Journal of Educational Technology & Online Learning
Volume 5 | Issue 3 | 2022
http://dergipark.org.tr/jetol

Evaluation of the effectiveness of different infographic designs[1]

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Suggested citation: Çaka, C. & Dursun, Ö.Ö. (2022). Evaluation of the effectiveness of different infographic designs. *Journal of Educational Technology & Online Learning*, *5*(3), 519-534.

Article Info

Keywords:

Academic achievement
Cognitive load
Counterbalanced design
Infographic
Multimedia
Motivation

Research Article

Abstract

With the developments in digital technologies, the increase in the amount of accessible information and the multimedia concept, it has become necessary to present complex information in a simplified manner. Along with this requirement, one of the current concepts that draw attention within the scope of multimedia concept is the infographic. The main purpose in the multimedia learning process is to achieve meaningful learning, and the effectiveness of the teaching material used in this process has gained importance. In this context, it was aimed to examine the reflections of different material designs on academic achievement, cognitive load, and motivation, including visual intense infographic, text intense infographic, and text only material. Based on the execution of all experimental mixed design was conducted with 58 teacher candidates. According to the quantitative and qualitative findings of the research, while academic achievement, cognitive load, and motivation vary significantly depending on the type of material, the aforementioned differences are significant in favor of the visual intense infographic expressed by the participants as a simple and concrete and therefore understandable.

1. Introduction

Learning systems based on virtual networks such as the internet, web technologies, local networks, virtual communication environments, portable smart environments are the basic education Technologies of the 21st century and while these technologies accelerated the transition to the visual world (Jukess, McCain & Crockett, 2010), they also paved the way for the use of applications such as online learning, web assisted learning, and mobile learning (Şimşek, 2009). Parallel to the increase in digital and online resources, the amount of accessible information and accordingly the amount of stimulus intensity faced is increasing. With this transformation process, while expectations from individuals have been increasing, it has become important to process information more easily and quickly (Siricharoen, 2013). In this process, traditional learning environments, which could not meet the requirements, were replaced by multimedia based on the integration of written materials with visual elements.

Although there are different definitions about the concept of multimedia, according to Mayer (2009), multimedia refers to the use of verbal and visual elements together in the presentation of materials. When the literature on the process of learning with multimedia is reviewed, it is seen that mostly experimental research has been carried out to verify the principles and assumptions introduced within the scope of

[1] This study is the summary of the doctoral dissertation titled 'Effect of Different Infographic Designs on Learning Outcomes, Cognitive Load, and Motivation' written by first author and supervised by second author.

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Doi: http://doi.org/10.31681/jetol.1075352
Received 17 Feb 2022; Revised 3 Jul 2022; Accepted 23 Aug 2022
ISSN: 2618-6586 .

theoretical foundations. The existing research generally focuses on examining the effectiveness of different multimedia designs in the context of various variables such as cognitive load in relation to academic achievement, attitude, motivation and multimedia design principles (Al Hosni, 2016; Anderson, Kardia, Gupta & August, 2019; Chicca & Chunta, 2020; Çakıroğlu & Taşkın, 2016; Çoruk & Çakır, 2017; Divarcı & Saltan, 2017; Herrlinger, Höffler, Opferman & Leutner, 2017; Leggette, 2020; Lindner, Eitel, Strobel & Köller, 2017; Münchow, Mengelkamp & Bannert, 2017; Plass, Heidig, Hayward, Homer & Um, 2014; Schüler, 2017). In this context, the findings from experimental research gain importance and guide the effective multimedia design process. When the literature is examined, it is seen that findings related to research involving similar processes may differ on the basis of participant features such as prior knowledge level, literacy skills, learning style, and different design suggestions for the design process are presented in line with the findings obtained by the researchers (Chicca & Chunt, 2020; Jian & Ko, 2017; Koć-Januchta, Höffler, Thoma, Prechtl & Leutner, 2017; Lee & Kim, 2016; Renkl & Scheiter, 2017; Schnotz et al., 2017). One of the remarkable elements in this context is the density used in the multimedia material design process. Although it is stated that it is more effective to present information using both text and visual elements rather than using only text in the learning process in light of both theoretical foundations and literature, there are different suggestions on the density of the text used. According to Krum (2013), users prefer to see more visuals and less text in the fast-learning process. Therefore, as supporting the content with a lot of text in design will make the target audience at first think that it is much more complex and time-consuming than it is in fact, the more visual the content will be, the more effective it will be. Dunlap and Lowethal (2016) state that visual elements can be supported with texts to attract attention and increase the confidence of users. Stating that the density of the text used in the design process is an important factor to be considered and emphasizes the need for experimental research to be conducted on this subject (Mayer, 2009).

