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Analysing Science Questions in terms of Visual Content in Higher Education Entrance Exams in Turkey

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Abstract

The aim of this study is to analyse the science questions in terms of visual content in the higher education entrance exams in Turkey. In this context, 1714 questions in total prepared by the Center for Measurment, Selection and Placement (CMSP) between 1999 and 2019 in the fields of Physics (n=631), Chemistry (n=553) and Biology (n=530) constitute the data source of the study. This study includes case study which is one of the qualitative research patterns. The data of the study are analyzed by descriptive analysis based on the visual content of questions according to the fields of science, their years and their roles in solving questions (partial role and full role). According to the results, the science questions: i) are concentrated on greatly physics in terms of visual content compared to biology and chemistry on the basis of fields; *ii)* although visual content varies slightly over the years in terms of its type, the formatted drawing image is used quite a lot compared to other types; *iii)* formatted drawing and measurement diagrams in the field of physics in many years, formatted drawing and graphics in the field of chemistry , and flowchart and graphics in the field of biology have been largely included and i*v)* the role of visuals in solving the question has been partial in physics in many years, and in chemistry and biology it has been found to have a partial role in some years and in some cases it has a full role. As a result of the study, it is understood that the science questions applied to students at the entrance to university in Turkey do not show a balanced distribution in terms of visual content type on the basis of fields.

Keywords: University Entrance Exams, Science Questions, Visual Representations

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INTRODUCTION

Science literacy for all students has been the target of many national and international reforms for more than two decades. The need for nations' science literacy is considered to be crucial to change especially between national and international exam scores and the unsuccessful outlook (Dupuis & Abrams, 2017). Exams often cause many students to be more stressful than ever before. Furthermore, students build their hopes on good exam results. Therefore, many students think that exam results are an important step in determining their life in the future (Setiawan, Garnierand & Isnaeni, 2019). It is aimed to understand what students learn, what they do not know well, or to be able to produce solutions to them by determining what kind of misunderstandings they have (Bulunuz, Bulunuz, Karagoz & Tavsanli, 2016). These exams, which are applied to make a judgment about students' learning levels, determine to what extent they are succesful in their intended achievements (Lidar, Lundqvist, Ryder & Ostman, 2020). These exams are examples of countries' high school and university entrance exams, as well as international exams such as PISA and TIMMS. These exams aim to summarize the achievements of the students in the learning process. The main logic in these exams is to understand the different modes that formulate the science language (He, Barrera-Pedemonte & Buchholz, 2019; Wiberg & Rolfsman, 2019). Furthermore, the science language of exams is an integration of texts, visual images (diagrams, images, graphics, maps, tables, charts) and mathematical expressions (Anagnostopoulou, Hatzinikita & Christidou, 2012a). However, evaluating student success in science is to test their knowledge both textually and visually (Dupuis & Abrams, 2017). Students have to accurately interpret what is requested in the questions and effectively pass on their scientific knowledge in order to succeed in the tests (Yeh & McTigue, 2009). In particular, students should use these skills at the highest level in science questions with visual content. Students need an in-depth understanding of knowledge in order to solve questions of science with visual content (LaDue, Libarkin & Thomas, 2015). Students use this information to interpret various forms of images in questions (Saß, Wittwer, Senkbeil & Koller, 2012).

The standard national tests are very important to evaluate students' science achievement and to increase the quality of education in the national context. Today, these tests influence the teaching way of teachers and students' learning in many countries (Anderson, 2012). Because both teachers and students have to respond in accordance with the standards of the exams. To put it simply, this means adapting the teaching content to the things tested (Hamilton & Berends 2006; Lidar et al., 2020). The standard science tests aim to evaluate both verbal and visual communication skills of student. This is because students both should interpret the task demands of the test correctly and should be able to transfer their scientific knowledge effectively in order to be successful in such evaluations (Yeh & McTigue, 2009). Therefore, it is necessary to configure the science teachers, the teaching process and course materials to support students to interpret science questions correctly in both national and international standardized tests (LaDue et al., 2015; Moon, Brighton, Jarvis & Hall 2007). University exams are the turning point in the career choices of students in the field of science in Turkey. In order for students to solve science questions in these exams, they must have an in-depth understanding of knowledge in the field and the ability to analyze many conceptual relationships when they graduate from high school. Since science questions require a wide range of knowledge and a connection between fields on many subjects, it is understood that it is the field where students have much difficulty in exams (She, Stacey & Schmidt, 2018). Moreover, science is the field where students answer questions at the lowest average in the annual university entrance exams in Turkey. These underachievements of students in the field of science are associated with many factors such as teachers, schools, resources and family. However, the effect of the structure of science questions on students' success in these exams is often overlooked.

The researches on the exams in Turkey are largely focused on questions in the secondary school to high school entrance exams and international exams such as PISA ve TIMSS (Atalmis, Avgin, Demir & Yildirim, 2016; Incikabi, Pektas & Sule, 2016; Turkoguz, Balim & Bardakci, 2019). It is seen that the international literature is particularly focused on the question structures in the university entrance exams (Borji & Sánchez, 2019; Kuramoto & Koizumi, 2018; Mohammadi, Moradi & Goldasteh, 2019; Rodrigo, Penas, Miyao & Kando, 2018). In these studies, science question structures are mostly evaluated in terms of compliance with teaching programs. However, it is understood that the studies evaluating the textual and visual content structure and function in the questions remain in a very limited number. It is seen that the studies, which examine questions in terms of visual content in particular, are very limited (Anagnostopoulou, Hatzinikita & Christidou, 2012b; Yeh & McTigue, 2009). Moreover, despite the importance of these exams upon Turkish society, it is appeared that the researches on science questions in the university entrance exams in Turkey remain very limited (Altun, Sendur & Alpat, 2016). However, it is understood that there is not any study examining science questions in terms of visual content conducted so far. This study contributes to the improvement of science questions in terms of visual content in the university entrance exams which will be continued to be applied at a national level in Turkey in the future. The study aims to examine the science questions in the university entrance exams in Turkey in terms of visual content. In this context, the main question in the study is: What are the visual content structures of science questions in the university entrance exams between 1999 and 2019 in Turkey? The sub-questions that lead to the work in line with this main question are as follows:

1. Are there any differences in the fields of science in the case of the visual content of the questions?

2. Is there a difference in the distribution of questions over the years in terms of visual content type?

3. Is there any difference in the distribution of the visual content status of the questions according to the science fields over the years?

4. Is there any difference in the distribution of the questions in terms of visual content type according to the science fields over the years?

5. Are there any differences in the distribution of the role of the image in solving the questions according to the fields of science over the years?

