Erzincan Üniversitesi Eğitim Fakültesi Dergisi

Erzincan University Journal of Education Faculty

2025 Cilt 27 Sayı 4 (665-681) https://doi.org/10.17556/erziefd.1653115

Araştırma Makalesi / Research Article

Analyzing 8th Grade Science Written Exams, Textbook Unit Assessment Questions, and 2013-2024 HSEE Questions: Representation Types and Transitions

8. Sınıf Fen Bilimleri Yazılı Sınavları, Ders Kitabı Ünite Değerlendirme Soruları ve 2013-2024 LGS Sorularının Analizi: Gösterim Türleri ve Geçişler

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Makale Bilgileri

Geliş Tarihi (Received Date)

08.03.2025

Kabul Tarihi (Accepted Date)

25.11.2025

Sorumlu Yazar

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Abstract: This study aims to examine the types of representation and the transitions between these representations in 8th grade science textbook unit assessment questions, science questions in the High School Entrance Exam (HSEE) between 2013-2024 and 8th grade science written exam questions. The document analysis method was implemented to carry out this study. The 8th grade science textbook intended to be taught for five years starting from 2018, HSEE science questions between 2013-2024 and 8th grade science written exam questions were used as data collection tools in the study. The data were subjected to content analysis. In the study, it was determined that the types of representation in all question types were generally centred on text and picture. In terms of transitions from one representation type to another, it was observed that written exam questions and unit evaluation questions were mostly text-to-text, and HSEE science questions were mostly picture-to-text. It was determined that the majority of the questions analysed were in the learning areas of "Living Things and Life", "Physical Phenomena" and "Matter and its Nature". These findings point to a systematic problem that hinders the development of representational competence in science education. This situation limits measurement validity and prevents students' multiple representation skills from being adequately assessed. The study makes a concrete contribution to the field by emphasising that assessment tools should be reviewed in terms of pedagogical diversity.

Keywords: Types of presentations, transition between presentations, central exams, end of unit assessment questions, written exam questions

Öz: Bu çalışmanın amacı, 8. sınıf fen bilimleri ders kitabı ünite değerlendirme sorularının, 2013-2024 yılları arasındaki Liseye Geçiş Sınavı (LGS) fen bilimleri sorularının ve 8. sınıf fen bilimleri yazılı sınav sorularının gösterim gösterim türleri ve bu gösterimler arasındaki geçişleri incelemektir. Bu çalışmayı gerçekleştirmek için doküman analizi yöntemi uygulanmıştır. Araştırmada veri toplama araçları olarak 2018 yılından itibaren beş yıl süreyle okutulması amaçlanan 8. sınıf Fen Bilimleri ders kitabı, 2013-2024 yılları arasındaki LGS fen bilimleri soruları ve 8. sınıf fen bilimleri yazılı sınav soruları kullanılmıştır. Veriler içerik analizine tabi tutulmuştur. Araştırmadatüm soru türlerinde gösterim türlerinin genellikle metin ve resim üzerine yoğunlaştığı belirlenmiştir. Bir gösterim türünden diğer bir gösterim türüne geçişler açısından yazılı sınav sorularının ve ünite değerlendirme sorularının en çok metinden metine, LGS fen bilimleri sorularının en çok resimdenmetine türünde olduğu görülmüştür. İncelenen soruların çoğunluğunun "Canlılar ve Yaşam", "Fiziksel Olaylar" ve "Madde ve Doğası" öğrenme alanlarında yer aldığı tespit edilmiştir. Bu bulgular, fen eğitiminde temsil yeterliliğinin gelişimini engelleyen sistematik bir soruna işaret etmektedir. Bu durum, ölçme geçerliğini sınırlamakta ve öğrencilerin çoklu temsil becerilerini ve özellikle gösterimler arası geçiş yeterliliğini yeterince değerlendirmenin önüne geçmektedir. Çalışma, ölçme-değerlendirme araçlarının pedagojik çeşitlilik açısından gözden geçirilmesi gerektiğini vurgulayarak alana somut bir katkı sunmaktadır.

Anahtar Kelimeler: Gösterim türleri, gösterimler arası geçiş, merkezi sınavlar, ünite sonu değerlendirme soruları, yazılı sınav soruları

Yıldırır, H. E., & Alkan, E., (2025). Analyzing 8th grade science written exams, textbook unit assessment questions, and 2013-2024 HSEE questions: Representation types and transitions. *Erzincan University Journal of Education Faculty,* 27(4), 665-681. https://doi.org/10.17556/erziefd.1653115

Introduction

The more different ways an information, situation or event is presented, the more people it offers the opportunity to address. Considering that people have different individual characteristics, information should be presented in different ways. Our curriculum also supports this idea. Teaching and presenting information and concepts in educational environments using different methods of presentation helps students to make disciplinary and interdisciplinary associations (Ministry of National Education, MoNE, 2018). Based on the idea that two visually different shapes, presentations or expressions are more effective than a single representation, the use of multiple representations in learning attractsattention (Ainsworth, 2006). The presence of many concepts and abstract subjects in science coursesmakes it difficult to learn these concepts, to establish relationships between concepts and to make connections between subjects (Avunç & Çağlar, 2021). Considering this situation, we can say that different representations such as visuals, diagrams, tables, texts and graphs should be used in textbooks.

During learning-teaching activities, the use of other auxiliary transfer elements as well as verba lexpressions provides the opportunity to make sense of the information and itspermanence in the mind (Bayri, 2014). Transferring knowledge, which is expressed as the presentation of knowledge, in different ways is important in science education as in other educational fields (Kurnaz et al., 2016). In order for concepts to be understood, learnt and used effectively, these concepts should be presented by using variousrepresentations. According to Kurnaz (2013), representation is the presentation of knowledge in a certain form(s). It is possible to transfer knowledge from one form to another form in different/same situations. The fact that an individual has the competence to transfer the knowledge he/she has learnt in different ways is an indicator of learning (Kurnaz & Yüzbaşıoğlu, 2013). Representations help students in understanding the subjects/concepts and ensuring permanence, as well as supporting teachers in transferring subjects/concepts. The use of appropriate representations in science courses and textbooks will help students understand abstract concepts more easily and reduce the difficulties they experience with these concepts (Upahi & Ramnarain, 2019). Representation is defined as making sense of an existing situation from different perspectives (Zou, 2000). These representations can be in different formats such as text, picture, photograph, graphic, table, mathematical expression, list, concept map, mind-map, etc. (Kurnaz et al., 2016). Karaca (2008) defines written text, one of the types of representation, as the concretisation of words. Written texts serve as a significant learning tool as they allow students to work independently, offer the chance for repetition, enable the adaptation of instructional materials to student characteristics, and facilitate in-depth understanding of a subject (Karaca, 2008). A table is a type of representation where data is systematically arranged by enclosing it within lines and dividing it intoequalsections (Pala & Başıbüyük, 2019).

The numerical data resulting from a study are organized and clarified using tables. Graphics, as a visual expression of numerical or verbal data, serves to show the relationships and trends between data (Oruç & Akgün, 2010), while also giving the opportunity to make comparisons between numerical expressions. Graphs are visual representations of relationships between numbers, pictures of mathematics (Demirci et al., 2006). A picture is a type of representation that reflects the observable characteristics of an object, eventor idea as a visual representation (Pala & Başıbüyük, 2019). In education, pictures are used to concretize concepts and facilitate understanding; they make abstract information more understandable and support students' visual memory (Oruç & Akgün, 2010). While pictures facilitate the identification of facts and events in texts, they increase the reader's interest in the text and give a positive perspective. They also help in transitions between texts (Yazıcı, 2006). This shows how visual materials can be used effectively in education. A photography is defined as "fixing the image on a special surface using various tools and materials" (Turkish Language Society, TLS, 2023). Photographs are visual elements that reflect the images of real objects and make them concrete. These visuals help to present information in a more understandable and interesting way (Yazıcı, 2006). In education, they contribute to students' better understanding of concepts and improve their learning processes. Mathematical expressions, another type of representation, consist of symbols such as %, f, ss, df, and equations and formulas such as $r = 0.53$, $p<0.01$, $t\ (332) = 3.456$, $\alpha = .05$ (Yeşildağ-Hasançebi et al., 2014). Since students develop from concrete to abstract, using concrete expressions is an important point in mathematics. In this context, numbers, equations and formulas need to be modeled with certain symbols and these modeling's are called mathematical expressions (Yeşildağ-Hasançebi et al., 2014). Multiple representation involves the simultaneous use of graphs, symbols, tables, and equations to interpret information in different ways.

