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| Research Article / Araştırma Makalesi |

Comparison of Visual Representations used in the Biology Units of 7th and 8th Grade Middle School Science Textbooks

Ortaokul Fen Bilimleri Ders Kitaplarının 7. ve 8. Sınıf Biyoloji Ünitelerinde Kullanılan Görsel Sunumların Karşılaştırılması

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Keywords

1. Visual Representations
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Anahtar Kelimeler

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Abstract

Purpose: This study was carried out to examine and compare the visual representations used in the biology units in 7th and 8th-grade middle school science textbooks with various criteria.

Design/Methodology/Approach: A document review model from qualitative data analysis was used for this research. The content and descriptive analysis techniques were used in the analysis of the textbooks. The code list used in this study consisted of five main categories, which were type of visual representation, surface feature of visual representations, captions of visual representation, the relation of visual representation with text, and function of visual representation.

Findings: As a result, visuals were used in different varieties and proportions according to the examined categories in both textbooks. The most common type of use was picture, followed by diagram. The examined rates of other subcategories of the categories were displayed in separate tables, as they showed differences at each grade level of the biology units. Highlights: When the findings were examined, it was found that the designs of the visuals in both textbooks and their relationships with the text were not sufficient to comprehend the biology subjects. For this reason, the biology content in these textbooks should be designed by taking into account the students' cognitive learning system, readability, and meaningful learning.

Öz

Çalışmanın amacı: Bu çalışma ortaokul 7. ve 8. sınıf fen bilimleri ders kitaplarındaki biyoloji ünitelerinde kullanılan görsel sunumları çesitli kriterler düzeyinde incelemek ve karşılaştırmak amacıyla yapılmıştır.

Materyal ve Yöntemi: Araştırma için nitel veri analizlerinden doküman inceleme modeli kullanılmıştır. Ders kitaplarının çözümlenmesinde içerik ve betimsel analiz teknikleri kullanılmıştır. Bu çalışmada kullanılan kod listesi görsel sunum çeşidi, görsel sunum yüzey özelliği, görsel sunum altyazısı, görsel sunumun metin ile olan ilişkisi ve görsel sunumun fonksiyonu olarak beş ana kategoriden oluşmuştur.

Bulgular: Sonuç olarak görseller her iki ders kitabında da incelenen kategorilere göre farklı çeşitlilikte ve oranlarda kullanılmıştır. En çok kullanım türü resim olmuştur ve bunu diyagram izlemiştir. İncelenen kategorilerin diğer alt kategorileri nin oranları ise biyoloji ünitelerinin her sınıf düzeyinde farklılıklar gösterdiği için tablolarda ayrı ayrı gösterilmiştir.

Önemli Vurgular: Bulgulara bakıldığında her iki ders kitabında da yer alan görsellerin dizaynlarının ve metin ile ilişkilerinin biyoloji konularını kavramada yeterli olmadığı bulunmuştur. Bu nedenle bu ders kitaplarındaki biyoloji içeriğinin öğrencilerin bilişsel öğrenme sistemi, okunabilirlik ve anlamlı öğrenmeyi de göz önüne alarak düzenlenmesi gerekmektedir

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INTRODUCTION

Textbooks are the primary education material that students and teachers use the most in educational settings since they reflect the curriculum and are easily accessible (Kesidou & Roseman, 2002; Unsal & Gunes, 2002; Yucel & Karamustafaoglu, 2020). For this reason, their design features of the content are a significant factor for learning. One of these design features of textbooks is the use of visual representations because many researchers has been agreed upon that using visual representations in the textbooks contribute to students' conceptual understanding and learning. Visual representations in textbooks mostly consist of many types including pictures, graphs, diagrams, tables, and equations and are useful in promoting scientific discourse especially in biology. As visual representations are the parts of science language discourse in biology, their appropriate usages have been a concern for the researchers (Akçay et al., 2020; Carney & Levin, 2002; Kozma & Russel, 1997; McTigue, 2009; Pekel, 2019; Wernecke et al., 2018). However, visual represenions have not been used consistently in the same form of design in biology textbooks. For this reason, many studies have been done to reveal the rates of usage different types of visual representations and the differences of their design features in each biology units, all which point to lack of standardization in their designs of visual representations with different rates of types usages, including missinformation and lack of labels and captions (Buckley, 2000; Pozzer Roth, 2003; Yilmaz et al., 2017; 2021). As the visuals representations, which are used in biology subjects, support learning and a standardized design feature has not been found in a biology unit of a textbook, this study was conducted to examine and compare the visual representations that were used in the biology units of the 7th and the 8th grade middle school science textbooks with various criteria.