Science Tests

Tests are used as the primary tool to evaluate the success of science education and to develop more effective educational programs (Sievertsen, Gino & Piovesan, 2016). Legislators and administrators in the community believe that the results of the tests are a reliable indicator of the knowledge that students have and their ability to use it. The assessments on student success in the field of science play an important role in changing the unsuccessful views of countries' science education policies (Lee & Stankov, 2018; Liou, 2017; Said, 2016; Shi, He, Wang, Fan & Guo, 2016). In addition, the science tests applied by the countries themselves make it possible to compare the individual performances of the students nationwide. These tests are often used to draw conclusions to understand learning outcomes in science courses that students receive at various class levels (Lofgren & Lofgren, 2017). Moreover, these tests are used to measure and monitor students' academic progress (Hursh, 2001; Dupuis & Abrams, 2017; Visone, 2010).

The Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), which are applied to evaluate the knowledge and skills acquired by students in the field of science, are the most important international exams. These exams are seen as a mirror of the education systems of the countries. Today, the results of these exams have become an important factor in the design of more effective education models in countries (Feniger & Leifstein, 2014; Grey &Morris, 2018; Yemini & Gordon, 2017). Moreover, the educational models of the countries overachieved these exams are examined by other countries. Therefore, countries plan their education policies by taking the example of the countries that are successful in these exams. International monitoring studies in education allows countries to see their situation and compare them to those of other countries. In this context, the results of international exams such as PISA and TIMSS are used as an instrument for improvements in education and policy-making. Among these exams, PISA, which is conducted to determine the science literacy competencies of 15-year-old students, is considered to be the most remarkable exam. 79 countries in total and more than 600,000 students participate in the PISA 2018 survey. The average scores of countries and economies in the field of science vary between 336 and 590 in PISA 2018. The countries with the highest success in this field are Singapore, China, Estonia and Japan. Science literacy defined within the scope of PISA research is considered as the ability of students to engage with science-related issues and to reflect on scientific facts. PISA science literacy includes the ability to explain facts scientifically. This exam requires students to remember their knowledge of a given condition and use their knowledge to interpret the facts associated with this condition. Students with this proficiency are expected to define, use and create descriptive models and representations. The science content areas in PISA 2018 include "Physical Systems", "Systems related to Living", and "Earth and Space Systems". The exam is held as computer-based with 6890 students from Turkey. When the class-level distributions of students in the sample of PISA 2018 in Turkey are examined, it is determined that 78.8% of the students continue to study in the 10th grade, 17.7% of the students continue to study in the 9th grade and 2.9% of the students continue to study in the 11th grade. According to PISA 2018 results, Turkey has made big progress in science literacy compared to the 2015 PISA results. Turkey has been one of three countries among OECD countries that have statistically significantly increased their scores in all three areas. Turkey, ranked the 54th in science literacy in PISA 2015 research, has moved to the 39th place in PISA 2018 research. Turkey has significantly increased its performance compared to 2015 and also increased its average score from 425 to 468. Turkey (0.3%) is above the OECD average (0.7%) in terms of the proportion of students below the 1b proficiency level of the students displaying the lowest performance in science literacy. The students in Turkey are (4.7%) in the level 1b, (20.1%) in the level of 1a, (32.8%) in the 2nd level, (27.3%) in the 3rd level, (12.3%) in the 4th level, (2.3%) in the 5th level and (0.1%) in the 6th (Ministry of National Education, 2019). In each cycle of PISA studies, an area is chosen as an area-weighted field and in-depth analyzes are performed in that area. In this context, the field of science literacy is chosen as weighted field in the PISA 2015 research. OECD has published some of the science questions asked to students in PISA 2015 on its website. It is understood that the shared questions consist of many different topics and various difficulty levels. Moreover, it is understood that the questions are supported by different visuals. A visually supported sample question about "Fossil Fuels" is included in Figure 1 (OECD, 2015).

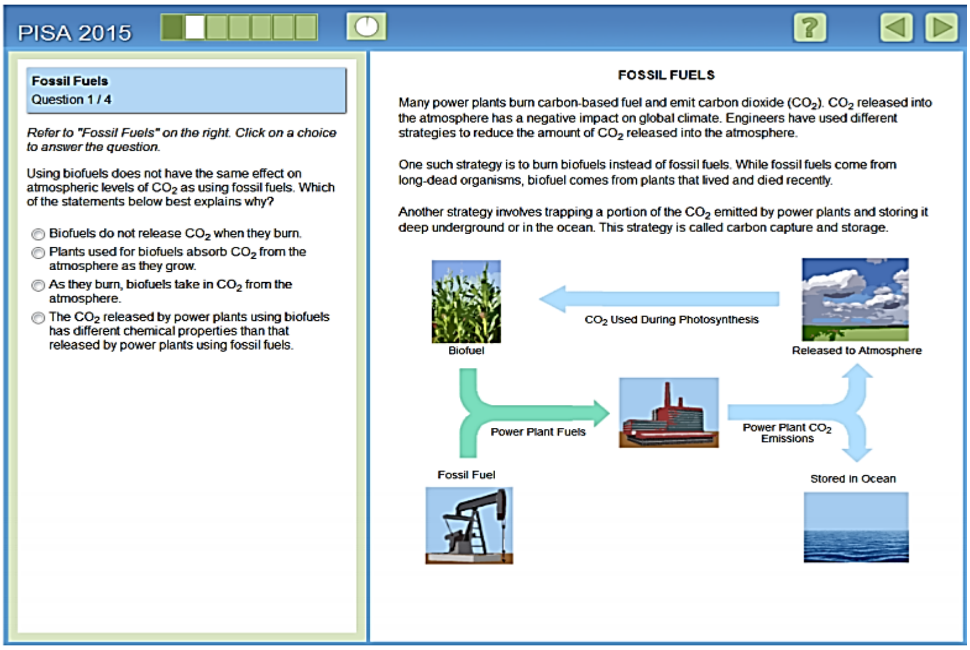

Figure 1. An example of the science questions asked to students in PISA 2015

Student Selection Exams for University in Turkey

In many countries, students have to take student selection exams to enter college after graduating from high school (Konecny, Basl, Myslivecek ve Simonova, 2012; Kusayanagi, 2013; Borji & Sanchez, 2019; Zhang, 2016; Zhang, Chen & Wang, 2014). The university entrance exams in Turkey have taken various names such as the student selection exam, the transition to higher education examination, undergraduate placement exam, higher education institutions exam. This exam includes a written exam which is applied once or twice a year at specific dates throughout the country by the Center for Measurment, Selection and Placement (CMSP) in Turkey. CMSP is the only test center in Turkey and in the world on this scale, providing exam services to over ten million candidates annually on a national scale. Until the 1960s, only some of the high school graduates in Turkey were admitted to universities without exams. With the increase in the number of high school graduates over the years, universities' own student selection methods have become unable to meet the need. "Inter-University Student Selection and Placement Center (I-USSPC)" was established in 1974 to serve the purpose. This institution was renamed as “Student Selection and Placement Center (SSPC)” with a law amendment made in 1981 and “Center for Measurment, Selection and Placement (CMSP)” in 2011. There are different applications in the world regarding the transition from high school to university. In Turkey, the system was developed with several changes within years and the university entrance system was finalized in 2017 (OSYM, 2020).