Literature Review

Prior Research on Science Textbooks

Analyzes of science textbooks show that these materials are handled in different dimensions in terms of pedagogical structure and teaching methods. Textbooks were analyzed from various perspectives such as inquiry-based teaching (Yılmaz, 2023), the suitability of experiment and activity sections for scientific inquiry (Oba & Köse, 2022), the level of representation of science and engineering practices (Gökdaş, 2023), visual design principles (Altay & Balım, 2023), the rate of including elements related to the nature of science (Ünlü SinnettJr& Akçay, 2021) and the use of multimodal descriptions (Demiralp & Demirbağ, 2024).In addition, the end-of-unit assessment questions in the textbooks and the questions within the subject contents were analyzed in terms of assessment-evaluation techniques, the knowledge and cognitive process dimensions based on the Revised Bloom's Taxonomy (RBT) (Köse, 2021), and the scope, approach, and distribution of measurement tools (Deveci & Altıntaş, 2022; Şen, 2021). In these studies, Yılmaz (2023) found that 3rd-8thgrade science textbooks were inadequate regarding inquiry-based teaching, while Oba and Köse (2022) found that the suitability of experiment and activity sections for scientific inquiry was low. Gökdaş (2023) stated that the level of representation of science and engineering practices in textbooks was low. Although Altay and Balım (2023) found the visual and linguistic designs of the books adequate, they identified deficiencies in the use of different teaching methods. Ünlü SinnettJr and Akçay (2021) stated that the textbooks contain the sub-dimensions of the nature of science at a limited level. Similarly, Atakan and Akçay (2024) analyzed 24 science textbooks used between 1926-2018. In the study, it was determined that NOS dimensions were inadequately represented in all textbooks. However, it was observed that this representation partially improved with the curriculum changes after 2000.Bayır and Kahveci (2021) stated that scientific process skills and STEM criteria were not sufficiently met in the textbooks, while Tezcan Şirin et al. (2022) stated that the activities in the textbooks were not suitable for the STEM perspective. Regarding representations and transitions between representations, Kurnaz et al. (2016) and Günay (2022) emphasized that representations other than text in textbooks are mostly limited to photographs and pictures, and therefore transitions are mainly from text to photographs or pictures.

Deveci and Altıntaş (2022) and Turan (2022) found that alternative assessment and evaluation techniques are only minimally included in textbooks. Köse (2021) determined that in science textbooks, traditional measurement and evaluation techniques are emphasized, most of the questions are at the recall and comprehension levels of the Revised Bloom's taxonomy, and knowledge processes are predominantly of the factual and conceptual knowledge types.

In the international literature, studies have also been carried out to analyze textbooks. Textbook analyzes, question types, and cognitive demands (Dávila & Talanquer, 2010; ManabuSumida, 2018; Yamaoka et al., 2015), the development of scientific skills (Morris et al., 2015; Sideri&Skoumios, 2021), and visual representations (Christidou et al., 2023; Park et al., 2025; Tang, 2023). Dávila and Talanquer (2010) found that, in terms of question types and cognitive levels, general chemistry textbooks in the United States predominantly contain questions at the application and analysis levels, and that analysis questions focus on inference rather than hypothesis formation or critical reasoning. A similar emphasis on lower cognitive demands has been observed in Japanese textbooks. Sumida (2017) found that the majority of 818 questions in primary science textbooks were closed-ended and yes/no questions, with 'why' questions constituting only 2%. Yamaoka et al. (2015) also found that secondary school science questions in Japan are predominantly short-answer and multiple-choice, with limited long-answer questions requiring reasoning. Regarding the development of scientific skills, international studies consistently show limitations in supporting higher-orderthinking skills. Morris et al. (2015) found that 20 US secondary school science textbooks offered limited opportunities for the repeated application of data interpretation and analysis techniques. Sideri and Skoumios (2021), analyzed 534 activities in Greek primary school science textbooks and reached similar conclusions, noting that while fundamental skills such as communication (100%) and observation (74.2%) were emphasized, higher-order skills such as hypothesis formation (9%), data interpretation (3.9%), and controlling variables (0.4%) were underrepresented.

Contemporary research underscores the strategic and multimodal role of visuals in science education. Christidou et al. (2023) observe a clear shift from decorative to functional visuals, with textbooks increasingly integrating diagrams and photographs to support conceptual understanding. This functional alignment is exemplified by Tang (2023), who reports that Australian textbooks systematically match visual types to genres, using photographs mainly for reports and stories, and diagrams for explanations and narratives. Further refining this perspective, Park et al. (2025), in a comparative study of Singaporean and South Korean textbooks, reveal distinct representational strategies. Singaporean visual sprioritize depicting realistic phenomena, while Korean material soften combine phenomena with scientific models. A critical commonality is the consistent use of textual elements to connect scientific terms with phenomena through everyday language. Collectively, these studies illustrate that while science textbooks across different regions employ context-specific visual strategies, they share a universal emphasis on the complementary relationship between visual and textual elements to foster higher-order thinking and conceptual learning.

Prior Research on Written Examination Questions of Science Teachers

In the literature, there are various studies focusing on the quality of science written exam questions and including teacher perspective (Arduç, 2024; Arı & İnci, 2015; Bahadır & Ozan, 2025; Bakırcı et al., 2024; Çolak & Ergül, 2024; Delal Turan & Özkaya, 2018; Kana et al., 2025; Ülger et al., 2022; Yüce &Kurbanoğlu, 2023). Among these studies, Arı and İnci (2015) evaluated the eighth grade Science and Technology course common exam questions and found that the questions were related to only 68 of the 137 learning outcomes in the programmed and that both the questions and the related learning outcomes were mainly concentrated at lower cognitive levels. In the study, although teachers found the number of questions sufficient, they emphasized that the selectivity and scope of the questions should be improved. Similarly, Delal Turan and Özkaya (2018) examined the distribution of science written exam questions according to Bloom's Taxonomy and supported this finding by revealing that 97.56% of the questions were at the lower cognitive level and only 2.44% were at the higher cognitive level. Ülger et al., (2022), who focused on teachers' question writing practices in exams, investigated the extent to which teachers who received context-based question writing training used such questions in written exams. The researchers found that only 1.33% of the 525 questions examined were context-based and stated that teachers attributed this situation to obstacles such as class pressure, lack of time, lack of resources and student attitudes. Finally, Arduç (2024) compared the exams prepared by teachers with the common exams organized by the MoNE and found that teachers thought that the common exam questions were mainly at the level of recall and comprehension and did not support 21st century skills. Another finding of this study is that the majority of teachers are against the common exam practice. In the related literature, there are also studies on the recent changes made by MoNE in the assessment and evaluation system. In these studies, teachers' opinions about exam questions were mostly investigated. For example, Çolak and Ergül (2024) found that science teachers believed in the benefits of skill-based questions, but they did not consider themselves sufficient in writing questions and complained about the lack of resources. The studies of Bahadır and Ozan (2025) and Bakırcı et al. (2024), which focused on the open-ended exam application, emphasized the positive aspects of this system such as measuring high-level skills, while revealing teachers' concerns such as non-objectivity of scoring, insufficient time and lack of documents. Kana et al. (2025) also supported these findings and found that teachers recognized the benefits of the new system but experienced difficulties due to difficulties in the preparation process and practical obstacles.