When the studies conducted on the process of learning with multimedia are examined in relation to material types, it is seen that various multimedia teaching materials such as educational software programs (Çakıroğlu & Taşkın, 2016; Çoruk & Çakır, 2017), video (Divarcı & Saltan, 2017; Yang, Huang, Tsai, Chung, & Wu, 2009), pictures (Anderson et al., 2019; Désiron, de Vries, Bartel & Varahamurti, 2017; Lindner et al., 2017) have been used. On the other hand, the use of infographics as an up-to-date multimedia tool has an important power in the field of education in the effective transfer of abstract, complex and intensive infographic design are limited to descriptive studies (Chicca & Chunt, 2020; Dunlap & Lowenthal, 2016). However, in the literature, it is stated that academic studies on the use of infographics in education and effective infographic design are limited to descriptive studies (Chicca & Chunt, 2020; Dunlap & Lowenthal, 2016; Kibar & Akkoyunlu, 2015; Matrix & Hodson, 2014; Vanichvasin, 2013).

Therefore, there is a need for new studies to test the power claimed to be possessed by infographics as an effective visual communication tool and teaching material. Thus, the aim of the current study is to determine the effects of the materials differing by text density on achievement, cognitive load, and motivation. To this end, answers to the following questions were sought:

1. Are these significant differences between the participants subjected to learning experiences based on different types of materials in terms of

- achievement level,
- cognitive load level,
- time spent,
- motivation?

2. Is there a significant difference between the pre-test and post-test scores of the participants subjected to learning experiences based on different types of materials?

3. What are the participants' opinions about the effectiveness of different types of materials?

2. Methodology

2.1. Research Model/Design

The current study employed the embedded experimental mixed design in which qualitative and quantitative methods are used together. Creswell and Clark (2015) state that the embedded mixed design can be used when the researcher has different questions that require different data types to examine the main purpose and improve the application of quantitative/qualitative designs and that the most common type of embedded mixed design emerges when the researcher embeds qualitative data into an experimental design that he/she designates as the basic design. In the current study, the counterbalanced design, one of the semi-experimental designs, forms the basic design of the study. The main purpose in the counterbalanced design including at least two experimental groups is the determination of the effect of different experimental interventions on the dependent variables and different experimental interventions are conducted in different orders in each experimental group (Fraenkel, Wallen & Hyun, 2012). The schematic representation of the counterbalanced design of the current study is shown Table 1.

Table 1.

Schematic representation of the counterbalanced design

Group	Intervention 1	Test 1	Intervention 2	Test 2	Intervention 3	Test 3
Group 1	X_1	$T_{1,1}$ $T_{1,2}$ Cognitive load Time spent Motivation	X_2	$T_{2,1}$ $T_{2,2}$ Cognitive load Time spent Motivation	X_3	$T_{3,1}$ $T_{3,2}$ Cognitive load Time spent Motivation
Group 2	X_2	$T_{2,1}$ $T_{2,2}$ Cognitive load Time spent Motivation	X_3	$T_{3,1}$ $T_{3,2}$ Cognitive load Time spent Motivation	X_1	$T_{1,1}$ $T_{1,2}$ Cognitive load Time spent Motivation
Group 3	X_3	$T_{3,1}$ $T_{3,2}$ Cognitive load Time spent Motivation	X_1	$T_{1,1}$ $T_{1,2}$ Cognitive load Time spent Motivation	X_2	$T_{2,1}$ $T_{2,2}$ Cognitive load Time spent Motivation

(X_1: visual intense infographic, X_2: text intense infographic, X_3: text only material)

2.2. Data Collecting Tools

Achievement Test

Achievement tests were developed to determine the prior knowledge and achievement levels of the participants regarding the three different subject contents presented in the current study. For each achievement test, reliability coefficient was calculated and to this end, Kuder-Richardson 20 (KR-20) built on the principle of calculating the internal consistency coefficient considering item difficulties when the item difficulties are different used (Fraenkel et al., 2011).

Cognitive Load Scale and Plug-in for Time Spent

In the current study, the cognitive load scale adapted to Turkish by Kılıç and Karadeniz (2004) was used in the measurement of cognitive load. In addition, the time spent by the participants on each material within the scope of the research was recorded. This process was carried out through a plug-in developed within the scope of research on the Moodle learning management system.