A test of multiple choice and open-ended questions is applied for high school graduates to get into universities in Turkey. Application of the exam simultaneously starts and is completed on the planned day and time in all the city centres inTurkey. Since the quotas of popular universities and departments are very limited, very few students can enter these universities as a result of these exams. However, students have the right to re-enter next year if they fail the exam. An evaluation system is used in which each four incorrect answers eliminate a correct answer to prevent students from answering randomly in exams. The performance of each student is calculated on the basis of the fields and the ranking is determined by CMSP. In this context, students make selections by taking into account the base points the universities and programs accepted in the past years. After these preferences, CMSP completes the placement of students in university and departments according to their success ratings. Both exam results and university placement results are published on CMSP's own website.

Students have to score high marks in these exams to enter popular universities and fields. Therefore, these fields where a limited number of students can enter are highly competitive. Moreover, schools, families and teachers in Turkey run against making the student successful within this period. The test content is the subjects in the courses that the students take during their high school years. Depending on the field, these exams include questions from many fields such as Turkish, mathematics, physics, chemistry, biology, social sciences. There are 20 questions in total respectively Physics (7), Chemistry (7), Biology (6) in the first part of this exam (BPT); 40 questions in total respectively Physics (14), Chemistry (12), Biology (12) in the second part of the exam (FBT) for the purpose of determining the proficiency of the students in the science fields. 2.296.138 people participate in the 2020-"The Exam of Higher Education Institutions (TEHEI), the Basic Proficiency Test (BPT) and 1.672.376 people participate to Field Proficiency Test (FPT) applied by CMSP throughout Turkey. According to 2020-TEHEI, 58.68% of candidates from the science-oriented field, which also includes science, score 170 and more. This is the minimum passing score applied to choose a 4-year undergraduate program in Turkey for 2020. It is seen that the raw score average of the 2020-BPT science tests is 2.67, and the 2020-FPT raw score average is 1.08 in Physics, 1.41 in Chemistry, 1.30 in Biology. However, when the numeric data shared by CMSP through its website are examined, the results show that students are very bad at answering correctly the science questions in both 2020-BPT and 2020-FP (OSYM, 2020). In addition, it is stated that 1,131,330 (47%) candidates in the physics subtest, 1,163,813 (49%) candidates in chemistry subtest 1,477,782 (62%) candidates in the biology subtest that all forms the science test have no correct answer in any question in the detailed exam evaluation report prepared for 2019-TEHEI (OSYM, 2019).

The students are concentratedly prepared for these exams by receiving private tuitions besides the education of the school. Science is the field in which the students are mostly in need of these private tuitions in Turkey. Within this period, students both repeat the science subjects they take during their high school years and solve a large number of questions. Moreover, teachers and institutions focus heavily on the sample questions and solutions to similar questions in the past years to ensure their students succeed in exams. The fact that the students understand the structure and solution techniques of the questions clearly affects their success in the university exams they will take. These questions in the field of science have various representations. These representations contain various forms, such as text, icons, equations, and visuals. Students need to have an in-depth conceptual understanding to understand and interpret these different usages in science questions. In particular, students not only need to have a wide knowledge structure but they need to have also analytical thinking skills to interpret questions of science with visual content.

Visual Representation and Students’ Evaluation of Questions in Science

Visual representations are called symbolic (figurative) representations in the related literature (Petersson, 2002). Symbolic representations include visual learning representations like diagrams, pictures, photos, models, charts, maps, tables, and various symbols (Coleman, McTigue & Smolkin, 2011; Moline, 1995; Roberts et al., 2013; Schraw, McCrudden & Robinson, 2013; Schraw & Paik, 2013; Vekeri, 2002). Presenting the content of science in different modes is quite important for the student to effectively configure knowledge. It is pointed out in the related literature that learning in science through texts and visual expressions is much more permanent than learning only through text for the student (Ardasheva, Wang, Roo, Adesope & Morrison, 2018; Gross, Wright & Anderson, 2017). Because students understand natural phenomena better while working with visuals on scientific texts in science (Mayer, 2013; Newman & Ogle, 2019). Presentation of science content through visual representation supports an in-depth understanding (Ainsworth, 2006, 2008; LaDue et al., 2015; Rau, 2018; Rau, Michaelis & Fay, 2015; Stieff, Werner, DeSutter, Franconeri & Hegarty, 2020; Tippett, 2016). National Research Council [NRC] (2012, 2013) and Next Generation Science Standards [NGSS] (2013) emphasize the importance of visual representation to understand science. According to NGSS Lead States (2013), in addition to writing in science, students' interaction with visual learning representations such as drawings, models, diagrams, charts and tables is critical for students to provide more effective scientific insight.

If it is not possible to observe and try processes and concepts, it is important to make these situations understandable with visual representations in a course (Preston, 2017). Coleman et al. (2011) indicate the use of visual representations for learning purposes has a strong effect on accurately explaining and sampling abstract concepts in science. Visuals in science are powerful learning tools for students (Carney & Levin, 2002; Guo, Wright & McTigue, 2018). This is because visual representations enable targeted messages in science with scientific texts to reach the student effectively. Many studies shows that it is greatly easier for students to understand the content of science enriched with visuals (Chang, 2012; Cheng & Gilbert, 2014; Wilson & Bradbury, 2019; Gou, Zhang, McTigue & Wright, 2017). Visual content is seen as a valuable teaching representation in science education as well as effective structures in evaluating students' science learning. Particularly in many countries, science questions in university entrance exams have parts that focus on students' visual content skills. Questions with this visual content require students to use their interpretation, analysis, reasoning, problem solving and in-depth thinking skills.

METHOD

The Design of the Study

This research is a case study created for the purpose of examining the questions of the science field in terms of visual content in the selection exam applied to higher education institutions after secondary education in Turkey. The case study focuses on in-depth examination and depiction of a phenomenon within certain limits (Merriam, 2002; Yin, 2009). In other words, it is a qualitative approach that the researcher collects information through various materials and documents relating to a particular phenomenon over a given period of time (Creswell, 2013). This is because the research is based entirely on document-based data, which is the focus of research on its own. Such a research is defined as a document review (Bretschneider, Cirilli, Jones, Lynch & Wilson, 2017; MacDonald & Tipton, 1996). Therefore, this research is a document review examining the visual content status of science questions in the exams applied for students entering university in Turkey between 1999 and 2019.

The Data Source of the Study

The data source of the study consists of the science questions in the selection exam applied to the students between 1999 and 2019. One or two exams every year for the students who have graduted from the high school to be able to get into universities are held by the Center for Measurment, Selection and Placement (CMSP). In this context, the science exams applied for the purpose of selecting students to place in the universities in Turkey were implemented as a single-stage exam system between 1999 and 2005 and as a two-stage exam system between 2006 and 2019. The documents of the study are obtained through open access via the web page of CMSP. The questions belonging to all years in the field of science include multiple choice items. The distribution of questions from the fields of science used in these exams according to the years is presented in Table 1.

