference in remembering domain of students' learning according to Bloom's revised taxonomy. In the works of Susskind (2005, 2008), presentations made in various learning environments did not lead to a statistically significant difference in test scores of students. However, in the case of measurements made using the concept map, a statistically significant difference was seen in favour of Prezi between experimental groups. In other words, concept map scores of the students who were taught by Prezi were higher. Given this difference, Prezi was more effective in teaching for conceptual learning. Not only does Prezi display the whole picture, Prezi also shows the

relationships between concepts and information. The features in Prezi offer even more effective learning by creating concept maps (Harris, 2011; Lorang, 2010; Manning et al., 2011; Prezi, 2012).

The results of this study were limited by the subject of computer network systems. Parker, Bianchi and Cheah (2008) reported that preferences of presentation software may vary by content area. Lecturers preferred PowerPoint to a larger extent in the natural sciences, rather than in social sciences and education. In this study, Prezi was found to be more effective for learning computer network systems, which have a well-structured and interrelated content. However, further studies are required to determine which medium will be more effective in different content areas for teaching more or less structured contents, or concrete or abstract subjects.

Conclusion

In this study, both Prezi and PowerPoint have similar effects on learning in the domain of remembering. We found that Prezi presentations resulted in a lower subjective cognitive load when compared to their PowerPoint counterparts. Moreover, Prezi demonstrated higher conceptual learning over PowerPoint. In consideration of these results, Prezi is more effective because the program displays in-depth concepts on a single canvas. Accordingly, Prezi reduces undesired cognitive load and increases conceptual learning. Overall, Prezi is recommended for use in lectures within the similar context of this research, to reduce cognitive load and increase conceptual understanding.

New research can be conducted to determine the effects of new models with PowerPoint in comparison to Prezi. Novel approaches have been developed for a more efficient utilization of PowerPoint. Lai, Tsai and Yu (2011a; 2011b) have developed a dual-slide presentation model containing a second presentation surface, allowing the use of extra explanation to enrich the PowerPoint presentations. Yu, Lai, Tsai and Chang (2010) determined that this approach was more effective. Yu, Liao and Su (2013) developed a system in which PowerPoint, as well as the facial and body language of the tutor, can be seen at the same time, which was found to be more effective.

This study also gives a clue to reducing cognitive load in a new way. Prezi's zoom in and zoom out feature gives an additional dimension for learning from instructional materials. Instructional materials generally provide for left and right, up and down and two-dimensional navigation. Besides them, Prezi lets learners move into or move out of the content. This feature may result in decreasing cognitive load and also disorientation whilst learning concepts. This kind of presentation of concepts is also like the environment in 3D video games, with which students are very familiar. In further studies, multi-dimensional instructional materials that allow more effective application of multimedia design principles for reducing extraneous cognitive load (Mayer & Moreno, 2003; Sweller, van Merriënboer, & Paas, 1998) may be investigated.

Based on the research results, the following suggestions can be made: Prezi may be a better alternative for more conceptual learning and to reduce the cognitive load. So Prezi can be used in other courses instead of Power Point. It should be given to the use of course materials which prepared with Prezi. Using Prezi should be encouraged for the students' active participation in class. Consequently, it was suggested that incorporating multimedia into the classroom necessarily provide a simple solution to improving the effectiveness of students' learning outcomes.

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