As stated above, visual representations (in short: visuals) in biology are used in various forms and purposes in textbooks. Particularly, the use of visuals allows the concretization of abstract concepts and theories in biology, by illustrating elements from daily life, and showing images of biological structures (Buckley, 2000; Larkin & Simon, 1995). There are many more examples of usage of visuals in biology, such as creating theories, taxonomies, specifying and marking parts of anatomical structures, and showing connections between concepts (Ryoo & Linn, 2012). For instance; subjects such as genetics, ecology, and blood structure contain abstract concepts. Visuals have an important place in learning to make easier such difficult subjects by establishing visual connections with various shapes, formulas, and pictorial representations between the key concepts of such subjects (Wood, 1999). Thus, with variety of visuals shapes, students can see the entities of these subjects, make connections between these subjects, and learn more easily. Without visuals, students may have difficulties on their own to make sense of such abstract concepts (Yılmaz et al., 2017; Wernecke et al., 2018).

In order for students to learn the subjects meaningfully, the designs of the visuals in the textbooks should be designed according to the students' grade levels because the abstract concepts in the content are higher in upper grades (Pinto, 2002). It is not always easy for students to understand the visuals and they are not able to make comments and connections with the content (Kozma & Russel, 1997). Textbooks should clearly provide information about visuals in order to reduce the cognitive load that might occur while students are learning the visuals. The purpose of the visuals in the textbooks and their connections with the content should also be arranged in accordance with the principles of cognitive learning (Smith et al., 2021). For these reasons, this study was prepared based on learning with visual representations and the cognitive load theory.

Learning with Visual Representations

Visual representations (briefly visuals) play an important role in supporting learning (Bernard, 1990; Kozma & Russell, 1997; Cook, 2006; McTigue, 2009; Ryoo & Linn; 2012). For this reason, many studies have been carried out on visuals in science teaching and learning, especially in science textbooks (Buckley, 2000; Vojíř & Rusek, 2019).

Visuals in science, at all grade levels including higher education, are also used for many different purposes such as creating theories, solving problems, and transferring to other contexts. Understanding the sciences requires both understanding the text and comprehending the visual content. For example, radiologists, who need to be experts on biological structures, must be able to understand and interpret the image contained in the X-ray. For this reason, they are called visual experts (Wood, 1999). Ryoo and Linn (2012) stated that in biology textbooks, visuals of content in photosynthesis, matter cycles and ecological energy flows, are often are often emphasized using formulas and arrows. The abstractness of these subjects is often reduced through the use of diagrams, schematic and realistic drawings, or photographs. In a related study, middles school students' understanding of energy transformation in photosynthesis with dynamic and static descriptive visuals. Due to these functions of visuals in science, visuals are also included in many textbooks in many ways such as graphics, pictures, drawings, tables and concept maps (Kozma & Russell, 1997).

Important factors to help students understand visuals include the teaching technique with appropriate learning theories and the design of textbook content (Cook, 2006; Yılmaz, et al., 2017). The visuals in the textbooks should also be arranged by showing what they mean in a clear way for students to connect the meaning in the textual content with the meaning on the visual content (Pozzer & Roth, 2003). Some of the methods used to make these connections are captions and labels (Gkitzia, etal., 2011). Bernard (1990) stated that long captions have some facilitating effects on comprehension and learning of complex visuals such as graphics. Additionally, McTigue's (2009) study with middle school students showed that the middle school students had difficulty in learning the structures that make up the diagrams. Those middle school students understood the diagrams better when there were features that clarified its components of structures such as labels and captions. In another study, by labeling the elements in the diagrams, the students understood their functions better (Mayer & Gallini, 1990). It should be noted that visuals alone do not have sufficient effect on students' understandings but should be used in connections within the content as necessary through labels and appropriate captions (Peeck, 1993). In this way, students are able to understand what the visuals mean more easily instead of trying to understand by looking at the surface of the visuals alone (Bernard, 1990).