Table 1. The distribution of science questions in university entrance exams on the basis of fields according to the years

Year	Physics	Chemistry	Biology	Total Number of Questions	Year	Physics	Chemistry	Biology	Total Number of Questions
1999	19	13	12	44	2011-2	30	30	30	90
2000	19	14	12	45	2012-1	14	13	13	40
2001	19	14	12	45	2012-2	30	30	30	90
2002	19	14	12	45	2013-1	14	13	13	40
2003	19	14	12	45	2013-2	30	30	30	90
2004	19	14	12	45	2014-1	14	13	13	40
2005	19	14	12	45	2014-2	30	30	30	90
2006-1	13	9	8	30	2015-1	14	13	13	40
2006-2	13	9	8	30	2015-2	30	30	30	90
2007-1	13	9	8	30	2016-1	14	13	13	40
2007-2	13	9	8	30	2016-2	30	30	30	90
2008-1	13	9	8	30	2017-1	14	13	13	40
2008-2	13	9	8	30	2017-2	30	30	30	90
2009-1	13	9	8	30	2018-1	7	7	6	20
2009-2	13	9	8	30	2018-2	14	13	13	40
2010-1	14	13	13	40	2019-1	7	7	6	20
2010-2	30	30	30	90	2019-2	14	13	13	40
2011-1	14	13	13	40	Total	631	553	530	1714

When Table 1 is examined, the exams between 1999 and 2009 are conducted as the Student Selection Exam (SSE), and there were 44 exam questions in the field of science (Physics 19, Chemistry 13 and Biology 12) in 1999. In the SSE conducted in 2000 and 2005, there were 45 questions in the field of science (Physics 19, Chemistry 13 and Biology 12) In 2006 and 2009, the exam was turned into two-stage exam system and there were 30 questions of science in SSE-1(Physics 13, Chemistry 9 and Biology 8) and there were 30 questions of science in SSE-2 (Physics 13, Chemistry 9 and Biology 8). Afterwards, the exam changed between 2010 and 2017 and there were 40 science questions (Physics 14, Chemistry 13 and Biology 13) in the first stage Higher Education Placement Exam (HEPE) and there were 90 science questions (Physics 30, Chemistry 30 and Biology 30) in the Undergraduate Placement Exam (UPE). Finally, the exam changed again between 2018 and 2019, and there were 20 science questions (Physics 7, Chemistry 7 and Biology 6) in the first stage called Basic Proficiency Test (BPT), and there were 40 science questions in the Field Proficiency Test (FPT) (Physics 14, Chemistry 13 and Biology 13). When the total numbers are examined, it is seen that there were 1714 science questions in total between 1999 and 2019, of which are 631 in physics, 553 in chemistry and 530 in biology.

The Analysis of the Data

The data of the study are descriptively analyzed in the context of the taxonomy that Yeh & McTigue (2009) classified visual content types. When the classifications on visual representations are examined in the relevant literature, it is observed that many of them are categorized under almost the same visual types (Lohse, Biolsi, Walker & Rueler, 1994; Moline, 1995). However, it is found that visual content evaluation in the researches just related to science exam questions is only included in the studies belonging to Yeh & McTigue (2009). Within this framework, all questions in the field of science applied in university entrance exams between 1999 and 2019 are evaluated by using the visual content classification that Yeh & McTigue (2009) define under eleven categories. These classifications are: *Formatted Drawing (C1), Illustrated Dictionary (C2), Measurement Diagram (C3), Flowchart (C4), Table (C5), Graphic/Histogram (C6), Section (C7), Hybrid (C8), Photo (C9), Natural Drawing (C10) and Map (C11)*. Furthermore, a second analysis is conducted by sampling the rubric, in which Yeh & McTigue (2009) define the role of the image in solving science questions. In this context, a two-level classification system is created and questions containing images are examined according to this system. The role of the image in answering the question is divided into two categories: partial and full role. The image, which has a partial role in answering the question, defines the situation in which the student should use both the image and the information in the root of the question in order to answer the question. The image, which has a full role, describes the situation in which only visual content is sufficient for the student to answer the question. Table 2 includes classification of visual content types, there are visual content samples about science questions in Table 3, and there are examples on the role of visuals in answering questions in Table 4. The data of this study are calculated as frequency and percentage values in the SPSS 18 Program.

Table 2. Classification system for visual content

Visual Type / Code Name	Description of The Image
Formatted Drawing / C1	Drawing the image only in an external way or the visual represented by a symbolic drawing.
Illustrated Drawing / C2	Naming picture sections with tags (e.g. Labeling root and leaves in plant growth).
Measurement Diagram / C3	Representation of a measurement within the visual (size, temperature, distance, etc.).
Flowchart / C4	It is the demonstration of stages of a process with arrows or numbers. (E.g. life cycle)
Table/ C5	Images formatted with cells that contain rows and columns.
Graphics /Histogram/ C6.	Reorganizing quantitative information in a visual format.
Section / C7	Marking the internal parts or processes of a structure with labels (E.g. Internal structure of blood vessels).
Hybrid / C8	Images with two or more visual types together.
Photo / C9	Using a photo of a topic (E.g. Picture of a glacier)
Natural Drawing / C10	A depiction of all the characteristics about a subject (e.g. A bird covered in beautiful feathers)
Map / C11	Marking to demonstrate geographical features spatially such as mountains and other structures (E.g. air stream map of United States)

*C: Code

The examples on visual content of science questions in the university entrance exams are shown in Figure 2 and Figure 3.

