International Journal of Progressive Education, Volume 19 Number 2, 2023

The Examination of Representations in Primary School Science Textbooks from the Perspective of Multimodal Genre Analysis

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Abstract

This study conducted a genre analysis to determine the representations in primary school science textbooks. Multiple representations in textbooks indicate multimodality. This study adopted a multimodal genre analysis approach to review the multiple representations in textbooks within the framework of the "scientific" genre. The sample consisted of two primary school textbooks taught to third and fourth graders within the scope of "the science" course in the 2021-2022 academic year. The data were gathered based on document analysis and analyzed using content analysis. Frequency and percentage were used for analysis. The results show that the most common representations in the textbooks are photographs and iconic diagrams. The third-grade textbook has more representations than the fourth-grade textbook. The representations in the textbooks are primarily associated with the scientific genres "explanation" and "information report." Of the scientific genres in the textbooks, photographs are primarily used in "information report," "explanation," and "narration." Iconic diagram representation is preferred in "experimental," "argumentative," and "technical procedure." Certain representations are predominantly used in the textbooks, indicating that the textbooks lack a diversity of representations. In addition, the scientific genres are underrepresented in the textbooks, suggesting that the textbooks underutilize the advantages offered by different types of representations. We recommend that textbooks should be enriched with representations and scientific genres.

Keywords: Genre Analysis, Multimodality, Representation, Science, Textbook

DOI: 10.29329/ijpe.2023.534.10

Submitted: 19/09/2022 **Accepted:** 27/02/2023 **Published:** 01/04/2023

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INTRODUCTION

Both verbal and nonverbal language is used to conduct all learning and teaching processes (Wellington & Osborne, 2001). We need more than verbal language to do science and communicate (Lemke, 1998). Combining verbal discourse, mathematical expressions, and visual representations rationally is necessary to perform, speak about, read, and write science (Lemke, 1998). Science education requires communication (verbal, visual, symbolic, graph, concrete, etc.) that employs various teaching approaches and satisfies different learning styles and abilities (Wellington & Osborne, 2001). In the framework of TIMSS 2019, there is an emphasis on visualizing information for science education and utilizing different types of representations in problem-solving (Mullis et al., 2021).

The use of multiple representations in education presents different perspectives, increasing information accuracy and precision, promoting various forms of expression of information, providing specificity, and presenting different levels of complexity and difficulty (Jong et al., 1998). Representations are artifacts as an integral part of the language of science, symbolize an idea or concept concerning science education, and can be used in different forms, such as analogies, verbal explanations, written texts, diagrams, and simulations (Tang et al., 2014).

The social semiotic theory is often used to understand the language in science education and the process of creating meaning (Tang et al., 2022). Teachers can use various semiotic modes (creating meaning using words, images, symbols, actions, and other ways of communication) in science education (Wellington & Osborne, 2001). Semiotic theory expresses the structure and functionality of language, visuals, and their combinations in a particular context (Hiippala, 2014). Genre and multimodality are two ways of applying social semiotics theory in science education. This study combined them and used them to examine textbooks.

Genre and Multimodality

Scientific language is examined on three levels: “vocabulary” (e.g., word and expression), “grammar” (e.g., sentence structure), and “genre” (e.g., discourse) (Tang & Rappa, 2020). “Genre” is related to the structure and organization of a text (Tang, 2022). Expressing the intersection of language and scientific practices, “genre” is about the purpose of a text's production, consumption, and presentation (Tang & Rappa, 2020). From the point of view of science education, the use of genre involves examining the linguistic structure of scientific texts (explanatory, experimental, etc.) (Tang et al., 2022; Tang & Rappa, 2020). Genre analysis is conducted to compare texts to describe their features, define the possibilities offered to readers by genres, and reveal the social function of genres (Bateman, 2014).

Nowadays, forms of communication are rapidly transforming, and the new understanding of texts does not fit into the existing typology of genres; therefore, researchers have revised the concept of genre to develop the multimodal genre analysis approach (Valerias Jurado & Ruiz-Madrid, 2015). From the perspective of social semiotics, the mode is a culturally and socially shaped source of meaning-making processes (Mills & Unsworth, 2017). Multimodality is the combination of multi-sensory and communicative modes, such as vision, sound, print, visual, video, music, etc., that produce meaning for any message (Dressman, 2019). From the perspective of social semiotics, some examples of modes are social semiotics, speech, gesture, written language, music, mathematical expressions, drawings, photographs, and digital motion images (Mills & Unsworth, 2017).