Another type of design technique is the use of indexing in the text such as using an expression like "Examine Picture 1”. This technique can help students establish a connection between the text and the visual. These expressions, which direct the reader from the text to the visuals, help the integration of the text and the visual (Pozzer & Roth, 2003). Similarly, indexes such as “Picture 1” should be included in the visuals’ captions in order to fully establish the connection between the text and the visuals. Studies on visuals indicate that presenting pictures and without any linkage to the texts can cause students' attention to be divided (Mayer & Moreno, 1998). Linking the visual to the text with some textual explanations with indexes can reduce or eliminate this distraction. Students become distracted by looking at the text and the image over and over when they do not make an immediate connection between them This is also called the split attention effect and one of the cognitive load types (Mayer & Moreno, 2003; Sweller, et al., 2019). The cognitive load theory is explained later in the next section.

Moreover, Pozzer and Roth (2003) stated that the purpose for using visuals in the text, namely its function of the visuals contributes to sense making. Their study revealed that the visuals were used in biology subjects for four different purposes: decorative, illustrative, explanatory and complementary. These four functions were used as the last category in the analysis in this study to reveal the functions of the visuals in the Turkish textbooks.

Cognitive Load Theory and Instructional Materials

The cognitive load theory explains the method of storing and learning information. In particular, the way, which learning materials are presented, has some effects on learning. For this reason, many studies on cognitive load theory have been conducted to show the effects of instructional materials (Mayer & Moreno, 2003). Among these studies, the cognitive load theory and visuals were examined according to the method of the connections of visuals to text their effects on learning (Vojíř & Rusek, 2019).

John Sweller explains in his study that the durations and limits of storing information of long term memory and working memory in the cognitive structure of learners’ memories are different from each other (Sweller, 1988). Working memory has a limited memory and processes all conscious activities in a limited capacity; however, long-term memory is unlimited and uses changing schemas to automatically store schemas effectively. During cognitive functioning, schemas, which can be numerous and complex, need to be configured. Schemas are formed by bringing together relevant parts of multiple pieces of information and removing irrelevant parts. When students try to learn more than one piece of information at the same time, they can create cognitive load because the capacity of the working memory is limited. Removing irrelevant information is called the "consistency effect." By removing the irrelevant parts, empty places in the working memory are created; which would otherwise be due to its limited capacity (Sweller, et al., 1998; 2016; 2019).

Sweller further recommends designing educational materials’ textual and representational content in relations to each other. Materials with related content play a role in reducing the cognitive load and improve learning (Sweller, 2016). For this reason, the design of the visuals is important because they have an effect on students’ cognitive load depending on the way they are presented, their nature, and how they are designed (Mayer & Moreno, 2003; Cook 2006,). While students learn with visuals, the content should be designed in such ways that provide some links between the textual content and the visuals. Otherwise, the visuals, unrelated to the texts, can overwhelm the capacity of working memory as unrelated information, which are able to cause extra information in the working memory. Therefore, the cognitive load theory suggests instructional materials and related student activities that help process information to optimize cognitive capacity and process (Sweller et al., 1998; 2019).

It is stated that students come across three different cognitive loads while learning with instructional materials (Sweller, 1988; Sweller et al., 1998; Cook, 2006). These are intrinsic cognitive load, extraneous cognitive load, and germane cognitive load. The sum of these three types of load constitutes the total cognitive load, and their sum should remain within the capacity of the working memory.

Intrinsic cognitive load is related to the nature of the subject to be learned. For example: if the subject is difficult and visual representations and textual connections require interaction with another discourse, the internal load increases and it has potential to exceed the capacity of working memory. In this case, learners experience difficulty in learning (Sweller, 1988; Cook, 2006).

Germane cognitive load occurs in the processes of creating and editing schemas. The capacity of the internal load does not change, and unlike the internal load, the germane cognitive load includes the external load which affects the quality of the instructional design. For this reason, instructional designers' controls of external load can optimize learning (Sweller, 2016).

Extraneous cognitive load is related to the way of information that is presented to students, and the quality design feature of the teaching material. Since the capacity of working memory is limited and the internal load is in a determined capacity and its capacity does not change in the working memory; in order to increase the working memory capacity, the teaching materials should be designed in a way that does not force the cognitive load capacity by especially considering extraneous cognitive load. For example, images should be in connection with the text in one piece of information other than separately as two pieces (Sweller et al., 1998; Sweller; 2016).