Prior Research on Central Examination (HSEE) Science Questions

Regarding the central exams, studies were conducted to evaluate HSEE and TBESE(Transition from basic education to secondary education)science questions according to the curricula and Revised Bloom's Taxonomy (RBT) (Akyürek & Aslan, 2020; Avcı et al., 2024), to analyze and compare TBESE, HSEE and PISA science questions (Çakır, 2019) and to examine TIMSS and HSEE questions in terms of different variables (Türkmen & Benzer, 2023a; 2023b). Şahin and Bursal (2024), on the other hand, aimed to examine the science questions in all Secondary Education Transition Central Examinations applied between 1998-2021 according to RBT. Recently, Aydın and Keskin (2025), aiming to examine the level of reflection of innovation skills, one of the 21stcentury learning skills, on HSEE science questions, analyzed the HSEE Science questions applied in Turkey between 2018-2023. In addition, Arık Güngör and Saraçoğlu (2023) aimed to evaluate the HSEE science questions applied between 2018-2021 in terms of Context-Based Learning approach. Kaya and Kara (2022) conducted a study to reveal the degree of compatibility of science questions in HSEE with the learning outcomes of the curriculum. Studies have also been conducted on eighth-grade students' views on HSEE (Çaylar, 2020) and science teachers' views on HSEE and TBESE examinations (Diken, 2020).Finally, there are studies in the literature in which both written exam questions and HSEE science questions were evaluated within the framework of the RBT (Koman et al., 2023; Polat & Bilen, 2022) and the questions in 8th grade science textbooks and the questions in HSEE were analyzed according to the same taxonomy (Güner, 2022).The researches present common findings that both HSEE and teacher written questions have an unbalanced distribution in terms of RBT and are insufficient in measuring higher level skills. In the study conducted by Şahin and Bursal (2024) covering the years 1998-2021, it was found that approximately three quarters (76%) of the 615 central exam science questions were at the recall and comprehension level, and there were no questions at the meta-cognitive knowledge and creation level. In the study, it was also determined that 71% of the HSEE questions were at the comprehension level. Aydın and Keskin (2025) determined that innovation skills were at a limited level in 2018-2023 HSEE science questions; the self-efficacy dimension was represented by 65% and the risk propensity dimension was represented by only 14% in the questions. Avcı et al. (2024) stated that most of the HSEE science questions between 2018 and 2022 did not comply with the learning outcomes, most of the questions were at the comprehension and application level, and there were no questions at the creation level. Kaya and Kara (2022) found that HSEE science questions were generally compatible with the learning outcomes of the curriculum, but there were problems at the level of covering the learning outcomes. Arık Güngör and Saraçoğlu (2023) determined that the rate of context-based questions in HSEE questions was low and there was no standard in this regard; however, they also found that the exam questions were in a structure that required thinking skills. Koman et al. (2023) determined that teacher questions were mostly concentrated at the level of factual knowledge and recall and comprehension, while HSEE questions were concentrated at the level of conceptual/operational knowledge and comprehension and analysis, but both were not homogeneously distributed. In the study, it was emphasized that HSEE questions were relatively higher level compared to teacher questions. Polat and Bilen (2022) found that 94.58% of the questions in TBESE and HSEE were at the lower level and only 5.42% were at the higher level cognitive levels, revealing that the central exams were inadequate and unbalanced in measuring higher level skills. Güner (2022), who conducted a concordance analysis, found that the HSEE questions overlapped with the learning outcomes by 65% in the knowledge dimension and 41.7% in the cognitive process, while these rates were 48% and 33.3%, respectively, in the textbook questions. He concluded that although HSEE questions were more compatible with the learning outcomes compared to the textbook, there was a significant discrepancy especially in the cognitive process dimension. As a result, although there are differences between teachers' exam questions, textbook questions and HSEE questions in terms of the distribution of the Revised Bloom's Taxonomy and outcome alignment, it is seen that all of them are limited in measuring higher order thinking skills. The quality of central examination questions has also been examined from an international perspective. Yamaoka et al. (2015) compared the questions in middle school science textbooks and high school entrance exams in Japan and found that questions requiring long written answers and reasoning were rare in both. This finding indicates that the problem of consistency between different assessment tools (textbook, written exam, central exam), which this study also focuses on in the Turkish context, has an international dimension.

Purpose of the Study

Numerous studies on textbooks, teacher written exams and central exams (HSEE), which are the three main tools of assessment and evaluation in science education, show that the questions in these tools point to a common problem: Cognitive demands are mainly concentrated on lower levels such as recall and comprehension, and higher-order thinking skills are not adequately measured (Köse, 2021; Arı & İnci, 2015; Şahin & Bursal, 2024). However, success, especially in skill-based exams, is closely related to the capacity to switch between different representations of knowledge (text, figure, graph, etc.) (Ainsworth, 1999; Avunç & Çağlar, 2021). However, the findings that the variety of representations and transitions in textbooks are limited (Günay, 2022; Kurnaz et al., 2016) to give the impression that this critical skill is not sufficiently supported in teaching and assessment processes. When the related literature is examined, although there are studies in which textbook questions, science teachers' written questions and HSEE questions are compared in terms of cognitive level or outcome alignment (e.g. Koman et al., 2023; Güner, 2022), whether the questions in these three instruments are similar in terms of transitions between representations has not been examined systematically. This study is motivated by this gap, in this study, it was aimed to evaluate the Science questions asked in the HSEE between 2013 and 2024, 8th grade Science textbook end-of-unit assessment questionsand 8th grade science written exam questions in terms of representation types and transitions between representations. To achieve this goal, the following questions were explored:

1. Which representation types are used in HSEE science questions, end of unit assessment questions in the 8th grade science textbook and 8th grade science written exam questions?
    - Which representation types are used in HSEE science questions between 2013-2024 and how often?
    - In the 8th grade science textbook end of unit assessment questions, which representation types are used and how often?
    - Which representation types are used in 8th grade science written exam questions and how often?
2. What is the nature of the transitions between the types of representation used in these questions?
    - In HSEE science questions, there are transitions between which types of representation?
    - In the end of unit assessment questionsin the 8th grade science textbook, there are transitions between which types of representation?
    - In the 8thgrade science written examquestions, there are transitions between which types of representation?
3. When the end of unit evaluation questions in the science textbook and the written science exam questions are compared with the HSEE science questions, do they show similarities in terms of representation types and transitions?

Method

Research Desing

In this study, the document analysis method, a qualitative research approach, was employed (Yıldırım & Şimşek, 2016). Document analysis is a systematic method used to examine and evaluate all documents, including materials in printed and/or electronic media (Kıral, 2020). For the purpose of the study, the necessity of analyzing HSEE science questions, end of unit questions in science textbooks and 8th grade science course written exam questions, which contain information about phenomena and sources, was effective in choosing this method.

Sample

The 8th grade science textbook (MoNE), HSEE booklets between 2013-2024 and 8th grade science written exams prepared by science teachers were used as documents in the study. Firstly, HSEE science questions between 2013-2024 were analyzed. These questions were obtained by downloading from the official website of the MoNE and 220 science questions were analyzed.

The 8th grade science textbook was accessed from the official website of the MoNE. In the 8th grade science textbook, it was determined that there were 171 questions in total. Since 113 of these questions were true/false, open-ended, puzzle, creating text based on visuals and structured grid type, they were not subjected to analysis and 58 multiple choicequestions were analyzed.

In secondary schools affiliated to the MoNE (5th, 6th, 7th and 8th grades), science is taught compulsorily for four class hours. Students are given a total of 4 written exams, two in the autumn term and two in the spring term. Written exam questions were obtained from teachers working in schools in Balıkesir, and teachers in neighbouring provinces were requested via e-mail and text messages. Purposive sampling method, one of the qualitative data collection strategies, was used to determine the science teachers from whom the written exam questions were collected. Purposive sampling does not involve probability and is used to investigate special cases with certain criteria by providing the opportunity to examine rich situations in depth (Büyüköztürk et al., 2019). In this context, it was aimed to reach the participants who could provide the richest and most relevant data in line with the purpose of the study. While determining the sample, it was paid attention that the teachers were working in a secondary school affiliated to the MoNE, teaching 8th grade science course, and volunteering to share the written exam questions they had. Participants with these criteria were first reached through the professional networks of the researchers, and then access to other suitable teachers in different provinces was provided. This approach enabled the selection of participants who would provide the most appropriate data for the research question and ensured diversity within practical access constraints. Therefore, the 24 teachers included in the study consisted of participants who fulfilled these criteria and volunteered to share data. A total of 50 written exams were obtained from 24 teachers working in different provinces in MoNE. A total of 1008 questions were obtained from these written exams and 246 of these questions were not analyzed because they were of fill-in-the-blank, true/false, structured grid, open-ended and puzzle types. 762 multiple-choice type questions were analyzed. The distribution of written exams by years and periods is presented in Table 1. The data used in the study were collected in a way to cover the current years starting from the 2017-2018 academic year when the HSEE was first implemented. However, due to the limited access to the teachers' exam archives of the previous years and the inability to obtain the exams of some periods completely, an irregular distribution was formed according to the years as seen in Table 1. This distribution reflects all available data and aims to make an evaluation based on the available data in line with the purpose of the study. As shown in Table 1,37 of the written exams belong to the autumn term and 13 of them belong to the spring term.

Table 1. Distribution of 8th grade science written exams

Academic Year	AutumnTerm	Spring Term	Total
2017-2018	-	1	1
2018-2019	1	2	3
2019-2020	1	-	1
2020-2021	6	6	12
2021-2022	23	1	24
2022-2023	-	1	1
2023-2024	6	2	8
Total	37	13	50

Data Collection and Analysis

In this study, firstly, textbooks, HSEE questions and written questions were obtained from the relevant official places. The number of multiple-choice questions in the end-of-unit assessment in the textbooks was determined and tabulated by examining the types of representation and transitions between representation types. HSEE questions were downloaded from the official website and analyzed and tabulated according to representation types. Written science questions obtained from science teachers working in different provinces were examined and multiple choice questions were tabulated. The tables were interpreted and the results were compared.

Content analysis was used to analyze the data. In content analysis, similar data are grouped according to specific concepts and categories, then organized and interpreted in a manner that is clear and comprehensible for the reader (Çalık &Sözbilir, 2014). The technique of content analysis include classifying data pertaining to the fundamental research issues (Bowen, 2009). Content analysis is a systematic and repeatable technique to reveal the presence of words or concepts in texts or structures consisting of texts. Content analysis involves several keysteps, including setting objectives, defining concepts, identifying the unit(s) of analysis, gathering relevant data, establishing a logical framework, creating coding categories, quantifying data, interpreting findings, and presenting the results (Akgün et al., 2020, p. 260).The questionsanalyzed within the scope of the study were coded according to representation types. The details of the stages followed in the study are as follows:

1. The end of unit evaluation questions and HSEE questions were obtained by downloading from official websites, and written exam questions were obtained from teachers working in MoNE.
2. Before starting the data analysis, categories were created based on the research in the field and the data collected. The questions within the scope of the research were analyzed in terms of learning domains, representation types and transition between representation types. The codes created for each question were determined by utilising the literature (Kurnaz et al., 2014; cited Kurnaz et al., 2016). For example, codes such as picture, graphic, mathematical expression, etc. were determined for representation types and transition between representation types.
3. At this stage, eachquestion was coded according to representation types and learning domains. Examples of representation types and transitions from textbook, HSEE questions and written questions are given in Table 2 below.