Instructional Materials Motivation Questionnaire

Within the context of the current study, the instructional materials motivation questionnaire adapted to Turkish by Kutu and Sözbilir (2011) was used to determine the motivation level of the participants subjected to learning experiences through different types of materials after each experimental intervention.

Weekly Feedbacks

Qualitative data of the study were obtained through weekly feedbacks. At the end of each week, the participants were asked to evaluate the materials they had received that week. Moreover, in the last week of the application, the participants were asked to compare the different types of materials they had received in all the former weeks according to learning, cognitive load, and motivation variables. In this process, open-ended questions were used to get the opinions of the participants on the effectiveness of different types. The data from weekly feedbacks were recorded on the online system.

2.3. Sampling or Study Group

The current study was conducted with the participants of 58 students taking the course "Special Teaching Methods I" in the education faculty of a state university. The participants were randomly assigned into the course, which was opened two groups based on the type of material. Thus, two-stage random assignment was performed in the current study. In this context, the sample random sampling method based on the principle of equal likelihood of each participant' being placed in the groups was used (Fraenkel et al., 2011; Huck, 2012). The participants are 20 people per week for each group, and the data of the relevant participant were not included in the research in cases such as not participating in the application in any week, missing the applications.

2.4. Data Analysis

The data collected to find answers to the research questions of the current study were analyzed by using the methods shown in Table 2.

Table 2.

Data analysis methods

Research Question	Analysis
1. Are there significant differences between the participants subjected to learning experiences based on different types of materials in terms of a. post-test scores, b. cognitive load level, c. time spent, d. motivation?	One-way and two-way ANOVA for repeated measurements
2. Is there a significant difference between the pre-test and post-test scores of the participants subjected to learning experiences based on different types of materials?	Dependent samples t-test
3. What are the participants' opinions about the effectiveness of different types of materials?	Content analysis

2.5. Research Procedures

In the research process, text-based and visual element supported materials were used. Each material was designed in such a way as their contents to be consistent with each other. Visual-intensive and text-intensive designed infographics were used as visual element supported materials. During the evaluation of the suitability of the designed infographics, expert opinions were sought.

Within the context of the current study, the classes were taught in two stages, on-line and face-to-face, for four weeks. Online materials presentation was preformed through Moodle learning management system. The reason why the Moodle learning management system was preferred is that it is free and open source, learner-centered and has add-on support features (Cole & Foster, 2007). Within the curriculum prepared in the context of the current study, different types of weekly activities such as content presentation in the Moodle learning management system, achievement test application, questionnaire application and feedbacks were created and added to the content of the relevant week and made ready for instruction. In-class activities were carried out in a laboratory environment where each participant could use a computer. In the light of the findings, the effects of different types of materials on academic achievement, cognitive load, and motivation were examined.

2.6. Findings and Discussions

Results related to the effect of material type and measurement time on achievement level

The first variable investigated in the current study is achievement level. Two-way ANOVA for repeated measures was conducted to determine the difference between the achievement scores of the participants subjected to different types of materials and different measurement times. Results obtained from this test are presented in Table 3.

Table 3.

Results of the ANOVA conducted to determine the participants' achievement levels in relation to material type and measurement time

Source of Variance	Sum of Squares	df	Mean Square	F	p	ηp^2	Observed Power	Significant Difference
Material	43.351	2	21.675	3.578	.031	.059	.653	1>2 1>3
Error (Material)	690.649	114	6.058					
Measurement Time	976.693	1	976.693	193.657	.000	.773	1.000	Post-test > Pre-test
Error (Measurement Time)	287.474	57	5.043					
Material*Measurement Time	30.109	2	15.055	4.598	.012	.075	.769	
Error (Material*Measurement Time)	373.224	114	3.274					

(1: visual intense infographic, 2: text intense infographic, 3: text only material)

According to the results of the analysis, the common effect of material type and measurement time on achievement is significant ($F_{(2, 114)}$=4.598, p<.05, ηp^2=.075). The ηp2 value denoting the effect size in Table 3 shows how much of the variance in the dependent variable is explained by the independent variable. According to Cohen (1988), when this value is in the range between .06 and .14, then it indicates a medium effect size. This difference has a medium effect size and adequate statistical power.