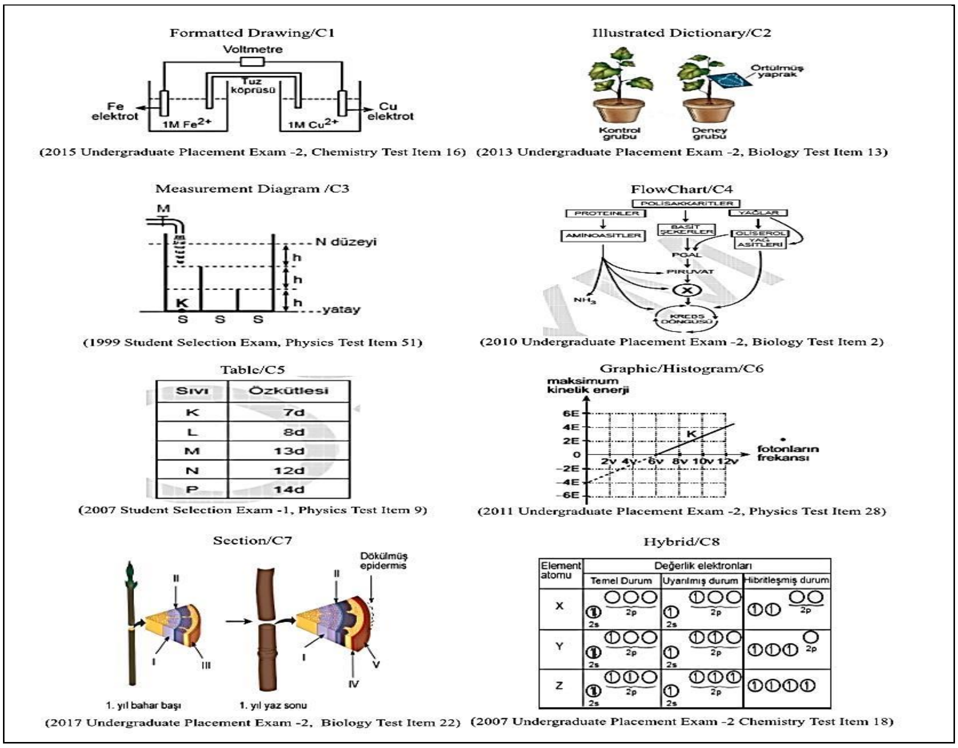

Figure 2. The samples of science questions containing images used in the university entrance exams in turkey

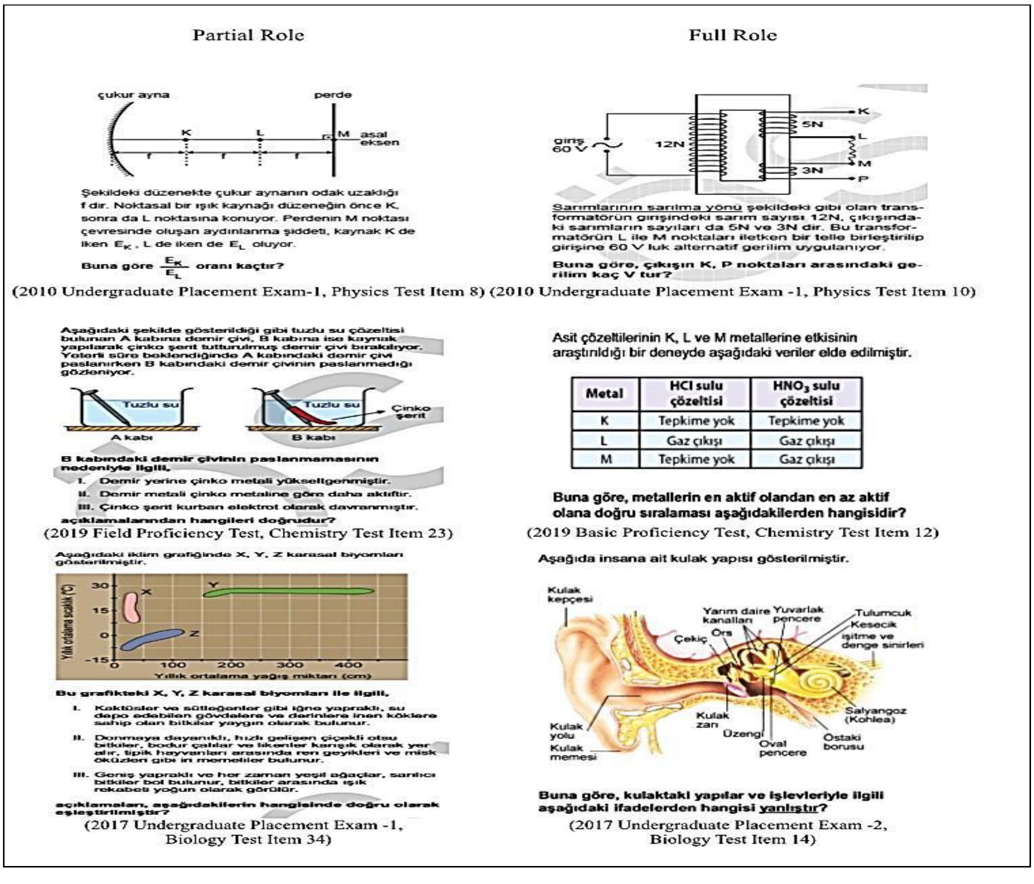

Figure 3. Examples on the role of visuals in answering science questions

Analysis Reliability of Data

Three assistant professors who are the expert in science education independently evaluated 52 questions from the field of science in the university entrance exams applied in Turkey between 1999-2019 in January 2020. The two experts here (identified as the second and third evaluator) are the authors of this study. Within the scope of the figurations to ensure data analysis reliability, it is obtained that the correlation value is .93 between the evaluations of the first and second experts, and it is .90 between the evaluations of first and third specialists. Following these high consistency values, two researchers jointly analyze all questions in the field of science between 1999 and 2019 in terms of their visual content. Some disagreements between the researchers regarding the category under which image will be evaluated are resolved by reaching a full agreement by including in the interview with the other expert.

Results

In this section, the results of the analysis on the science questions in terms of visual content in the university entrance exams applied in Turkey are presented. The distribution of the visuals used in the science questions in the university entrance exams within the fields and all science questions is shown in Chart 1.

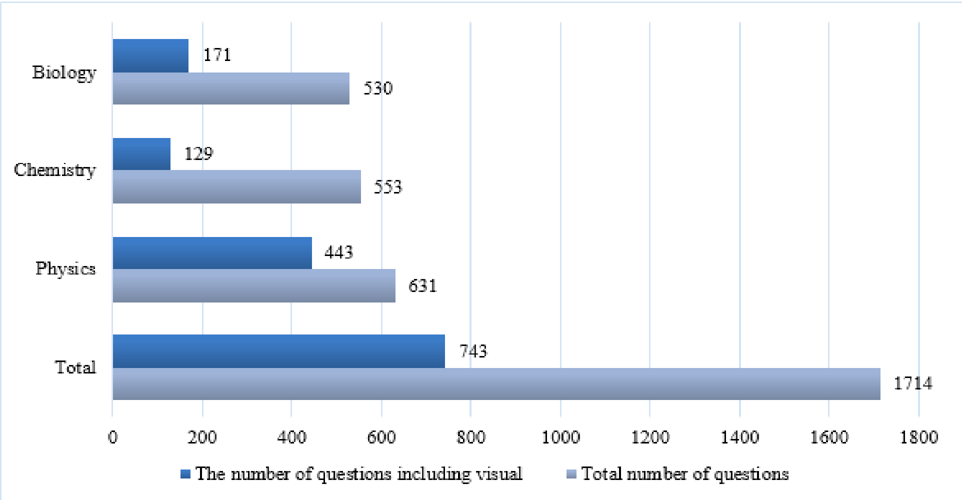

Chart 1. The distribution of visuals used in science questions in university entrance exams within fields and total questions

When the Chart 1 is examined, there are 1714 questions in the field of science between 1999 and 2019 total, and 743 of these questions are found to have visual representation. In addition, it is determined that visual representation is mostly used in physics questions (n= 443) and used in chemistry questions at the very least (n=129).