Table 2. Examples of transition between types of representation

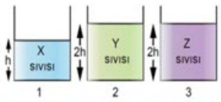
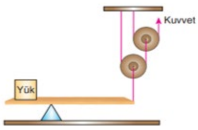
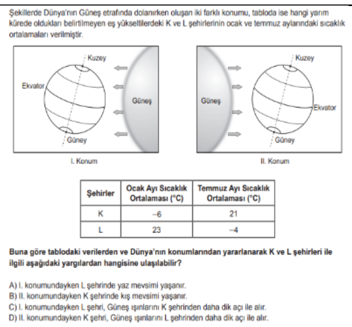
Questions	Explanation	Transition between representations
Tatlı su kaynakları Dünya'daki su kaynaklarının yaklaşık %3'ü kadardır. Bazı araştırmacılar bu kaynakların bilinçsiz kullanımının devam etmesi hâlinde yakın bir gelecekte Dünya üzerinde su kıtlığı yaşanacağını öngörmektedirler. **Buna göre aşağıdakilerden hangisi araştırmacıların öne sürdüğü bu sorunu önlemeye yönelik uygulamalardan biri olamaz?** A) Yağmur sularının depolanarak bahçe sulamasında kullanılmasına yönelik sistem tasarlanması B) Tarlaların zamanından önce ve fazla sulanmasını engellemek için toprağın nemini ölçen bir araç geliştirilmesi C) Barajlarda toplanan suyun dağıtım sistemine gönderilmeden önce arıtma sistemine alınması D) Lavabo giderlerinden akan suyun toplanarak arıtılması ve bahçelerde kullanılabilecek hâle getirilmesi	The given question is a 2018 HSEE question. The question asks for an answer based on the text. The text is basic in the item root of the question. For these reasons, the question is classified as "text" representation type. In the solution part, since the options contain verbal information, the representation type is classified as "textual".	Text to text
Bir hayvan hücresindeki solunumda; **▲ maddesi kullanılır ve enerji verir.** **■ maddesi parçalanma sonucu oluşan gazdır.** **Bu bilgilere göre, ▲ ve ■ ile belirtilen maddelerin solunum denkleminde doğru yerleştirilmiş hâli aşağıdakilerin hangisinde verilmiştir?** A) ▲ + Oksijen → ■ + Su B) ATP + ■ → ▲ + Su C) Oksijen + Su → ▲ + ■ D) ▲ + ATP → ■ + Oksijen	The given question is a 2014 HSEE question. The question asks for an answer based on the text. Text is the basis of the item root of the question. For this reason, the question stem is classified as "text" representation type. In the solution part, since the options include reaction and equation, it was effective in classifying it as "mathematical expression".	Text to Mathematical Expression
 Yukarıdaki özdeş kaplarda, verilen miktarlarda X, Y ve Z sıvıları bulunmaktadır. **Kap tabanındaki sıvı basınçları 1 = 3 > 2 şeklinde olduğuna göre, sıvı yoğunlukları hangi seçenekte doğru sıralanmıştır?** A) X = Z > Y B) Y > X = Z C) X > Z > Y D) Y = Z > X	The question given is a written question. The question asks for an answer based on the picture. In the item root of the question, "picture" is basic. In the solution part, the fact that the options are given as the relationship between size and smallness has been effective in classifying it as "mathematical expression".	Picture to Mathematical Expression
 Bir öğrenci basit makinelerden yararlanarak tasarladığı düzeneği yandaki gibi çiziyor. Öğrencinin tasarladığı düzenekle ilgili aşağıdaki ifadelerden hangisi yanlıştır? A. Düzenek kuvvetten kazanç sağlar. B. Düzenekte iki tane sabit makara vardır. C. Düzenek iş yapma kolaylığı sağlar. D. Düzenekte işten kazanç yoktur.	The given question belongs to the 8th grade science textbook. The question will be solved based on the picture. In the itemroot of the question, "picture" is the basis. Since the options are given as textual in the solutionpart and interpreting the picture leads to verbal information, the type of representation is classified as "textual".	Image to Text
Kütleleri eşit olan saf K, L ve M sıvılarının ilk sıcaklıkları ve özdeş ısıtıcılarla eşit süre ısıtıldıktan sonraki son sıcaklıkları tabloya kaydediliyor. Madde / İlk sıcaklık (°C) / Son sıcaklık (°C) K / 12 / 18 L / 26 / 51 M / 45 / 51 **Bu deneyde K, L ve M sıvılarında hâl değişimi gözlenmediğine göre öz ısıları ile ilgili olarak aşağıdakilerden hangisi doğrudur?** A) K = M > L B) K = L = M C) L = M > K D) K > L > M	It is the HSEE questionheld in the 2nd semester of the 2016-2017 academic year. The question will be solved based on the table. In the item root of the question, "table" is the basis. In the solution part, the fact that the options are given as the relationship between size and smallness has been effective in classifying them as "mathematical expression".	Table to Mathematical Expression
A, B ve C kürelerilyle ilgili aşağıdaki bilgiler veriliyor. • A ve B küreleri birbirine elektriksel itme kuvveti uygular. • B ve C küreleri yalıtkan iplerle tavana asıldığında kürelerin arasındaki uzaklık artar. Buna göre A, B ve C kürelerinin elektriksel yükleri aşağıdakilerden hangisi olabilir? A / B / C A. + / − / + B. − / + / + C. + / − / − D. − / − / −	The given question belongs to the 8th grade science textbook. Since the question is not asked to be solved based on the text, the item root is taken as "text" representation type. In the solution part, the options were classified as "mathematical expression" due to expressions such as +, -.	Text to Mathematical Expression

Table 2. (continued)


Şekillerde Dünya'nın Güneş etrafında dolanırken oluşan iki farklı konumu, tabloda ise hangi yarım kürede oldukları belirtilmeyen eş yükseltilerdeki K ve L şehirlerinin ocak ve temmuz aylarındaki sıcaklık ortalamaları verilmiştir.

Şehirler	Ocak Ayı Sıcaklık Ortalaması (°C)	Temmuz Ayı Sıcaklık Ortalaması (°C)
K	–6	21
L	23	–4

Buna göre tablodaki verilerden ve Dünya'nın konumlarından yararlanarak K ve L şehirleri ile ilgili aşağıdaki yargılardan hangisine ulaşılabilir?

A) I. konumundayken L şehrinde yaz mevsimi yaşanır.
B) II. konumundayken K şehrinde kış mevsimi yaşanır.
C) I. konumundayken L şehri, Güneş ışınlarını K şehrinden daha dik açı ile alır.
D) II. konumundayken K şehri, Güneş ışınlarını L şehrinden daha dik açı ile alır.

(see question above)	The given question is a 2019 HSEE question. The question consists of a picture and a table, and both should be evaluated together for the solution. The verbal explanations in the question stem are not considered as a separate "transition" element because they define the informational ready present in the picture and table. In the solution process, since the options were based on interpreting the data in the picture and table, these options were categorised as "textual". Therefore, in the question, a transition was made from the picture and table to the text.	From Picture and Table to Text

Validity and Reliability

All questions in the science textbook, written exam questions and HSEE questions were analyzed by the second author. In order to determine the reliability of data analysis, a total of 208 questions, including 12 questions (20% of 58 unit evaluation questions) in the 8th grade science textbook, 152 questions (20% of 762 science written exam questions) and 44 questions (20% of 220 HSEE science questions) were analyzed by the first author. Miles and Huberman (1994) reliability formula [Reliability = Agreement / (Agreement + Disagreement)] was used to calculate the percentage of agreement between the researchers. As a result of the analysis, the reliability value of the HSEE questions was 98.21%, the reliability value of the unit evaluation questions in the 8th grade science textbook was 91.67% and the reliability value of the science written questions was 97.58%. These results show that the agreement between the evaluators is above 80%, which is sufficient for reliability (Miles &Huberman, 1994). At the end of this process, communication was ensured between the assessors, the questions with different opinions were reviewed, discussed and a consensus was tried to be reached.

Findings

The results of the analyzes conducted in this section are presentedunder three main headings: "Findings on the analysis of HSEE questions (2013-2024) in terms of representation types," "Findings on the analysis of unit evaluation questions in the 8th grade science textbook in terms of representation types," and "Findings on the analysis of 8th grade science written exam questions in terms of representation types."

Findings on The Analysis of HSEE Questions Between 2013-2024 in terms of Representation Types

The representation types and transitions between representation types of HSEE questions conducted and published between 2013-2024 were analyzed. 220 HSEE questions were analyzed. The findings of the transitions between representation types are given in Table 3, Table 4, Table 5, Table 6, and Table 7.