In order to relate these quantitative findings to qualitative findings, the participants' opinions about comparative materials evaluations were examined in relation to achievement. When all the materials were evaluated in terms of achievement, according to the great majority of the participants, the most effective material is the visual intense infographics (*f*=33) while the least effective material is the text only material (*f*=33). The participants expressed these opinions by relating them to the concepts emphasized in the evaluations they made separately for all types of materials. The participants' opinions about the factors influential on achievement are presented in Figure 1 through association with the themes obtained from each material evaluation.

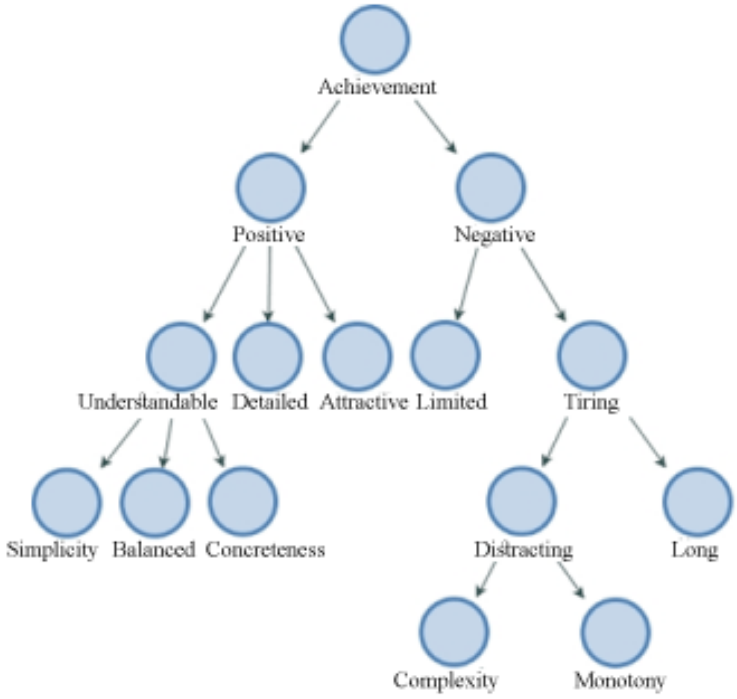

Fig. 1. Themes related to achievement

Participants who think that the infographic-based materials support the effective learning process and are effective on achievement explained this situation with these materials' being understandable and attractive. A participant mentioning that with increasing visual elements in a material, the concreteness also increases explained his/her opinions as follows: "*Visualization of the content in our minds in visual intensive infographics enables us to grasp the subject more easily and quickly. That is, it becomes possible to connect events with each other, visualize and imagine them. (P-57)*" Another participant emphasizing the simplicity in infographic-based materials expressed his/her opinions as follows: "*Recalling and comprehending was easier in visual and text-intensive infographics because the information was presented directly without being complicated. (P-54)*" Another participant thinking that an instructional material enhanced with attractive elements has positive effects on achievement expressed his/her opinions as follows: "*In my opinion, what is important in recalling and comprehending is to draw the attention of the student and to make him/her willing to learn. I think, this is possible only with a material enriched with visuals, paintings,*

and examples. (P-16)" On the other hand, the participants thinking that the text only material is not effective on achievement explain this with the belief that this material is tiring as it is distracting and long. A participant pointing out the complexity of the text only material explained his/her opinions as follows: "*While reading the text material, I think the recall and comprehension are low and there is information confusion as bits of information are confused. (P-19)*" Another participant who emphasized the distractive nature of the material due to its monotony expressed his/her opinions: "*It was difficult for me to recall in the text material because it was a plain text without any element that can draw attention or raise curiosity. In others, even the smallest arrow used helped me remember some information and solve questions in the posttest. (P-35)*"

In summary, according to the findings obtained from the quantitative data, achievement varies significantly depending on the type of material and the difference is in favor of the visual intensive infographics. According to the findings obtained from the qualitative data, the most effective material in terms of achievement in the learning process is the visual intensive infographics and this finding supports the finding obtained from the quantitative data.

Results related to the effect of material type on the level of cognitive load

Another variable investigated in the current study is the level of cognitive effort made by the participants in the learning process.

One-way ANOVA for repeated measures was conducted to determine whether there is a significant difference between the levels of cognitive load of the participants subjected to different types of materials. Results of this test are presented in Table 4.

Table 4.