On the other hand, the multimodal genre analysis approach considers the concept of species in its most general form as a goal-oriented activity based on social motivation to provide multimodal communication (Xia, 2020). Multimodal genre analysis is not limited to written language and verbal elements but also includes the combination of different forms of expression that best convey messages by using other possibilities and epistemological commitments provided by representations (Valeiras-Jurado, 2012). At this point, the creation of the multimodal model, the essence of which is the design process, includes the order of the design, epistemology (for each element), and decision-making processes about the mode (Kress, 2003).

From the point of view of science education, the content and activity employed in different types of representations cause students to communicate with learning objects in different roles/dimensions (Kress, 2003). Salloum (2021) examines intertextuality in science education and argues that multimodality is necessary, but not enough, to improve students' conceptual understanding of science subjects. Moreover, the intertextuality between multiple modes points to the significance of discourse style and science language variables. However, researchers maintain that traditional scientific genres are boring and unpleasant genres that cause female students to lose interest in science (Hildebrand, 1996; Keys, 1999).

Understanding and using different types (explanatory, argumentative, descriptive, etc.) in science education are the basic components of scientific literacy (Yore et al., 2004). Tang and Rappa (2020) state that teachers and students have difficulty defining the structural and linguistic forms of these types (explanatory, informative, experimental, argumentative) and understanding why they are used and what they do in a typical science class. The focus of teaching and scientific explanations is the meaning embedded in different types of representation and the coordination of those types of representations (Tytler & Prain, 2010). In other words, not focusing on representations and their scientific styles causes a problem (Tang & Rappa, 2020). An essential component of science education is to help students understand the rationale for how scientific knowledge is generated, validated, and communicated according to specific types rather than presenting them with a simplified "scientific method" (Tang & Rappa, 2020).

Scientific explanations based on multiple representations help students develop a scientific understanding (Tytler & Prain, 2010). In recent years, there has been a growing body of research that explains how representations are used to construct scientific explanations in science education (Park et al., 2020); Tang et al., 2022; Yeo & Gilbert, 2017). However, the concept of species is unclear for some researchers as it involves examining a limited number of genres through student drawings (Park et al., 2020). They regard it as a concept limited to a specific subject (Yeo & Gilbert, 2017). Moreover, some researchers conduct genre analyses to examine the types of representations produced by students while learning concepts (Tang et al., 2022). The present study adopted a genre analysis perspective to investigate the multiple representations in textbooks, which are critical materials for learning processes.

Science Education and Textbooks

Textbooks are sources of information and essential teaching tools students benefit from during their school years (Liu & Khine, 2016). Almost seven in ten teachers of primary school fourth-grade students use textbooks as primary sources of information (65%), while the rest use them as complementary sources (35%) (Mullis et al., 2008). Therefore, the accuracy and quality of the content of textbooks are critical for the effectiveness of educational processes (Liu & Khine, 2016).

Multimodality in textbooks allows designers to use different epistemological positions and learning theories (Bezemer & Kress, 2010). All representations have different meanings, essential aspects, and limitations (Wellington & Osborne, 2001). From the point of view of science education, the interaction of verbal and visual elements in textbooks promotes learning and develops interpersonal meaning (Koutsikou et al., 2021). Verbal text and visual association should help students participate actively and gain familiarity with the content of teaching materials (Koutsikou et al., 2021). From this point of view, one mode (writing, procedural type, etc.) may emphasize a transferring learning-teaching approach, another (visual, concept cartoon, etc.) may highlight the constructivist approach, while another may emphasize inductively and other deductive learning processes (Bezemer & Kress, 2010). At this point, it is necessary to look at the process of creating meaning in science education in the multimodal structure created by the semantic relationship between verbal and visual modes (Tang, 2021). The harmony and cooperation between verbal and visual modes help students make sense of multimodal science materials (Koutsikou et al., 2021). We should consider the educational function of visuals rather than their aesthetic and decorative functions before we use them to discover their potential as learning tools (Postigo & López-Manjón, 2019). Representations in science textbooks determine which representations teachers use in their lectures and how they use them (Bergqvist & Chang Rundgren, 2017). Therefore, we should analyze how multiple representations are integrated into textbooks.

Many researchers focus on science textbooks (İnaltekin & Göksu, 2019; Khine & Liu, 2017; Liu & Khine, 2016; Liu & Treagust, 2013). Vojíř and Rusek (2019) determined that it was mostly American researchers who examined science textbooks, followed by Turkish researchers. For example, Turkish researchers address the scientific process skills (Bayir & Kahveci, 2022), scientific content (Yılmaz et al., 2021), scientific process, life, and engineering skills (Ecevit et al., 2022), nature of science components (Duruk & Akgün, 2020; Uluçınar Sağır & Soylu, 2021), learning approaches (Sarıoğlan et al., 2016), assessment and evaluation approaches (Köse, 2021), analogies (Kıvanç & Aydın, 2021; Köse, 2022), and cultural elements (Guvendi, 2021) in science textbooks.