Upon analyzing Table 3, it is evident that 169 of the HSEE questions administered between 2013 and 2024 utilized the picture representation type. Among these picture representation types, text (f=126) was the most common, picture (f=25) was the second most common, mathematical expression (f=16) was the third most common, and graphic (f=2) was the least common. In the HSEE questions, noquestion was found in the transition type from picture to table. In terms of learning domains, it is seen that the most common type of transition from picture to text is "Living Things and Life" (f=52), the most common type of transition from picture to picture is "Physical Phenomena" (f=15) and the most common type of transition from picture to mathematical expression is "Physical Phenomena" (f=8). In addition, the type of transition from picture to graph is found in the learning domains of "Earth and Universe" and "Matter and its Nature" with only one question each. It is seen that the representations used in HSEE questions mostly belong to the learning areas of "Living things and Life" and "Physical phenomena".

Table 4 shows that 114 of the HSEE questions asked between 2013 and 2024 used text representation type. Among these text representation types, text (f=86) was used the most, picture (f=18) was used the second, mathematical expression (f=8) was used the third, and graphic (f=2) was used the least. In addition, there were no questions in the HSEE questions in the type of transition from text to table. Regarding learning areas, the analysis shows that the transition from text to text mostly belongs to the learning area of 'Living Things and Life' (f=46), the transition from text to picture mostly belongs to 'Physical Phenomena' (f=8), and the transition from text to mathematical expression mostly belongs to 'Living Things and Life' (f=5). In addition, the type of transition from text to graph is in the learning area of "Matter and its Nature" with 2 questions. It is seen that the types of representation used in HSEE questions belong mostly to the learning domain of "Living Things and Life".

Table 3. Distribution of transitions from pictures to other representation types by learning area

Learning areas	To table		To text		To mathematicalexpression		To graphic		To picture	
	f	%	f	%	f	%	f	%	f	%
Earth and Universe	-	-	3	2.38	-	-	1	50	1	4
Living Things and Life	-	-	52	41.27	1	6.25	-	-	6	24
Matter and its Nature	-	-	25	19.84	7	43.75	1	50	3	12
Physical Phenomena	-	-	46	36.51	8	50	-	-	15	60
Total	-	-	126	100	16	100	2	100	25	100

Note. f = frequency; % = percentage. Dashes (–) indicate no transitions observed.

Table 4. Distribution of transitions from text to other representation types by learning area

Learning areas	To table		To text		To mathematicalexpression		To graphic		To picture	
	f	%	f	%	f	%	f	%	f	%
Earth and Universe	-	-	6	6.98	-	-	-	-	1	5.56
Living Things and Life	-	-	46	53.49	5	62.50	-	-	6	33.33
Matter and its Nature	-	-	14	16.28	1	12.50	2	100	3	16.67
Physical Phenomena	-	-	20	23.25	2	25.00	-	-	8	44.44
Total	-	-	86	100	8	100	2	100	18	100

Note. f = frequency; % = percentage. Dashes (–) indicate no transitions observed.

Table 5. Distribution of transitions from tables to other representation types by learning area

Learning areas	To table		To text		To mathematicalexpression		To graphic		To picture	
	f	%	f	%	f	%	f	%	f	%
Earth and Universe	-	-	1	9.10	-	-	-	-	-	-
Living Things and Life	-	-	4	36.36	-	-	-	-	-	-
Matter and its Nature	-	-	6	54.54	3	75	1	50	1	50
Physical Phenomena	-	-	-	-	1	25	1	50	1	50
Total	-	-	11	100	4	100	2	100	2	100

Note. f = frequency; % = percentage. Dashes (–) indicate no transitions observed.

Table 6. Distribution of transitions from graphic to other representation types by learning area

Learning areas	To table		To text		To mathematicalexpression		To graphic		To picture	
	f	%	f	%	f	%	f	%	f	%
Earth and Universe	-	-	-	-	-	-	-	-	1	25
Living Things and Life	-	-	3	21.43	-	-	-	-	-	-
Matter and its Nature	-	-	10	71.43	-	-	-	-	-	-
Physical Phenomena	-	-	1	7.14	-	-	-	-	3	75
Total	-	-	14	100	-	-	-	-	4	100

Note. f = frequency; % = percentage. Dashes (–) indicate no transitions observed.

Table 7. Distribution of transitions from mathematical expressions to other representation types by learning area

Learning areas	To table		To text		To Mathematical Expressions		To graphic		To picture	
	f	%	f	%	f	%	f	%	f	%
Earth and Universe	-	-	-	-	-	-	-	-	-	-
Living Things and Life	-	-	1	16.67	-	-	-	-	1	50
Matter and its Nature	-	-	4	66.66	3	75	-	-	1	50
Physical Phenomena	-	-	1	16.67	1	25	-	-	-	-
Total	-	-	6	100	4	100	-	-	2	100

Note. f = frequency; % = percentage. Dashes (–) indicate no transitions observed.

Table 5 shows that the table representation type was used in 19 of the HSEE questions from 2013 to 2024. Among these table representation types, text (f=11) was used the most, mathematical expression (f=4) was used the second most, and graphics and pictures (f=2) were used the least. In addition, there were no questions in the HSEE questions in the type of transition from table to table. In terms of learning domains, it is seen that the transitions from table to text belong mostly to the learning domain "Matter and its Nature" (f=6) and from table to mathematical expression belong mostly to the learning domain "Matter and its Nature" (f=3). In addition, the transitions from table to graph and picture are in the learning areas of "Matter and Nature" and "Physical Phenomena" with one question each. It is seen that the types of representation used in HSEE questions belong mostly to the learning domain of "Matter and its Nature".

When Table 6 is analyzed, 18 of the HSEE questions asked between 2013 and 2024 used graphic representation types. It is seen that the most common type of graphic representation was text (f=14) and the second most common type was picture (f=4). In addition, there were no questions in the HSEE questions in the transition type from graph to table, from graph to mathematical expression and from graph to graph. According to learning areas, "Matter and its Nature" (f=10) and "Physical Phenomena" (f=3) are the most frequently occurring transitions from graphic to text and graphic to picture, respectively. It is understood that the types of representation used in HSEE questions are mostly in the learning domain of "Matter and its Nature".

When Table 7 is analyzed, mathematical expression representation type was used in 12 of the HSEE questions asked between 2013 and 2024. It is seen that the most common type of mathematical expression representation was text (f=6), the second most common type was mathematical expression (f=4), and the least common type was picture (f=2). In addition to this, there were no questions in the HSEE questions in the type of transition from mathematical expression to table and from mathematical expression to graph. In terms of learning domains, it is seen that the transition from mathematical expression representation type to textbelongs mostly to the learning domain "Matter and its Nature" (f=4), and the transition from mathematical expression to mathematical expression belongs mostly to the learning domain "Matter and its Nature" (f=3). In addition, the transitions from mathematical expression to picture were in the learning domains of "Living Things and Life" and "Matter and Nature" with one question each. It is seen that the representations used in HSEE questions mostly belong to the "Matter and Nature" learning domain.

Findings on The Analysis of End of Unit Evaluation Questions in The 8th grade Science Textbook in terms of Representation Types

Within the scope of the research, the end of unit assessment questions in the 8th grade science textbook were analyzed on the basis of unit, types of representation according to learning areas and transition between representation types. The end of unit evaluation questions consist of different types of questions (open-ended questions, T-F questions, puzzles, structured grid). The total number of questions is 171 questions. However, 113 questions of different types were not included in the analysis in terms of representation types and transitions. The remaining 58 multiple-choice questions were analyzed in terms of representation types and transitions between representations. The distribution of multiple-choice questions in the science textbook according to the learning domain is presented in Figure 1.

As seen in Figure 1, the 8th grade science textbook has the most questions in the learning area of "Physical Phenomena" (f=23), secondly "Living Things and Life" (f=20), and thirdly "Matter and Its Nature" (f=12). The least number of questions is in the learning area of "Earth and Universe" (f=3). Table 8 presents the representation types and transitions among the multiple-choice questions included in the unit evaluation sections of the 8th grade science textbook.

When Table 8 is analyzed, it was determined that 30 text, 24 picture, three table and one graphic representation types were used in the unit evaluation questions in the 8th grade science textbook. Among these questions, three were from the "Earth and the Universe" learning area, 20 from the "Living Things and Life" learning area, 12 from the "Matter and Nature" learning area, and 23 from the "Physical Phenomena" learning area. Mostly (f= 27) text representation types were used in the questions. Among the text representation types, text (f=27) was used the most, followed by mathematical expression (f=2) and picture (f=1) was used the least. From picture representation types, text (f=20) was the most common, mathematical expression (f=3) was the second most common, and picture (f=1) was the least common. There were questions in which transitions were made from table representation type to text (f=3) representation type and from graphic representation type to text (f=1) representation type. In terms of learning domains, all questions (f=3) in the "Earth and the Universe" learning domain switched from picture to text type. In the learning domain of "Living Things and Life", it was observed that most of the questions (f=11) switched from text to text, secondly (f=6) from picture to text, thirdly (f=2) from table to text and least (f=1) from picture to picture. In addition, in the learning domain of "Living Things and Life", there were no questions that made transitions from text to picture, from text to mathematical expression, from picture to mathematical expression and from graphic to text. In the learning domain of "Physical Phenomena", it was observed that there were mostly (f=10) transitions from text to text, secondly (f=9) from picture to text, thirdly (f=2) from text to mathematical expression and from picture to mathematical expression.