Results of the ANOVA conducted to determine the participants' levels of cognitive load in relation to material type

Source of Variance	Sum of Squares	df	Mean Square	F	p	ηp^2	Observed Power	Significant Difference
Material	54.839	1.605	34.163	14.176	.000	.199	.994	3>1 3>2
Error (Material)	220.494	91.497	2.410					

(1: visual intense infographic, 2: text intense infographic, 3: text only material)

According to the result of the analysis, the participants' level of cognitive load varies significantly depending on material type ($F_{(1.605, 91.497)} = 14.176$, $p < .05$, $\eta p^2 = .199$). This difference has a large effect size and adequate statistical power.

On the other hand, in order to reveal whether there is a significant difference between the amounts of time spent by the participants on different types of materials, one-way ANOVA for repeated measures was conducted. Results of this test are presented in Table 5.

Table 5.

Results of the ANOVA conducted to determine the amounts of time spent by the participants in relation to material type

Source of Variance	Sum of Squares	df	Mean Square	F	p	ηp^2	Observed Power	Significant Difference
Material	834.698	1.735	481.006	16.261	.000	.222	.999	2>1
								3>1
								3>2
Error (Material)	2925.943	98.913	29.581					

(1: visual intense infographic, 2: text intense infographic, 3: text only material)

According to the result of the analysis, the amount of time spent by the participants varies significantly depending on material type ($F_{(1.735, 98.923)}$=16.261, $p<.05$, ηp^2=.222). This difference has a large effect size and adequate statistical power.

In order to associate these quantitative findings with qualitative data, the participants' views on comparative material evaluations in relation to cognitive load were examined. When all the materials were evaluated in the context of cognitive load, it was found that the material that created the most cognitive load according to the vast majority of the participants was the text only material (f = 45), while the least cognitive load was created by the visual intensive infographics (f = 40). The participants explained these views by associating them with the concepts they emphasized in their evaluations made separately for each type of material. The participants' opinions about the effects of factors influential on cognitive load are presented in Figure 2 by associating with the themes obtained from the evaluation of each type of material.