Importance of the Study

Textbooks are fundamental teaching materials, that students can access information from which are primarily used in lessons throughout their education life (Chambliss & Calfee, 1998). They are especially important in countries such as Turkey which has a central education system and where the most of students go to public schools (Kahveci, 2010). The contents of the textbooks should be arranged in a way that enables students to learn meaningfully with combination of visual representation with the text (Pekel, 2019; Pozzer & Roth, 2003). For this reason, the design of the visuals in the textbooks is important.

Due to the importance of textbooks in teaching and their possible shortcomings, many studies have been carried out to examine the qualities of textbooks. The most common types of research on science textbooks include revealing the distributions of visual representations based on their types (pictures, diagrams, etc.), counting and showing different types of representations in a specific topic (Slough et al., 2010; Ge et al., 2018; Parthasarathy & Premalatha, 2022). In addition, as previously discussed, functions of visuals have been studied in biology textbooks (Pozzer & Roth, 2003; Utami & Subiantoro, 2021).

The studies specific to Turkey include the examination of chemistry images in the high school textbooks using various criteria (Kapıcı & Acıkalın, 2015). In biology, the method of inclusion of visuals in the nature of science in textbooks was also examined (Irez, 2009). Further, the misconceptions in the visuals of the certain biology units in Turkey have been determined (Yılmaz et al., 2017; Pekel, 2019). Another study has looked at visuals in the middle school science textbooks to find out the proportions of the categories such as the gender of the scientists and the captions of visuals (Kahveci, 2010; Karacam, et al., 2012). However, a study has not been conducted to determine and compare the design of visuals on the biology subjects in the middle school textbooks in the 7th and 8th grade textbooks in Turkey. This type of study is necessary because the inappropriate use of visuals has been concerns of research in Turkey and many inappropriate usages have been found in certain topics with particularly a limited visual design category in the middle school science textbooks (Akçay et al., 2020; Pekel, 2019; Yilmaz et al., 2017; 2021). Consequently, it is essential to examine the visuals' design features of biology topics in science textbooks with various categories to show how their designs were and how inadequate designs might affect learning with visuals. The biology units in the 7th and the 8th grade science textbooks are cognitively connected together (Sternberg, 2003). Therefore, this study is important to show the qualities of design features and effects and restrictions on learning of visual representations of biology units at these grade levels textbooks. The following research question was used in this study:

What are the differences between the designs of the visual representations used in the biology units in the 7th and the 8th grade science textbooks?

METHOD

In this study, the qualitative design research method is used following the document review model. This method reveals descriptive and in-depth information of the content that allows documents to be examined with themes and codes (Yıldırım & Şimşek, 2003). In this study, this method was preferred because it was suitable for the aim of the study to examine the visuals with appropriate codes under the certain categories.

Textbook Selection

The purpose of this study was to examine the visuals in the biology units of the 7th and 8th grade science textbooks used in Turkey. The main data collection sources in the study were selected by the purposeful sampling.

The middle school science textbooks taught in the 2020-2021 academic year were selected and the visuals in the units belonging to the biology subjects were analyzed.These books were designed to use for some following academic years for the whole country. Since the connections of the visuals with the text would also be examined, all the visuals used in the content of the subject were selected in the process of determining the visuals. As the usage of visuals by the same publishers were similar, different publishers were selected to show how visuals were designed at both of grade levels. Thus, more examples of design features of representations revealed in different textbooks. The visuals in the questions at the beginning of the unit, at the end of the chapters and at the end of the units were excluded from the analysis becuase they did not match in terms of content. For these reasons, only the visuals in the textual content were examined. The units used in the analysis in the 7th and the 8th grade textbooks are given in Table 1 below.

Table 1. The information of Units and Publishers

Grade Level	Unite Name	Pages	Publisher
7	Unit 2: Cell and Divisions	44-73	MEB
	Unit 6: Reproduction, Growth and Development in Living Things	184-202	
8	Unit 2: DNA and the Genetic Code	37-73	SDR Dikey
	Unit 6: Energy Conversions and Environmental Science	185-223	

Data Analysis

Descriptive and content analysis techniques were used to examine the textbooks. The content analysis is an analysis technique that allows determination of codes and their categories in the documents by calculating their percentages and frequencies of the codes (Silverman, 2001). Descriptive analysis also allows reusing the codes in the literature (Yıldırım & Şimşek, 2003). In this study, the visuals in the biology units of both textbooks were coded with the categories, and their percentages and frequencies were calculated. Some of the codes, which were previously used in similar textbook analysis, adapted to analyze of visuals for this study.