Findings on The Analysis of 8th Grade Science Written Questions in terms of Representation Types

In order to analyze 8th grade science written exam questions, 24 teachers were reached and 50 science written exams were obtained from these teachers. 37 exams from the autumn term and 13 written exams from the spring term were analyzed. The 762 questions in these exams were analyzed according to representation types. The inconsistency between the number in the table and the number of representation types is due to the use of more than one representation type in some questions. The 8th grade science written exam questions analyzed according to representation types and transitions between them are given in Table 9.

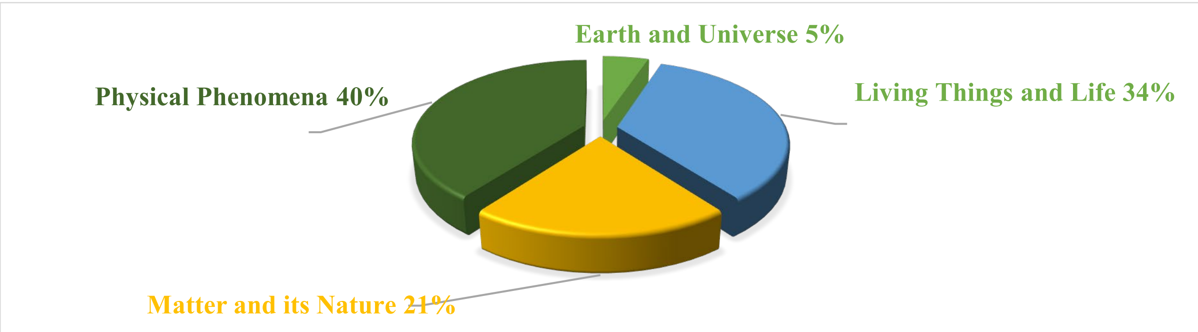


Figure 1. 8th grade science textbook: Distribution of unit evaluation questions according to learning areas

Table 8. Analysis of end of unit evaluation questions in 8th grade science textbook

Learning areas/ Unit	Transitions Between Types of Representation T-T f	T-P f	T-ME f	P-P f	P-T f	P-ME f	TA-T f	G-T f	Total f
Earth and Universe/ Seasons and Climate	-	-	-	-	3	-	-	-	3
Living Things and Life/DNA and GeneticCode	7	-	-	1	-	-	1	-	9
Physical Phenomena/Pressure	5	-	-	-	4	2	-	-	11
Matter and its Nature/ Matter and Industry	6	1	-	-	2	1	1	1	12
Physical Phenomena/ Simple Machines	2	-	-	-	4	-	-	-	6
Living Things and Life/ EnergyConversions and Environmental Science	4	-	-	-	6	-	1	-	11
Physical Phenomena/ ElectricCharges and ElectricEnergy	3	-	2	-	1	-	-	-	6
Total	27	1	2	1	20	3	3	1	58

*Text to Text:T-T, Text to Picture:T-P, Text to Mathematical Expression:T-ME, Picture to Picture: P-P, Picture to Text: P-T, Picture to Mathematical Expression: P-ME, Table to Text: TA-T, Graphic to Text: G-T

Table 9. Analysis of 8th grade science written examination questions in terms of types of representation by learning areas

Learning areas		Transitions Between Types of Representation*																						
		T-T	**T-P**	**T-ME**	**T-TA**	**T-PH**	**T-G**	**P-P**	**P-T**	**P-ME**	**P-G**	**G-G**	**G-P**	**G-T**	**G-ME**	**TA-TA**	**TA-T**	**TA-ME**	**TA-P**	**TA-G**	**ME-ME**	**ME-T**	**PH-T**	**Total**
		f	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**	**f**
Autumn Term	Earth and Universe	51	1	1	-	-	-	1	61	9	3	1	1	5	-	-	7	-	-	-	-	-	-	141
	Living Things and Life	110	1	29	-	1	-	5	34	9	-	-	-	4	2	-	7	6	-	-	6	1	2	217
	Matter and its Nature	49	4	4	2	-	-	3	35	5	1	1	1	2	2	1	3	1	1	-	2	8	-	125
	Physical Phenomena	35	5	-	-	-	-	11	43	24	1	-	2	1	-	-	-	-	-	-	-	-	-	122
Spring Term	Earth and Universe	3	-	-	-	-	-	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	6
	Living Things and Life	26	-	2	-	-	-	2	21	21	-	-	-	1	-	-	-	-	2	-	-	3	2	80
	Matter and its Nature	22	2	2	-	-	2	-	13	8	-	-	-	10	2	-	4	2	1	2	-	1	1	72
	Physical Phenomena	19	4	5	-	-	-	2	23	25	-	-	-	-	-	-	-	-	-	-	2	3	1	84
	Total	315	17	43	2	1	2	25	230	101	5	2	5	24	6	1	21	9	4	2	10	16	6	847

*Text-text:T-T,Text-Picture:T-P, Text to Mathematical Expression:T-ME, Picture to Picture: P-P, Picture to text: P-T, Picture to Mathematical Expression: P-ME, Picture to graphic: P-G, Graphic to graphic: G-G, Graphic to Picture: G-P, Graphic to text: G-T, Table to table : TA-TA, Table to text: TA-T,Table to Mathematical Expression: T-ME, Table to Picture: TA-P, Table to graphic: TA-G, Mathematical Expression to Mathematical Expression: ME-ME, Mathematical Expression to text: ME-T, Photograph to text: PH-T

According to Table 9, text representation type was used in 380 of the 8th grade science written exam questions. Among these text representation types, it is seen that the most common type was text (f=315), the second most common type was mathematical expression (f=43), the third most common type was picture (f=17) and the least common type was photograph (f=1). When the questions asked in the text representation type are analyzed according to the learning areas, it is seen that most of the written exam questions are in the learning area of "Living Things and Life" (f=169), secondly "Matter and its Nature" (f=87) and thirdly "Physical Phenomena" (f=68). In the picture representation type, it is seen that the most frequent transition is made to text (f=230), secondly to mathematical expression (f=101), thirdly to picture (f=25) and finally to graphic (f=5). When the questions asked in the picture representation type were analyzed according to the learning areas, the most common questions were in the learning area of "Physical Phenomena" (f=129), secondly in "Living Things and Life" (f=92), and thirdly in "Earth and Universe" (f=74). In the graphic representation type, it is seen that the most common type of graphic representation is text (f=24), the second is mathematical expression (f=6) and the third is picture (f=5). When the questions asked in the graphic representation type are analyzed according to the learning areas, it is seen that there are questions mostly in the learning area of "Matter and its Nature" (f=18), secondly in the learning area of "Earth and Universe" (f=9) and least in the learning area of "Physical Phenomena" (f=3). In table representation type, it is seen that most of the questions are text (f=21), secondly (f=9) are mathematical expressions, and the least number of questions (f=1) are transition to table. When the table representation types are analyzed according to the learning areas; there are questions mostly in the learning areas of "Matter and its Nature" (f=15) and "Living Things and Life" (f=15), secondly in the learning area of "Earth and Universe" (f=7). In the table representation types, there were no questions in the representation type belonging to the learning domain of "Physical Phenomena". Among the mathematical expression representation types, text (f=16) was the most common, and mathematical expression (f=10) was the second most common. When the mathematical expression was analyzed according to learning areas, it was mostly found in the learning area of "Matter and its Nature" (f=11), secondly in "Living Things and Life" (f=10), and thirdly in "Physical Phenomena" (f=5). There are a total of 6 questions that transition from photograph to text. These questions were in the learning areas of "Living Things and Life" (f=4), "Matter and its Nature" (f=1) and "Physical Phenomena" (f=1).

Discussion, Conclusion and Recommendations

The present study focused on determining the types of representations and the types of transitions between representations in the unit evaluation questions in the 8th grade science textbook, 8th grade science written exam questions, and HSEE questions. In this direction, the results of HSEE questions, unit evaluation questions in the 8th grade science textbook and 8th grade science written exam questions are presented under the relevant subheadings respectively. It is noteworthy that the analysis of science textbooks and high-stakes exams is a significant field of research not only in Turkey but also worldwide (Vojíř&Rusek, 2019), which underscores the global relevance of this study's focus.