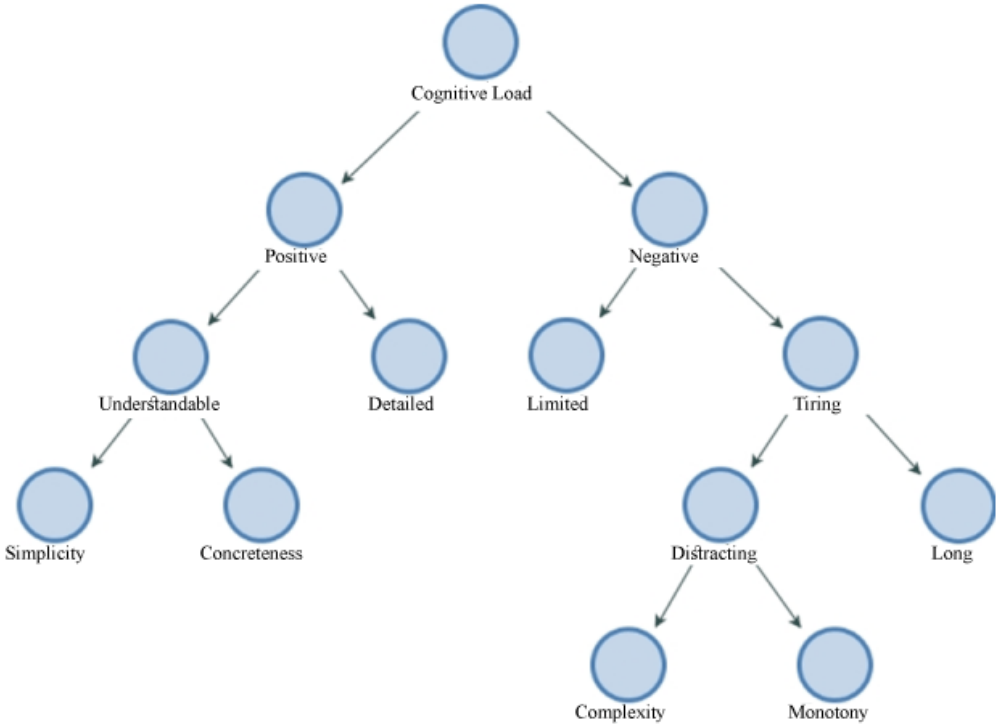

Fig. 2. Themes related to cognitive load

According to the participants thinking that the visual intensive infographics created less cognitive load, this was so because this material was more comprehensible as it presented simple and concrete content. In this connection, some of the participants' opinions are as follows: "*I made the least cognitive effort while working with the visual intensive infographics because the information was presented in a concise manner to promote retention (P-57)*". Another participant expressed his/her opinions as follows: "*I did not invest much cognitive effort in the visual intensive infographics. I thought this was because of the experiences on the subject, examples given in the material and the visuals used (P-25)*". On the other hand, according to the participants thinking that the text only material had negative effects on cognitive load, this was so because the material was tiring as it was distracting and long. A participant emphasizing the complexity of the text only material expressed his/her opinions as follows: "*I can say that the text only material was the material I made the greatest effort on. My experiencing difficulty in comprehending over time made me bored of the text and then I became distracted (P-19)*". Another participant pointing out the distraction resulting from the monotonous structure of the material expressed his/her opinions as follows: "*As the text was a plain text, I read it just to finish. I could not visualize anything on the basis of the text, and I got distracted (P-41)*".

In summary, according to the findings obtained from the quantitative data, the level of cognitive load required by the text only material is higher than the level of cognitive load required by the visual intensive infographics and the difference is significant. According to the findings obtained from the qualitative data, the text only material creates a high level of cognitive load in the learner, while the text only material created a high level of cognitive load in the learner, the visual intensive infographics created a low level of cognitive load, which supports the findings obtained from the quantitative data.

Results related to the effect of material type on motivation

Another variable investigated in the current study is the level of cognitive effort made by the Another variable investigated in the current study is motivation and, in this regard, whether the participants' level of motivation varied depending on the type of material used was examined. To this end, one-way ANOVA for repeated measurements was conducted. Findings of this test are presented in Table 6.

Table 6.

Results of the ANOVA conducted to determine the participants' levels of motivation in relation to material type

Source of Variance	Sum of Squares	df	Mean Square	F	p	ηp^2	Observed Power	Significant Difference
Material	5.285	1.757	3.008	14.371	.000	.201	.997	1>3 2>3
Error (Material)	20.962	100.137	.209					

(1: visual intense infographic, 2: text intense infographic, 3: text only material)

As a result of the analysis, it was concluded that the participants' level of motivation varied significantly depending on the type of material ($F_{(1.757,\ 100.137)} = 14.371$, $p<.05$, $\eta p^2=.201$). This difference has a large effect size and adequate statistical power.

In order to associate these quantitative findings with qualitative data, the participants' views on comparative material evaluations in relation to motivation were examined. When all the materials were evaluated in relation to motivation, the most effective material according to the majority of the participants was the visual intensive infographics (*f*=42), while the weakest material was the text only material (*f*=55). The

participants explained these views by associating them with the concepts they emphasized in their evaluations made separately for each type of material. The participants' opinions about the effects of factors influential on motivation are presented in Figure 3 by associating with the themes obtained from the evaluation of each type of material.