The distributions of the visuals used in the science questions in the university entrance exams according to their types are shown in Table 3.

Table 3. The distribution of the visuals used in the science questions in the university entrance exams according to their types

Year	Total number of questions	C1	C2	C3	C4	C5	C6	C7	C8	The number of Questions with visuals
1999	44	11	0	7	2	0	2	0	0	22
2000	45	10	0	7	1	0	5	1	0	24
2001	45	12	1	6	1	0	5	1	1	27
2002	45	10	0	6	1	1	4	0	0	22
2003	45	14	0	7	1	2	4	0	1	29
2004	45	12	0	2	1	0	5	0	0	20
2005	45	15	0	4	1	4	2	2	2	30
2006-1	30	8	0	3	0	0	3	0	2	16
2006-2	30	8	0	1	1	0	1	1	1	13
2007-1	30	9	0	3	1	3	2	0	0	18
2007-2	30	8	0	3	0	0	2	1	2	16
2008-1	30	10	0	3	1	4	2	0	0	20
2008-2	30	7	0	5	1	1	2	0	0	16
2009-1	30	7	0	1	0	3	2	0	1	14
2009-2	30	8	0	1	1	0	2	0	2	14
2010-1	40	7	0	3	0	3	3	0	2	18
2010-2	90	17	2	8	2	4	3	0	1	37
2011-1	40	9	1	3	2	4	2	1	1	23
2011-2	90	18	1	4	3	1	4	2	2	35
2012-1	40	10	1	2	1	1	4	0	0	19
2012-2	90	15	0	6	3	0	4	0	1	29
2013-1	40	11	2	0	0	2	4	1	0	20
2013-2	90	18	3	3	3	3	6	1	0	37
2014-1	40	6	0	2	2	4	5	0	1	20
2014-2	90	19	2	2	3	2	4	0	1	33
2015-1	40	4	1	0	2	4	5	1	1	18
2015-2	90	15	5	1	2	1	4	0	0	28
2016-1	40	6	0	0	0	4	2	0	1	13
2016-2	90	14	6	1	1	5	3	0	0	30
2017-1	40	8	2	0	0	3	2	0	1	16
2017-2	90	14	2	3	2	1	3	1	1	27
2018-1	20	1	0	0	1	1	0	1	0	4
2018-2	40	7	1	1	1	1	3	0	1	15
2019-1	20	4	0	0	2	1	0	0	1	8
2019-2	40	6	3	0	0	1	0	0	2	12
Total	1714	358	33	98	43	64	104	14	29	743

When the distribution of the images included in the science questions in the university entrance exams is examined in terms of their types according to the years in Table 5, it is observed that the formatted drawings (n=358) are mostly preferred, while the categories like the section (n=14), hybrid (n=29) and illustrated dictionary (n=33) are preferred less. In addition, it is found out that the types of visual representation called picture, natural image and map are not used in any questions. On the other hand, it is found out that the highest use of visual content is identified in the exams held in 2010-2 and 2013-2 (n=37) while the least use of visual content is identified in the exam held in 2018-1 (n=4).

The percentaged distributions of the science questions in the university entrance exams in terms of visual content according to the fields and total number of questions are given in the Chart 2.

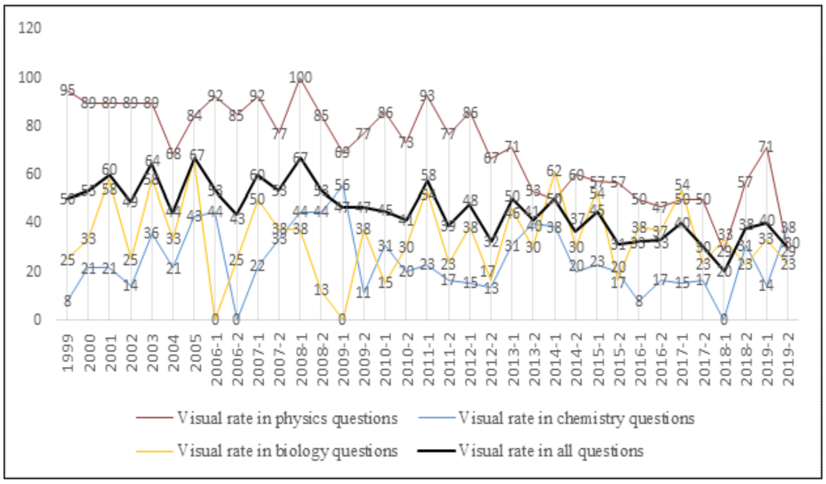

Chart 2. The percentaged distributions of the science questions in the university entrance exams in terms of visual content according to the fields and total number of questions

There is the percentaged distribution of the visual content on the basis of the fields according to the years and in terms of the total number of science questions in the university entrance exam in Chart 2. When it is examined according to the years, there appears to be a decrease in the percentage of the visual content used in the questions asked in the field of physics. In particular, it is understood that all the questions asked in the field of physics include (100%) visual representation in the exam held in 2008-1 When the questions asked in the field of chemistry according to the years, it is found out that there is no visual content in the exams held in 2006-2 and 2018-1, and the similar situation is valid for biology in the exams held in 2006-1 ve 2009-1. Moreover, it is detected that the visual representation is mostly used in the field of chemistry in 2009-1 (56%) and in the field of biology (67%) in 2005. The percentaged distribution of visual content types used in the questions of physics, chemistry and biology is seen in Table 4.

Tablo 4. The percentaged distribution of the questions on the fields of science in the university entrance exams in terms of visual content on yearly basis

Year	Physics Visual Code							Chemistry Visual Code							Biology Visual Code						
	1	2	3	4	5	6	8	1	2	3	4	5	6	8	1	2	4	5	6	7	8
1999	58		32			5				8							17		8		
2000	47		37			5							21		8		8		8	8	
2001	47		32			11		14					7		8	8	8		17	8	8
2002	47		32			11		7				7					8		17		
2003	53		37					21					14		8		8	17	17		8
2004	53		11			5		7					14		8		8		17		
2005	63		21					14				14	14		8		8	17		17	17
2006-1	62		23				8						33	11							
2006-2	62		8			8	8										13			13	
2007-1	62		23		8							11	11		13		13	13	13		
2007-2	46		23				8	11					11	11	13				13	13	
2008-1	69		23			8		11				22	11				13	25			
2008-2	38		38			8		22				11	11				13				
2009-1	46		8		8		8	11				22	22								
2009-2	54		8			8	8	11									13		13		13
2010-1	50		21				14					15	15					8	8		
2010-2	43		27			3		10	3				7		3	3	7	13			3
2011-1	64		14		7	7						15	8			8	15	8		8	8
2011-2	47		13			10	7	10	3			3			3		10		3	7	
2012-1	71		14										15			8	8	8	15		
2012-2	40		20			3	3	7			3		3		3		7		7		
2013-1	57				7	7			8			8	15		23	8			8	8	
2013-2	40		10			3		20	3			10	7			7	10		10	3	
2014-1	29		14			7						15	23		15		15	15	8		8
2014-2	40	3	7			7	3	17					3		7	3	10	7	3		
2015-1	29	7			7	7	7					15	8				15	8	23	8	
2015-2	40	10	3			3		10	3			3	3			3	7		7		
2016-1	36				14								8		8			15	8		8