The coding list was created as a result of various methods. The first category, "type of visual representation", was created with the content analysis of the visuals in the textbooks by comparing the visuals' types' differences and similarities in each textbooks. Three other categories were adapted from Gkitzia et al. (2011). These are surface features of the visuals, the captions, and the relatedness to the text**.** The other two categories from Gkitzia's (2011) study, "connection between multiple representations" and "multi-representation types", were omitted because they were specific for images on chemistry subjects and did not match the visuals used in the biology subjects of the selected textbooks. The category named "the function of the visual" used by Pozzer and Roth (2003) in the analysis of the visuals in the biology textbooks was adapted to analyze the visuals' functional properties.

The reliability and the validity of the codes were determined by face validity through taking opinions from two other researchers in the relevant field (Yıldırım & Şimşek, 2003). The previous use of four of the categories added provided content validity to the study. In their study, Gkitia et al (2003) determined the appropriateness of these codes was determined and a refined using the result of the pilot analysis. For coding reliability, the author coded the images twice with a one-month break. Two different researchers also coded 20% of the images. Reliability was approximately 89% (Miles & Huberman, 1994). The discrepancies were coded again by discussion until consensus was reached. The coding was was compiled in an excel spreadsheet and the percentage and frequency values calculated. Further analysis was carried out using the SPSS 21 program.

Coding List

The coding list includes five main categories which consist of types, surface features, captions, relatedness and functions of visual representations. The first category is the type of visual representation created after analyzing the types of representations found in the two textbooks. This category includes five subcategories: pictures, diagrams, tables, graphs, and equations. It is important to note that the pictures subcategory included photos, regular pictures, and drawings because their function is similar in general.

The second category is the surface feature of visual representation i.e clarity and meaning of surface features are presented on a representation. This category includes three subcategories: (1) ambiguous, (2) implicit, and (3) explicit. The ambiguous feature means that the surface of the representation is not clear, does not adequately represent the explanations in the text, and does not include labels and captions. Implicit means visuals that are clear but lack sufficient labels and captions. Visuals without labels and captions were also coded as implicit because the shapes and images on them were basic and at times unconnected to the content. The explicit feature means that learners can understand the meaning of the visual through labels and captions and the visual and the concept are well represented. To adapt the visuals to the analyzed textbooks for this study, some of the visuals withouht labels and captions were also coded as implicit because the visuals had some basic images and drawings on them which showed some relation to the textual content.

The third category is the caption of the visuals. This category was evaluated with three sub-categories: (1) not available, (2) short/problematic captions, and (3) appropriate captions. Pilot analysis showed that some visuals did not have captions. In addition, some of them were used like labels to express only the name of the visuals. The indexing was also problematic. Indexes were also absent in many of the long captions. However, the captions, those with some long descriptions and explanations, were coded as appropriate to adapt the codes for this study in order to provide a degree in between codes of the design of the visuals. Therefore, the coding was adapted in this way for this study.

The fourth category is the relatedness to the text. This category had five subcategories including (1) not related partially, (2)related and unlinked, (3) partially related and linked, (4)completely related and unlinked, and (5) completely related and linked. The degree of connection of the visuals was determined by the presences of expressions in the text such as “in the picture below” and indexes (in Table 1, as shown in Picture 1).

The fifth category is the function of the visual representation. This category had four subcategories: (1) decorative, (2) illustrative, (3) explanatory, and (4) complementary. First, “decorative visuals” means that the visual does not have captions and indexes in the text, and its direct description is not included in the text. The second subcategory, illustrative, are the visuals with short captions. In the absence of captions, such visuals were coded as illustrative by looking at the expressions in the textual content such as “as shown in the picture” or there needs to be matching the description with the visual in the text . This was also for the adaption the codes to this study. The third subcategory, explanatory, means that visuals have long captions that provide descriptions or explanations. The fourth subcategory, complementary, means that visuals have more detailed descriptions and labeling that provide more information to the text.

FINDINGS

According to the results of the analysis, different values were found in the 7th and 8th grade biology units for each category. The frequencies and percentages of the number of types of 7th and 8th grade visuals obtained as a result of coding each category of biology units are presented in Table 2 below.