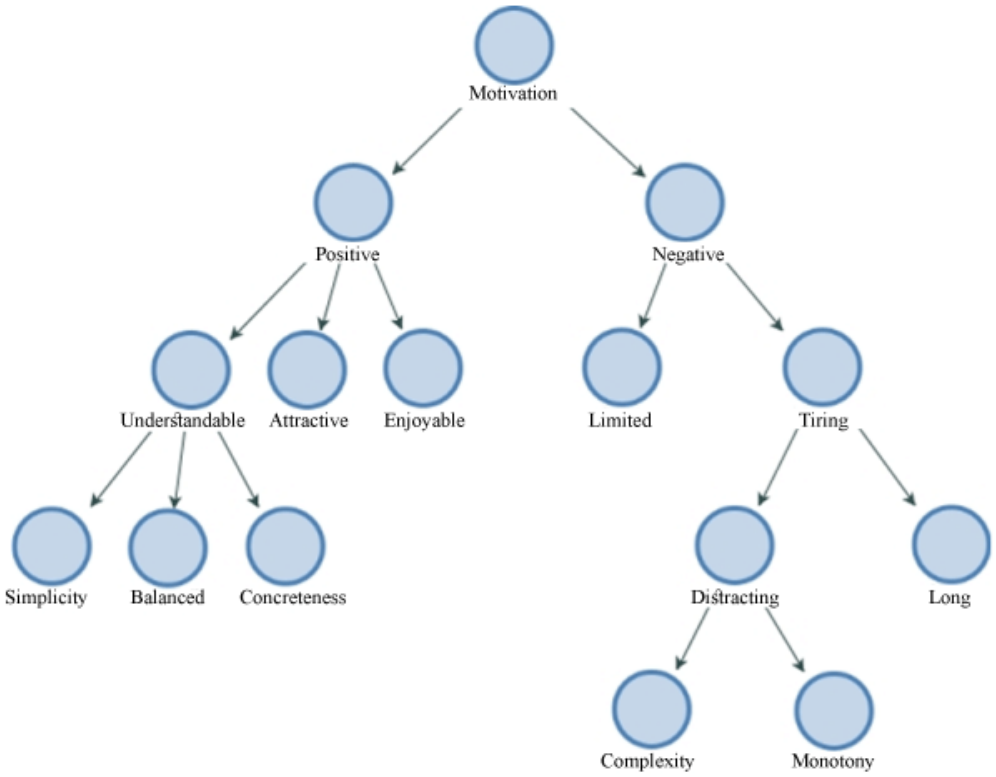

Fig. 3. Themes related to motivation

According to the participants thinking that infographic-based materials were more effective on motivation, this was so because these materials were comprehensible as they presented simple, balanced and concrete content and were attractive and enjoyable. In this regard, one participant expressed his/her opinions as follows: "*I only read the text only material and I didn't understand anything. I even do not remember anything. In the other materials however the concise presentation of the content with the support of instructional schemes and visuals allowed us to be introduced to the information we need in an effective manner; thus, contributed to our learning. In terms of motivation, all the materials except for the text only material, particularly the visual intensive material were nice and satisfying for me (P-6)*". The participant K-14 emphasizing the attractiveness of infographics expressed his/her opinions as follows: "*For me, the visual intensive infographics and text intensive infographics were highly attractive and made me feel I could do, achieve it. And I did so. With increasing visuals, motivation also increases, I think*". According to the participants thinking that the text only material had a negative effect on motivation, this was so because the material was tiring as it was distracting and long. One participant emphasizing the complexity of the text only material expressed his/her opinions as follows: "*The text only material was really boring. I just read it to finish so that I would start the test because as I could not understand which information was important, I just read and while I was reading, I forgot what I had read (P-23)*". Another participant emphasizing the distraction resulting from the monotonous character of the material expressed his/her opinions as follows: "*The text material was not interesting. There was a plain text that I had to read and there was no coloring; paragraphs were not separated from each other. Therefore, I got bored while reading the text. It did not motivate me (P-15)*".

In summary, according to the findings obtained from quantitative data, motivation differs significantly according to the type of material, and the difference is in favor of the infographic-based materials. According to the findings obtained from the qualitative data, the most effective material in relation to motivation is the visual intensive infographics, while the weakest material is the text only material and this finding supports the findings obtained from the quantitative data.

3. Discussion, Conclusion, and Suggestions

When the findings of the current study are evaluated in general, according to the data obtained from the pre-test and post-test applied to evaluate the effectiveness of different material types in terms of academic achievement, the effect of the material type and the measurement time on academic achievement is significant, and there is a significant progress from the pre-test to the post-test in all the material types. The biggest difference in terms of material type appeared in the visual intensive infographics. When all materials are evaluated in relation to academic achievement based on the opinions of the participants, the most effective material is the visual intensive infographics, while the weakest material is the text only material. The participants emphasized that the infographic-based materials were comprehensible and attractive and that with increasing visuals, concreteness and accordingly retention also increased. On the other hand, they emphasized that as the text only material was long and distracting, it presented tiring and momentary learning experience. Thus, it can be said that the participants' opinions about different types of materials supported the findings derived from the quantitative data. There are studies in the literature reporting similar in the literature. Dunlap and Lowenthal (2016) pointed to the importance of the use of visual elements to draw attention and commanding trust in users and Anderson et al. (2019) emphasized the importance of the use of visual elements to grasp the knowledge. It is stated by Chicca and Chunta (2020) in the guideline that offers guidance to educators in the effective use of infographics to increase student achievement that infographics can be used as a teaching-learning strategy that makes it easy to attract attention and make complex information understandable. Similarly, Holsanova et al. (2009) stated that, as an attractive teaching material, infographics contribute to the sustainability of the learner interest. Infographics that improve reading skills in learners (Davis & Quinn, 2013) also support meaningful learning process (Alrwele, 2017). In another study on the effect of learning with multimedia on achievement and metacognitive skills, it is stated that the learning process with visual elements is more effective on achievement compared to learning only with text material (Lindner, Eitel, Barenthien & Köller, 2018).