Frequency of Representation Types Used in HSEE Science Questions between 2013-2024 and the Nature of Transitions between Representation Types

In the HSEE science questions between 2013 and 2024, it is seen that the most common representation types are picture (f=146) and text (f=91). Table (f=19), graphic (f=16) and mathematical expression (f=12) representation types were used at a low rate. These findings show that the types of representation in the central exam questions are not distributed in a balanced way and certain types are emphasised. The limited use of different types of representation indicates that the question design may be insufficient in terms of representation diversity. Altan Kurnaz and Yüzbaşıoğlu (2013), who analyzed the types of representation and the transitions between them in the Science and Technology/Science questions in the secondary school entrance exams [HSEE, Secondary Education Institutions Selection and Placement Examand Level Determination Exam (LDE)] between 1998 and 2012, concluded that the most commonly used representation type was figure. The fact that the central exams between 1998-2012 and the central exams between 2013-2024 still focus on the same types of representation shows that the logic of the preparation of the exam questions and the formats of measuring the gains have not changed. Yüzbaşıoğlu et al. (2021) analyzed the science questions asked in central exams (LDE, TBESE and HSEE) between 2013-2021. The researchers stated that there was not muchdifference between these exams in terms of representation types. In particular, the LDE's had the highest number of questions with graphs and multiple representations, while the HSEE exams were dominated by text and multiple representations. In TBESE exams, it was found that all types of representations analyzed were used. The fact that pictures are the most frequently used representation type is not limited to central exams; a similar situation is also observed in science textbooks. Günay (2022) found that photographs and pictures were the most frequently used representation types in secondary school science textbooks. The use of pictures and photographs is generally explained with reasons such as increasing the desire to read, gaining a positive perspective on the subject and facilitating comprehension (Yazıcı, 2006). This dominance of textual and pictorial representations is not unique to the Turkish context. For instance, Beerwinkle and Nelson (2024) found that while visuals in US middle school science textbooks were well-integrated with the text, a lack of instructive captions could hinder students' effective interpretation of these visuals. However, considering that the curriculum (MoNE, 2018) emphasizes high-level skills such as reading and interpreting graphs, creating tables and data analysis, as well as the ability to switch between different representation types, it can be concluded that the distribution of representation types in the central exam questions is not 'balanced'. What is meant by the concept of 'balance' here is not an equal number of questions from each representation type in absolute terms, but the provision of representation diversity in order to measure all of the multifaceted skills targeted by the curriculum at a reasonable level. The findings show that the exams predominantly use figure and text-based representations, while representation types such as graphs, tables and mathematical expressions, which are more suitable for measuring data analysis, modelling and abstraction skills, are not given enough space. As a result, it is understood that the current exams lack the diversity of representations to cover the range of skills emphasised in the curriculum and this may limit the measurement validity. Therefore, it is a pedagogical necessity to give more weight to representation types such as graphs, tables and maps, which are more effective in measuring 21st century skills (data literacy, analytical thinking, etc.).

When the transitions between representation types are analyzed, the most frequent transitions in 2013-2024 HSEE science questions are pictures and transitions from pictures to other types of representation. Transitions from pictures to text are much more common than transitions from pictures to other types (mathematical expressions, graphs or pictures). Similarly, Yüzbaşıoğlu et al. (2021) found that in central exam questions, question stems are usually in picture/figure representation type, while the answerparts are in text representation type. The second most frequently used representation type is text, but there are also transitions from text to other types. Transitions from text to text are more frequent than transitions from text to other types (mathematical expression, graph or picture). Tables are the third most frequently used representation type, and transitions from table to text are more common than transitions from table to other types. Transitions from graphs to other types of representation were also observed, but the majority of these transitions were to text and some to pictures. Finally, in a very small number of questions, transitions from mathematical expressions to other types of representations were observed. Half of these transitions were made to text and the other half to mathematical expressions or pictures.

When the distribution of the central exam questions according to the learning domains is analyzed, it is seen that 37.68% of the questions come from "Living Things and Life", 33.10% from "Physical Phenomena" and 26.05% from "Matter and its Nature". The "Earth and the Universe" domain has a share of only 3.16%(Table 3, 4, 5, 6, and 7). These findings reveal that the central exam questions do not show a clear distribution in terms of learning domains and representation types. Other studies analyzing science questions in central exams have reported similar findings regarding representation types (Günay, 2022; Kurnaz & Yüzbaşıoğlu, 2013; Yüzbaşıoğlu et al., 2021).

This disparity may be partly due to the structure or content of the units or topics in each learning domain. Indeed, the nature of the learning domains significantly influences which types of representations are more commonly used. For example, areas such as "Physical Phenomena" and "Matter and its Nature" are naturally more prone to representations such as graphs and diagrams since they are intertwined with quantitative data, formulae and models. On the other hand, manytopics in the field of "Living Things and Life" (digestive system, heredity, etc.) can be represented more frequently with text and explanatory diagrams because they are descriptive and process-oriented. The "Earth and the Universe" domain has a natural potential for various types of representation such as maps and models. This structural perspective is in line with the literature (Ainsworth, 2006; Gilbert, 2005) that emphasises the need for different types of representations in different disciplines. For example, Gilbert (2005) emphasised that the use of models and visual representations in science education is critical for understanding abstract concepts, but different types of representations are needed in different disciplines (physics, chemistry, biology). Ainsworth's (2006) concept of "changing representations" (representational fluency) is of key importance here. He stated that students' ability to represent a concept in different ways (text, formula, graph, diagram) and to switch between these representations is an indicator of deep understanding. In conclusion, the predominance of the textual representation type may not only be a pedagogical preference, but also a structural situation arising from the contextual characteristics of certain learning domains. However, this situation should not justify the current imbalance, but should be seen as an opportunity to be utilised by those who design exams and teaching. The importantthing is to unlock the potential for multiple representations inherent in each learning domain. For example, the "digestive system" can be assessed not only with text but also with diagrams, tables or graphs. Therefore, it is suggested that exams and textbooks should include the various representations appropriate to the nature of the domain in a more systematic and balanced way so that students can develop a more holistic and in-depth understanding.

8th grade Science Textbook: The Frequency of the Types of Representation Used in the Unit Evaluation Questions in the 8th Grade Science Textbook and the Nature of the Transitions Between the Types of Representation

When the 8th grade science textbook unit evaluation questions were analyzed, it was seen that the questions were mostly in text (f=30) and picture (f=24) representation types. Presentation types such as table (f=3) and graphic (f=1) were used veryrarely. The most frequently used representation type in the evaluation questions was found to be text. Transitions from the text representation type were also mostly made to the text type. In addition, transitions from text to picture and from text to mathematical expression were also observed. Transitions from the second most frequently used representation type, picture, to text, picture and mathematical expression were also observed. The results of this study are similar to the findings of Günay (2022). Günay (2022) determined that the use of pictures and photographs was predominant in the unit evaluation questions in secondary school science textbooks. In addition, he stated that dual representation types (list + picture, table + picture, picture + mathematical expression, table + mathematical expression) were rarely used. Similarly, Kurnaz et al. (2016) examined the types of representation and transitions used in 6th, 7th and 8thgrade science and technology textbooks. The researchers stated that, apart from text, pictures were mostly used, but the association between representations was insufficient. Keleş (2023) analyzed the visual presentations in biology units in 7th and 8th grade science textbooks. He found that the most frequently used visual type in both textbooks was pictures. Keleş (2023) analyzed the visuals in the textbooks in terms of type, surface features, subtitles, relationship with the text and the function of the presentation and stated that the designs of the visuals in the biology units in both textbooks were inadequate in terms of teaching and learning quality, and that somevisuals were likely to impose cognitive load on students. Akçay et al., (2020) analyzed the visuals in 12 secondary school science textbooks used in Turkey between 2002 and 2017 in terms of graphic types, gender representations, association with text, captions, formality and functions of visual images. The researchers found that charts and graphs were rare in secondary school science textbooks, and iconic representations such as photographs and drawings were predominantly used. This finding shows that the subjects in secondary school science textbooks are mainly taught with concrete images. There are similar situations in science textbooks used internationally. Tindani et al. (2021) analyzed Indonesian science textbooks in terms of types of representations and found that the most common type of representations were pictures (82.8%), while equations, diagrams and charts were very rarely encountered. Similarly, Liu (2016) analyzed the diagrams (iconic, schematic, chart and graphical) in science textbooks in Bahrain and found that iconic diagrams (such as pictures and drawings) were mostly used in the textbooks, while diagrams in the form of charts and graphs were used the least. Lee (2010) analyzed the visual representations used in US textbooks over the last 60 years and found that visuals such as photographs were used more frequently than schematic and explanatory visuals to familiarize students (as cited in Liu, 2016). Science is a course in which abstract concepts are taught and these concepts are analyzed. Since abstract concepts are too small to be seen with the nakedeye, they are usually represented by schematic representations, graphs and tables (Akçay et al., 2020). For this reason, including more than onetype of representation in both lectures and unit evaluation questions in textbooks and providing content that will enable students to make connections between these representations will make learning easier and more permanent.