Table 2. Frequency and Percentage Values of Types of Visual Representation

Types of Visual Representation	7th Grade Textbook		8th Grade Textbook	
	f	%	f	%
Picture	46	63.9	85	70.2
Diagram	25	34.7	26	21.5
Table	1	1.4	6	5.0
Graphic	-	-	1	.8
Formula	-	-	3	2.5
Total	72	100	121	100

As shown inTable 2 the 8th grade textbook had more visuals in the biology units than the 7th grade ones (f:121 and f:100). The varieties of visuals were also used in the two textbooks in different proportions. There was more variation in the 8th grade textbook, with few graphics and formulas. The amount of pictures in were higher in the eight grade textbook (70.2% versus 63.9%) as were tables (5% vs 1,4 %). However diagrams used in the 7th grade textbook were higher than the 8th grade textbook (34.7% vs. 21.5%). While formulas and graphics were used in the 8th grade textbook (.8% and 2.5% respectively), they were not found in the 7th grade textbook.

The frequencies and percentages of the number of surface features are presented in Table 3 below:

Table 3. Frequency and Percentage Values of Surface Features Analysis

Surface Feature	7th Grade Textbook		8th Grade Textbook	
	f	%	f	%
Ambigious	4	5.6	8	6.6
Implicit	23	31.9	56	46.3
Explicit	45	62.5	57	47.1
Total	72	100	121	100

As shown in Table 3, ambigious visuals in the 8th grade textbook were slightly higher than that of the 7th grade (6.6% vs. 5.6%). In addition, the type of implicit surface was found to be higher in the 8th grade textbook than in the 7th grade textbook (46.3% vs 31.9%). On the other hand, the explitcit visual type was found at a higher rate in the 7th grade textbook than in the 8th grade textbook (62.9% vs. 47.1%).

The frequencies and percentages of captions are presented in Table 4 below:

Table 4. Frequency and Percentage Values of Caption Analysis

Captions	7th Grade Textbook		8th Grade Textbook	
	f	%	f	%
Not avaiable	9	12.5	91	75.2
Short	45	62.5	9	7.4
Appropriate	18	25.0	21	17.4
Total	72	100	121	100

As shown in Table 4, the most of the visuals in the 8th grade textbook fell in the “not available” subcategory (f:91, 75.2%). In contrast the 7th grade textbook in this subcateogry was found to be quite low (12.5%). The rates of short captions were found to be higher in the 7th grade textbook than in the 8th grade textbook (7.4% vs. 62.5%). Appropriate captions of the long and descriptive type were found to be more in the 7th grade textbook than the 8th grade textbook (25.0% vs. 17.4%).

The frequencies and percentages of relatedness of the visuals to the text are presented in Table 5 below.

Table 5. Frequency and Percentage Values of the relatedness to the text analysis

Relatedness to the text	7th Grade Textbook		8th Grade Textbook	
	f	%	f	%
Not related	-	-	-	-
Partially related and unlinked	4	5.6	8	6.6
Partially related and linked	10	13.9	49	40.5
Completely related and unlinked	52	72.2	34	28.1
Completely related and linked	6	8.3	30	24.8
Total	72	100	121	100

As shown in Table 5, the 2nd subcategory, partly related and unlinked, was found in approximately similarly proportions to the both textbooks (6.6% and 5.6%). The third subcategory, partially related and linked, was higher in the 8th grade textbook than the 7th grade textbook (40.5% vs. 13.9%); The fourth subcategory, completely related and unlinked code, was quite higher in the 7th grade textbook thanthe 8th grade textbook (72.2% versus 28.1%). The ratio of the last subcategory, completely related and linked codes, was found as higher in the 8th grade textbook than in the 7th grade (24.85% vs. 8.3%).

The frequencies and percentages of the function category are shown in Table 6 below.

Table 6. Frequency and Percentage Values of Function Analysis

Functions	7th Grade Textbook		8th Grade Textbook	
	f	%	f	%
Decorative	5	6.9	8	6.6
Illustrative	49	68.1	73	60.3
Explanatory	5	6.9	22	18.2
Complementary	13	18.1	18	14.9
Total	72	100	121	100

As shown in Table 6, the visuals used for decorative purposes were found as close to each other in the both textbooks (6.9% and 6.6%). The proportions of visuals used as illustrative were found to be slightly higher in 7th grade textbooks than 8th grade one (68.1% and 60.3%). While the visuals used as explanatory were found more in the 8th grade textbook compared to the 7th grade textbook (% 18.2 vs. %6.9%), the proportions of complementary visuals were slightly higher in the 7th grade textbook than in the 8th grade textbook (18.1% vs. 14.9%).