According to the data obtained from the cognitive load scale and the time spent add-on administered to evaluate the effectiveness of different types of materials in terms of the level of cognitive load, the cognitive load levels of the participants differ significantly according to the type of material and the difference is in favour of the text only material. In other words, as the density of visual element increased, the cognitive load level and the time spent on the material decreased. In the context of cognitive load, according to the participants' opinions regarding different teaching materials, the most effective material was the visual intensive infographics, while the weakest material was the text only material. The participants emphasized that the materials based on infographics were simple and concrete and therefore understandable. On the other hand, although the text only material offered detailed content, it was emphasized that it was distracting as it was complex and monotonous and that it was perceived to be long by the reader. When the literature on this subject is reviewed, it is seen that there are studies supporting these findings. According to Noh et al. (2015), text-based presentations make learning monotonous and distract the attention of the learner. This prevents holistic thinking and negatively affects comprehension. It is argued that as information comprehension and processing processes become faster in materials in which verbal and visual elements are used together, the time spent while dealing with such material decreases (Bayraktar & Camnalbur, 2012; Siricharoen, 2013). Similarly, according to the findings of the studies by Lindner et al. (2017) and Schüler (2017), the participants who used integrated text and images spent less time in the application process. The

time spent for learning is related to the cognitive load and as the time spent for learning decreases, cognitive load level decreases (Moreno & Mayer, 2007), achievement increases (Hembroke & Gay, 2003).

According to the data obtained from the questionnaire administered to evaluate the effectiveness of different material types on motivation, the motivation levels of the participants differ significantly according to the type of material, and this difference is in favour of materials based on infographics. It is stated in the literature that the instructional materials designed as enhanced with design elements such as colour and figure increase motivation through the positive emotions they create in the learner and facilitate understanding (Münchow et al., 2017). According to the participants' opinions about the motivational effect of different teaching materials, the most effective material is the visual intensive infographics, while the weakest material is the text only material. The participants emphasized the fact that the materials based on infographics are understandable as they are simple and tangible and that they are attractive and enjoyable as they are enhanced with visual elements. On the other hand, they emphasized that the text only material is distracting and perceived to be long by the reader as it is complex and monotonous. In the relevant literature on this subject, it is stated that the elements of fluency and entertainment increase the attractiveness of the instructional material and positively affect motivation and support permanence (Alqudah, Bin Bidin & Hussin, 2019; Münchow et al., 2017; Young, Bridgeman & Herms-DeSantis, 2019). In the process of contributing to the sustainability of the learner interest, it is emphasized that the teaching material should be interesting (Noh et al., 2015) and fun (Ainley & Ainley, 2011). Metacognitive skills are related to planning, motivation, evaluation and regulation in ensuring motivation and regulating cognitive processes (Stark, Brünken & Park, 2018). In this context, it was stated that the use of visual-aided material attracts the attention of learners and positively affects their motivation and was remarked that learners complain about the length and complexity of traditional text-based teaching materials compared to multimedia applications.

To summarize, in reference to the findings obtained from the data of the current research, which was carried out to determine the difference between the academic achievement, cognitive load and motivation levels of the participants who had learning experiences based on different types of materials, a significant difference was obtained in relation to all the variables. This difference was found to be favour of the visual intensive infographics in all the variables. While the visual intensive infographics, as a simple, tangible and understandable teaching material, increased the level of motivation and achievement by providing attractive and enjoyable learning experience, reduced the cognitive load and time spent. On the other hand, the text-based teaching material, which the participants thought to be distracting and long, was the weakest teaching material in terms of all variables. Therefore, while the text only material provided instant learning for the participants, the visually intensive infographics provided a more effective learning experience and supported the meaningful learning process with their visual features.

In future research, the differences between the material preferences of groups can be examined by conducting similar studies with samples having different levels of readiness in terms of learner characteristics such as content knowledge, literacy skills and spatial skills which determine the effectiveness of multimedia teaching materials. The current study lasted four weeks. Therefore, it is limited in terms of ensuring information transfer and retention. Thus, longitudinal studies can be conducted to determine the state of information transfer and retention. In the process of learning with multimedia, due to the expertise reversal effect, the design that is effective at the beginning level may lose its effectiveness with increasing expertise of the learner. In this context, future research may examine this expertise reversal effect by presenting materials progressing from the text only to visually dense materials and from the visually dense to the text only materials. In addition, by making the participants achieve in the multimedia material design process, the effect of the design process on metacognitive skills can be investigated.

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