2016-2	33	3	3		3	3		13	3							13	3	13	7		
2017-1	29				7	7	7		8			8			31	8		8	8		
2017-2	37		10			3		10					7			7	7	3		3	3
2018-1	14				14												17			17	
2018-2	36		7	7		7		15	8			8							15		8
2019-1	57						14					14					13				
2019-2	21						7	23	8			8				15					8
Total	45	1	15	<1	2	4	2	9	2	<1	<1	5	7	<1	4	3	8	5	7	3	2

There are the percentaged distributions and average percentages of the visual content types preferred in the questions of physics, chemistry and biology in the university entrance exams on yearly basis in Table 6. When Table 6 is examined, it is understood that in terms of visual content C1 (45%) is preferred much higher than the other types of visual contents in the questions of physics. In addition, it is determined that the visual types like C3 (15%) and C6 (4%) are also used frequently in the questions of physics. Moreover, it is seen that the visual types like C5 and C8 are used within the questions of physics even in limited numbers in different years. Nonetheless, it is understood that the visuals like C2 and C4 are within the very least questions of physics and in a very small number of years. It is noticeable that C1 (9%), C5 (5%) and C6 (7%) are used more than other types of visual content used in chemistry questions. Besides, C3, C4 ve C8 are used in chemistry questions at a very low rate (<1) compared to other visual types. C4 (8%) and C6 (7%) are used more than other visuals in terms of the type of visual content used in biology questions. In addition to these, it is understood that the visual content types like C9, C10 and C11 are not included in any year in the questions within all fields of science. Yet, it is found out that the C7 is not contained within the questions of physics and chemistry, and the C3 is not included in biology questions. Furthermore, it is determined that the usage rates of C4 in the field of physics, C3, C4 and C8 in the field of chemistry are below 1%. When we look at the rates of the diversity of visual usage on the basis of all science fields, it is seen that this situation is more balanced in the questions of biology.

The percentaged values defining the role of the visual content in solving the science questions are included in Chart 3.

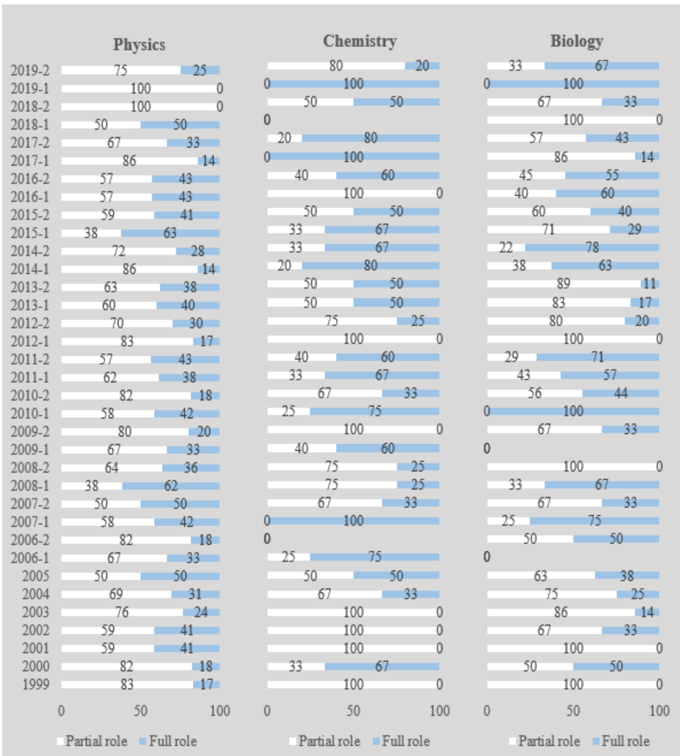

Chart 3. The percentaged distribution on the role of visuals in solving the science questions

The percentaged rates on the role of the visual representation in answering the science questions are shown in Chart 3. When the percentaged distributions are examined, it is observed that most visual questions in the field of physics have a partial role in many years, and moreover, all visual questions in the field of physics have a partial role in the 2018-2 and 2019-1 exams. It is understood that all questions with visuals in the field of chemistry have a partial role in the 1999, 2001, 2002, 2003, 2009-2, 2012-1 and 2016-1 exams in chemistry, and all of the visual questions in the 2007-1, 2017-1 and 2019-1 exams have a full role. However, it is understood that all questions with visual in the field of biology are partial in the 1999, 2001, 2008-2, 2012-1 and 2018-1 exams, and all visually images have a full role in the 2010-1 and 2019-1 exams. In addition, in chemistry in the 2006-2 and 2018-1 exams and in biology 2006-1 and 2009-1 exams it is seen that no role is observed because no visual is used.

Discussion, Results and Suggestions

In this study, the science questions involved in the university entrance exams in Turkey between 1999 and 2019 are examined in terms of visual content. The status of the visual content in the questions indicates the important results in terms of the fields of science, years and roles in solving questions.

The visual content in analyzed questions is found to be concentrated mainly on physics compared to the fields of chemistry and biology. Many concepts in the field of physics are often difficult to be understood by students through oral or written texts. Therefore, these concepts in the field of physics should be supported with visuals that students will understand correctly (Martin, Mullis, Foy & Stanco, 2012). The situation that arises here can be explained by the fact that the experts preparing questions in the field of physics understand the importance of supporting the content of the subjects not only with text but with visuals (Yeh & McTigue, 2009). On the other hand, it is an astonishing result that visual content is much less involved in questions in chemistry and biology than in physics. Since both the fields of biology and chemistry contain largely abstract concepts, visuals play an important role in students' meaningful understanding of the knowledge in these fields. This situation can be explained by the fact that the experts preparing the questions of biology and chemistry create question content only through texts instead of the visual supported question content because this question structure is easier to prepare than the latter. This is because choosing and preparing a visual suitable for the content of a question in science is often seen as a laborious task. Moreover, it is a fact that for an expert preparing questions presenting the problem regarding the science content by associating it with an original image requires a truly creative thinking. The fact that the images in the questions do not show a balanced distribution for each science discipline indicates that the experts who prepare these questions are either not provided with the field-specific visual content training or are weak about it. It can also be said that while creating question pools for biology and chemistry fields, it is not paid attention to display a balanced distribution on the basis of fields for both visual and text-only questions.