DISCUSSION

This study was conducted to reveal and compare the design fetures of visual presentations used in biology units of the 7th and 8th grade science textbooks. The visuals coded with the categories and their subcategories were examined in t both grade levels. The results showed ratios of design features based on the codes of the visuals differed in the both textbooks.

First of all, the proportions of the visuals' types were found similar in the both textbooks. The most commonly used visual type was found as the pictures. The pictures were used in higher numbers than the diagrams in both textbooks (about 70% in both textbooks). Diagrams are important visuals for biology content because they provide more information than pictures, as they show the structural parts of the visuals and the connection between the parts (Ge et. al, 2018; Larkin & Simon, 1995; Utami and Subiantoro, 2021). Thus, the use of diagrams should be more, especially since as mentioned earlier diagrams show the parts that make up the biological structures and make easier for students to understand those structures (Mayer & Moreno, 2003; Yılmaz et al., 2017; 2021). Lastly, there were found some grahics and formulas in the 8th grade level textbooks in the biology units. Tables could show main information all together; therefore, using different types of representations could be more beneficial to students (Akçay et al., 2020). Not having formulas might be because of the nature of Biology.

Considering the visual surface ratios' results examined in the second category, the ratios of visuals described as explicit in the 7th grade textbooks were more than the 8th grade visuals. Surface features should present what the images mean and the explanations as described in the text. In particular, the labels and captions on the images provide information about what the images mean (Pozzer & Roth, 2003). This result overlapped with Pekel (2019) study. In his study, Pekel found that the images were not labeled appropriately in the 8th grade science textbook. Since it might be difficult for students to try to understand which information the visual represent just by looking at the visual without such labels and captions, the 8th grade visuals with an implicit surface structure would probably increase the cognitive load (Sweller et al., 2019). For these reasons, the 8th grade textbook was found to be more inadequate in this category than the 7th grade textbook in terms of students' understanding of the visual surfaces.

The caption category's findings, which were similar to visual surface results, were found to be higher in the 7th grade textbook than in the 8th grade textbook. 75% of the visuals in the 8th grade textbook had no captions. In addition, the appropriate captions in both textbooks were low. Considering the general characteristics of the captions, there were not enough index expressions such as "Picture 1" or "Diagram 1" in both grade levels of the textbooks. The index expressions direct students to images and help them connect to the text, clarify the image, and so reduce the cognitive load (Pozzer & Roth, 2003). Not having captions would probably cause attention split effect so would cogntive load (Mayer & Moreno, 1990). As mentioned before, captions provide information about how the image is used for and add meaning (Bernard, 1990). Therefore, lack captions and problematic captions were likely to cause an increasement in the externous cognitive load. This is because visuals might not be adequately comprehended by students, as it might not provide the integration of the visuals with the text (Sweller, 2019).

The fourth category, relatedness to the text, revealed some differences in the both textbooks. The rates of the subcateories showed variation for both textbook. There were similarities in the way that visuals contained multiple features but only one feature was described in the text. These caused low relatedness codes. Also pictures were used where fuaframs of tables would have been more appropriate in increasing the relatedbess. Studies have shown that students have the most difficulty in learning the concepts in biology; however, when the images representing the concept in the textbooks are used appropriately, it is easier for students to learn these concepts (Pozzer & Roth, 2003; Yılmaz et al., 2017). Such inadequate connections and unrelated visuals are also likely to impose a cognitive load on students as the unrelated information increases the capacity of working memory and could cause cognitive load thus it could be possible for students to have difficulties in learning of the visuals in both textbooks (Sweller et al., 2019).

The last category was the function of the visuals. The rates of visuals as illustrative in this category were found to be higher in the both textbooks than in other subcategories (68.1% and 60.3%). The use of visuals in the textbooks as an illustrative might help students see what the biological structures were. Thus, students could easily access the subject described in the content with examples and what these biological structures were in the subjects, and so, they might not need to imagine this structure in their minds themselves (Pozzer & Roth, 2003). Contrary to Pozzer and Roth's (2003) definition, some of the images coded as illustrative did not contain captions and labels. However, in this study, they were coded as illustrative because there were similar expressions or definitions related to the visuals that were found within the text. If students did not read these expressions in the text carefully, these pictures would remain as decorative for them. These type of visuals might create a cognitive load on them as they would be extra information unrelated to the text and would force the limitation of working memory (Sweller et al., 2019). In addition, the possibility of not having captions in such visuals and the effect of distraction should also be considered for possibility of causing cognitive load (Mayer & Moreano, 2003). These results showed that the functions of the visuals were used as quite basic, the more informative functions of the visuals were not included in the textbooks in sufficient quantities, and some of the visuals had the potential of causing cognitive load and diminish learning. Visuals had low complimentary and explanatory categories which can have negative consequences to learning (Mayer & Moreano, 2003).