When the distribution of the unit evaluation questions analyzed within the scope of the study according to the learning domains is examined, it is seen that 39.65% of the questions come from "Physical Phenomena", 34.48% from "Living Things and Life" and 20.70% from "Matter and its Nature" domains. The "Earth and the Universe" field has a share of only 5,17%. These findingsreveal that the unit evaluation questions do not show a clear distribution in terms of representation types and learning areas. In addition, it was determined that there was not an equal distribution of questions in terms of learning areas on unit basis and the number of questions was insufficient. The low number of unit evaluation questions may be due to the fact that not all of the learning outcomes within the unit are questioned. As a matter of fact, Güler Göbekli (2022) examined the unit assessment questions in the 5th, 6th, 7th and 8th grade science textbooks used in the 2020-2021 academic year. The researcher determined that there were no questions about some objectives, some questions met several objectives at the same time, and somequestions were out of objectives. Similarly, Sözeri et al. (2024) evaluated the science sample questions published by the MoNE in the 2021-2022 academic year, the end-of-unit assessment questions in the 8th grade science textbook, and the 2022 HSEE science questions in terms of the 2018 Science Course Curriculum (SCCP) objectives and science process skills. The researchers determined that some of the objectives encountered in the end-of-unit assessment questions of the textbook were not encountered in the sample questions and HSEE science questions.

8th Grade Science Written Exam Questions: Frequency of Use of Types of Representation and Nature of Transitions Between Types of Representation

When the science written examquestions were analyzed, it was seen that text (f=380) representation type was used the most, followed by picture (f=361), graphic (f=37) and table (f=37) representation types (Table 10). Transitions were made from text representation type to text, picture, mathematical expression, table, photograph and graphic types. The most common of these transitions was text-to-text transitions (f=315) (Table 10). There are transitions from picture representation type to picture, text, mathematical expression and graphic types. Among these transitions, transitions from picture to text (f=230) are the most common (Table 10). From the graphic representation type, transitions were made to graphic, picture, text and mathematical expression types, and among these transitions, transitions from graphic to text (f=24) are more common than the others(Table 10). Transitions were made from table representation type to table, text, mathematical expression, graphic and picture types. In addition, mathematical expression (f=26) and photograph (f=6) representation types were also included(Table 10).

While transitions were made from mathematical expression to mathematical expression and text types, it was determined that transitions were made only to text type from photograph. When the written exam questions prepared by science teachers were analyzed in terms of transitions between representation types, it was determined that almost half of the questions had transitions in the text representation type. In written exam questions, it was found that most of the transitions were made to texttype in all representation types such as text, picture, table, graph, mathematical expression and photograph. This situation is similar to the central exam questions and unit evaluation questions. The fact that students are usually intensively exposed to a certain type of representation may cause them to be inadequate in using other types of representation and switching between these types. As a matter of fact, Ezberci et al. (2015) stated that the majority of 6th, 7th and 8th grade students were unsuccessful/inadequate in text, picture, graphic and table representation types and transitions between these types. This widespread inadequacy underscores a critical need for a shift in educational practices. The pedagogical contribution of using multiple representations becomes evident in two main areas. First, it promotes deeper conceptual understanding; when a concept is presented through text, a diagram, and a graph, students can form richer, more interconnected mental models, moving beyond rote memorization to genuine comprehension (Wu&Puntambekar, 2012). Second, it directly cultivates higher-order thinking skills and scientific literacy. Interpreting a graph, analyzing a table, or translating information from a picture into text are fundamental practices in science that enhance students' analytical and evaluative abilities, better preparing them for the complexities of real-life problem-solving (Kozma& Russell, 2005). Consequently, addressing this imbalance is essential for developing scientifically competent individuals.

When the distribution of the written exam questions examined within the scope of the study according to the learning domains is analyzed, it is seen that 35.06% of the questions come from "Living Things and Life", 24.31% from "Physical Phenomena" and 23.26% from "Matter and its Nature". The "Earth and Universe" domain was represented by 147 questions (17.36%). The findings reveal that the distribution of science written exam questions does not show a clear distribution according to the types of representation, but the distribution according to the learning domains is close to each other.

Analysing HSEE Science ExamQuestions, 8th Grade Science Textbook Unit Evaluation Questions and 8th Grade Science Written Exam Questions in terms of Types of Representation and Transitions Between Representations

When HSEE science questions, 8th grade science textbook unit evaluation questions and written exam questions are analyzed in terms of representation types and transitions between representations, it is seen that text and picture representation types are generally predominant. In particular, it was found that text was the most frequently used representationtype in transitions from one representation type to another. This shows that transitions between other types of representation are ignored. In the unit evaluation and written examquestions in the science textbook, text was the most frequently used representationtype and transitions were also made to texttype. In HSEE science questions, on the other hand, the picturerepresentationtype was used more frequently and transitions were generally made from picture to text. These findingsreveal that there is a difference between textbookquestions and HSEEquestions in terms of representation types. However, in transitions between representations, it was observed that transitions to texttype were similar in all three question types.

These results revealed that there are critical differences and common weaknesses between the central exam (HSEE), textbook unit assessment and written examquestions in terms of representation types and transitions between representations. In line with these findings, the following recommendations were developed to address these differences and weaknesses.

Firstly, changes in the curriculum and materials development processes are recommended. Textbooks should be at the centre of this effort, since, as Weiss et al. (2001) show, 95% of teachers use textbooks as the main source for planning instruction and assigning homework. Therefore, it is vital to review the content of textbooks. In this context, the emphasis on "the use of information in different formats" in the curriculum of the Presidency of the Board of Education should be handled in a more functional way during the preparation and examination of textbooks. By establishing a direct cooperation mechanism between the units analysing textbooks and the Board of Education on the importance of representation types and transitions, this emphasis can be reflected in the content of the textbooks. Ainsworth's (2006) DeFT (Design, Functions, Tasks) framework, which emphasises the critical role of multiple representations in the learning process, can guide this process. In line with this framework, multiple representations should be systematically included in textbooks, taking into account that the designed use of different types of representations together provides students with a deeper understanding of scientific concepts. As a practical step, the MoNE should revise the new generation of textbook writing guidelines to require the use of at least three different types of representations such as graphs, tables, diagrams and mathematical representations in each unit. The use of visual-schematic representations such as digestive system diagrams or hereditypedigrees should be encouraged, especially in "Living Things and Life" units where descriptive texts are predominant. Similarly, unit assessment questions should be diversified in line with the distribution of representations in the central exams by eliminating the use of only text and pictures.

The ultimategoal of this material reform is to ensure consistency in terms of representation types and transitions between unit assessment questions in textbooks, teachers' written exams and HSEE questions. As supported by Önder (2016), the similarity of written examquestions in schools to the questions in central exams positively affects student achievement. Therefore, teachers' use of questions similar to the HSEE format and containing multiple representations in their lessons and written exams will facilitate students' familiarization with the exam format and increase their success.

As a second suggestion, it is essential to support teachers' professional development in this area. The main aim of these trainings should be to equip teachers with the "representational competence" emphasised by Kozma and Russell (2005) - the ability to use and switch between different types of representations to help students understandscientific concepts. This competence not only facilitates students' understanding of complex concepts, but is also an integral component of scientific literacy. In-service training programmes for teachers should include modules on multiple representations in science education. These modules should include concrete examples of classroom practice, such as how to translate a diagram into textor how to interpret and convert a graphinto a table. In addition, practical assessment and evaluation trainings should be organised so that teachers can designquestions in their written exams that are appropriate to the HSEE format, include more than onetype of representation, and measure the ability to move between representations. As emphasised by Prain and Tytler (2012), teachers' including more activities that require students to draw their owndiagrams, create models or express an event with different representations in their lessons will make a critical contribution to students' development of "representational competence" mentioned by Kozma and Russell (2005).

Finally, arrangements can be made to increase the content validity of central exams. While preparing the exam questions, a balanced distribution of representation types should be aimed to coverall learning areas in order to increase measurement validity. In particular, the proportion of graph, table and diagram-based questions that measure students' data analysis and modelling skills should be increased. Masrifah et al. (2020) emphasised that the use of different representation types supports meaningful learning. Therefore, including more questions in central exams that require students to interpret and switch between different types of representations is not only a measurement requirement but also a pedagogical imperative that promotes deep conceptual understanding. The scope of the assessment can be extended by including visual representations (e.g., different circuit diagrams, incorrect graphical interpretations) not only in the question stem but also in the answerchoices. Integrating evidence-based international frameworks into question design processes, such as the functional relationship between visual types and scientific types (explanation, report, experimental narrative), as emphasised by Tang (2023), would further enhance the pedagogical quality of questions.

Author Contributions

All authors took an equal part in all processes of the article. All authors have read and approved the final version of the study.

Ethical Declaration

The authors declare that the study is not subject to ethics committee approval and that the rules set out by the Committee on Publication Ethics (COPE) were followed throughout the study.

Conflict of Interest

The authors declare that there is no conflict of interest with any institution or person within the scope of the study.

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