It is determined that the science questions in terms of the visual type are concentrated on largely formatted drawing according to all years. That formatted drawing is mostly preferred in the analyzed exam questions may result from easier preperation of this type because formatted drawing visuals are a simple and symbolic presentation of a content in science. On the other hand, it is understood that the use of hybrid, which represents the combination of the content with more than one visual type in a science question, is rather weak. The low preference of the images of hybrid in the questions can be explained by the fact that the experts do not know these structures adequately. It can also be difficult to convert a science content to a question with the interaction of multiple images. Contrary to this research, Yeh & McTigue's (2009) indicate that commonly used visuals are illustrated dictionaries, graphics and hybrids in their studies in which they examine the visual content of science questions in student selection exams in United Sates of America. In fact, it is understood that hybrid is preferred extensively when analyzed various materials such as science textbooks, supplementary references, science journals. In addition, it is observed that photographs, natural drawings and maps, which take an important place in many models where visual representations are classified in the literature, are not included in any questions in all years. In science, students need visual representations such as photographs, natural pictures and maps from the universe they live in to make sense of the content correctly and to remember it more easily (Chang, 2012; Slough, McTigue, Kim & Jennings, 2010; Wilson & Bradbury, 2016). Today, most of the written materials in science are depicted naturally through current and retrospective photographs, depictions through the drawings that are closest to reality, and maps representing spatial information from a particular place are used extensively (Coleman, et al., 2011; McTigue & Flowers, 2010; McTigue & Flowers, 2011). Especially in recent years, many subjects in science are included in the content that requires students to relate spatially from the current life. Considering the explanations regarding these images, it is a surprising result that these structures are not included in the analyzed science questions. It is thought that the reason for not using the visuals in science questions is due to preferring to present the subject with familiar visual representations on the basis of science disciplines. Considering the richness of the content of science, students can mix many of the shapes and symbols. Moreover, students cannot associate situations, objects, events and processes that represent the content of science with their own mental models (Lindner, Eitel, Strobel, & Koller, 2017). It is an unexpected finding that these images are not preferred in the analyzed questions.

When the distribution of use of visuals in science questions according to years on the basis of fields is examined, it is determined that the use of visuals in the questions of physics has decreased significantly in recent years. Moreover, it is understood that this has decreased in recent years while the images are used in almost all or the vast majority of the questions of physics in many years. However, it is observed that the use of visuals in the questions of chemistry has decreased significantly in recent years and has not been used at all in some years. It is found out that the use of visuals in the questions of biology has shown certain increases and decreases over the years and has never been used in some years, however, there has been a certain increase in visual use in recent years. The decrease in the number of visual content usage in the questions of physics and chemistry in recent years indicates that the question pool created by experts has turned into a predominantly textual orientation. Moreover, it can be said that the questions directly evaluating student’s knowledge level in these two fields are mostly concentrated. However, it can be shown as the reason behind the increase in the visual contents in the field of biology in recent years is that the subjects in the curriculum are taught to the students through very rich printed and digital visuals in schools today and this is taken into consideration by the specialists.

When the distribution of visual types in the questions on the basis of the fields is evaluated, it is understood that the formatted drawing is mostly included in the field of physics. On the other hand, it is observed that the illustrated dictionary and flow chart are less preferred in the questions of physics. It is determined that the formatted drawing, table and graphic images become prominent in the questions of chemistry. However, it is understood that the use of the measurement diagram, flow chart and hybrid in the questions of chemistry remains very low. Flowchart and graphic images are found to be more preferred in the questions of biology. Yet, it is found out that there are no photos, natural drawing and map in any science questions. Besides, it is indicated that there is no section in any questions of physics and chemistry and no measurement diagram in any questions of biology. The reason for the prominency of formatted drawing in the questions of physics and biology is that it is the easiest and most appropriate visual representation to convert the knowledge content into a question (Yeh & McTigue, 2009). In particular, it is known that the formatted image in various sources of knowledge is heavily preferred to simplify the complexity of the subjects in both areas. Therefore, while preparing questions in these two areas, it can be said that experts use the formatted drawing, which is the easiest and familiar visual type in modeling abstract and complex information. However, it is not surprising that the topics in the field of biology contain a variety of facts and processes on the basis of living things and life, and that flow diagrams and graphics are the most suitable visuals to support the questions prepared in this field.

When the role of visuals is evaluated in solving questions, it is determined that visuals in the questions of physics often have a partial role in many years. It is also understood that all or the vast majority of visual questions in physics have a partial role in recent years. It is determined that the visuals in the questions of chemistry show partial and full role-weighted distribution in various years, however, in some years, all of the questions have partial or full roles. It is found out that the visuals in the questions of biology show a partial and full role-weighted distribution in various years. However, it is understood that all of the visuals in the questions of biology have partial or full role in some years. It is also understood that the explanations, numbers and symbols with the texts are exactly the same as the image added to the question and look like their repetition in the analyzed questions. To be more precise, the content of the question that will be asked only with visual or text seems to be repeated twice. Therefore, visuals have a full role in such a question and the text is understood as unnecessary. In addition, the intense prominency of the partial role in the questions in the fields of science indicates that some questions are difficult to be structured only by visual (Anagnostopoulou et al., 2012). This is because the visuals alone remain weak in the ability to present many subjects in science. Therefore, while preparing questions on such issues, some supportive information is needed in additin to the visual (Yeh & McTigue, 2009; Saß, Schütte & Lindner, 2017).

This study, which presents important results on the visual structure of science questions in Turkey's 20-year university entrance exams, is seen as valuable in terms of contributing to the experts who have prepared the science question for university entrance exams. The results provide clues to policy makers on measurement and evaluation and experts who prepare questions in terms of improving visual content in the field of science and moving it to better points. The number and diversity of visual content in exams clearly indicate the production of comparison and discussion between the fields of science. Although the total use of various visual types remains weak on the basis of science fields, it is seen that different types of visuals are included in the exams to evaluate student performance in various years. In addition, the revealed results that some images show a special spread to the disciplines of science, or rather, it is understood that these disciplines are the most representative images of the subject content. However, given the science question pools in the university entrance exams, the discussions on the intensity of the visual types that are weak or not in the questions chosen for years can be considered as a limitation of this study.

The way students interpret the information should be diversified by including the visual types used poorly in the questions according to the science fields in the content of the questions in the future exams. It should be provided the expert preparing science questions with a training opportunity in the context of visual content. The scientists from the fields of science should be able to come together to discuss which topic contents can be represented by visuals, or what kind of visuals can be presented with a more appropriate representation, and they should be able to create a relevant question-preparation guide. In addition, the necessary improvements should be made in the context of visual contents in high school programs by evaluating the statistics of the science question types with visuals that are correctly answered by the students. As a final recommendation, science exams can include question structures in which the students will draw their own mental models related subjects.

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