As described aboves, visuals were used in different types and proportions in each category in both textbooks. The visuals were not used in a standardized design in each textbook. This was demonstrated by the variations in each category. The use of visuals in different textbooks in comparable patterns as well as their intergration with text is important for students to comprehend and learn biology subjects meaningfully (Pozzer & Roth, 2003). In particular, visuals should be given clearly in connection with the text; thus, students do not develop cognitive load while learning with visuals (Sweller, 2016; Sweller et al., 2019). Considering the findings, the designs of the visuals in the biology units in the both textbooks had some insufficient visual designs in terms of teaching and learning quality since some of the visuals were highly likely to bring cognitive load to the students.

CONCLUSIONS RECOMMENDATIONS AND LIMITATIONS

This study was carried out to reveal and compare the designs of the visuals used in the biology units of the 7th and the 8th grade textbooks. In the light of the findings, some suggestions were made in this study that will be helpful in improving future versions of the textbooks. The findings obtained as a result of the study showed that the visuals in both textbooks could cause cognitive load for learners. More in depth learning could occur if more attention is paid to the design of visuals e.g clearly labeling the parts of a biological structure that are described within the text, including vivid and clear captions, etc.

Another factor, which should be considered on the design of the textbooks, was the lack of indexing. Indexing was an emerging category could be used in the future studies. Indexes are expressions that can guide students to make a connection between the text and the visuals which should have numbers in the text with relevant caption. In order to establish connection between the text and the visuals and not to create an external load, the use of indexing in a standard method that can provide the link that should be included both in the text and in the images.

Finally, the functions of the visuals were also examined in this study and these functions were mostly found as illustrative. Considering the functions of visuals that have potential to increase learning, more sophisticated ones like explanatory and complementary functions should be included more in textbooks. Apart from these codes, more codes can be analyzed by considering criteria such as the places of visuals in the content and indexing.

This study shows the importance of taking students' learnings theories should be taken into considerations while designing the visuals. In particular, visuals should be designed with the intent of reducing the cognitive load that may occur while learning In this study, visuals were coded using categories firmly grounded in the cognitive load thoery whose importance should be used in future studies for the benefit of the learners.

One limitation of the study was that the visuals were analyzed by reading the content and each visual was analyzed carefully during coding, which took long time. Therefore, lower grades, 5th and 6th grade levels, were not coded for this study. This is one of the limitations of this study. By examining the 5th and the 6th grade level textbooks of biology units, students can benefit more from the content of the textbooks. This kind of study can be recommendation for the future studies.

Another limitation was that actual visuals from the textbooks could not be displayed in the study. This is because a funding was not received for this study to pay for copyright permission. However, in future studies, this kind of study can be prepared as projects for getting funds and code samples can be explained on the visuals for future researchers.

In conclusion, textbooks are the primary educational materials for students from all diffferent economical levels. For this reason, the content of the textbooks should be arranged by taking into account primarily cognitive learning theories, readability, and meaningful learning. There are many studies about the analysis of textbooks for different purposes in the literature which continue to increase interest among research. More textbook analysis studies have been carried out in the USA and Europe than in other countries including Turkey (Vojir & Rusek, 2019). As the concepts in biology are difficult to learn (Yılmaz et al., 2017), textbook analyses should be done with the same rigour worldwide to increase quality of textbooks. In addition, in-service training should be given to teachers on the use of the visuals in the textbooks with the correct design. Such studies involving visuals in biology will increase the instructive quality of the textbooks which will be of benefit to students, curriculum developers, and teachers.

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Statements of publication ethics

I hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Ethics Committee Approval Information

In this study, the document analysis model, one of the qualitative research methods, was used to analyze the visual representations' usage rates according to determined categories. Thus, ethics committee approval was not required for document analysis research.

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