Eroğlu Doğan et al. (2020) argue that most Turkish researchers assess science textbooks in terms of content but rarely analyze them in terms of style, language, and expression criteria. Vojíř and Rusek (2019) observe that most researchers focus on the content of science textbooks. On the other hand, there has been a growing body of research into the multiple representations in textbooks because they make texts more appealing to teachers (Vojíř & Rusek, 2019). However, there is little research on the visual-verbal elements in textbooks (Tang, 2022), as most researchers concentrate solely on the titling and indexing of representations (Khine & Liu, 2017; Slough et al., 2010). In other words, researchers have understudied in what context/discourse representations are used in textbooks and how they support one another concerning texts (Tang, 2022). Moreover, researchers who examined the relationship between visuals and texts in the context of genre analysis focused chiefly on secondary school (Tang, 2022) and preschool (Koutsikou et al., 2021) textbooks.

Most researchers examine secondary school textbooks, and there are fewer studies on primary school science textbooks than their secondary school counterparts (Eroğlu Doğan et al., 2020; Vojíř & Rusek, 2019). Postigo and López-Manjón (2019) examined the biology topics in primary and secondary school science textbooks in Spain and concluded that the educational type did not matter. This suggests we need more species analysis to investigate multiple representations in primary school science textbooks. Moreover, educational genres in learning processes vary across countries depending on their national education systems (Foster & Russell, 2002). In this context, Turkish researchers who focus on multiple representations in science textbooks examine the distribution of representations in secondary school textbooks (Şantaş, 2017). Barış et al. (2020) conclude that representations appeal to specific topics limited by textual connection and titling. Researchers also concentrate on the distribution of representations at different grade levels (İnaltekin & Göksu, 2019) and review them in terms of visual design principles limited by photograph and drawing elements (Shahinpoor & Alpan, 2021). We can argue that researchers turn a blind eye to the "scientific genre" dimension regarding the use of representations. Therefore, we think that our results will provide important information regarding the status of science textbooks in Türkiye.

Research Objective

This study aimed to investigate the multiple representations in primary school science textbooks within the context of the scientific genre. We think this study will present important results given the effect of multimodality on learning and the importance of scientific genres and representations. The following are the research questions:

1. What representations are used in primary school science textbooks?

2. What is the distribution of the representations in primary school science textbooks regarding the subject area and grade level?

3. What is the distribution of the scientific genre with which the representations are associated?

4. What is the distribution of the representations and scientific genres across chapters in the textbooks?

METHOD

This study adopted a document analysis model, a qualitative research approach involving the systematic examination or evaluation of printed and digital materials (Bowen, 2009).

Research Material

The research materials were two science textbooks (third and fourth grades) published by the Ministry of National Education in accordance with the decision of the Ministry of National Education Board of Education and Discipline (Date: 25.07.2018 & No: 99) for the 2021-2022 academic year. This study focused on those textbooks because they were prepared in collaboration with academics.

Data Collection Tools

The data were collected using a content review form developed by the researchers. The form was used to determine the multiple representations in the textbooks and the scientific genre with which they were associated. The form consisted of three parts. The first part focused on the variables of "grade level," "unit," and "analysis unit." The second part addressed the representations in the textbooks. The third part focused on the variables of the "scientific genre." The frameworks developed by Tang (2022) were used to examine the representations and scientific genres in the textbooks (Tables 1 and 2). Unlike Tang (2022), we also focused on "concept cartoons" within the framework of the types of representations in the textbooks. Inter-rater coefficient reliability stated in the following section can provide an idea about the validity and reliability of the form.

Table 1 Framework for Coding Multiple Representations in Textbooks

Representation Type	Features
Photograph	A realistic image of an object taken with an optical camera
Diagram	Hand-drawn or computer-generated graphs that show the objects' physical properties (shape, size, parts, and relationships). Diagrams are iconic (images look like the object they represent); They may be schematic (images are symbolic or fictitious) or both.
Network graph	It is a graph showing the conceptual and qualitative relationships between visual components (geometric shapes, lines, and words), e.g., flowchart, decision tree, mind map, Venn diagram.
Graph	It is a type of representation that shows quantitative information through the position and size of visual components.
Map	Graph showing layered information about specific locations on Earth
Table	Organized arrangement and display of words, numbers, or symbols to emphasize their relationship
Equation	Symbolic expression, including scientific notation and algebraic symbols
Scientific image	Images by specialized scientific equipment, such as X-ray, electron microscope, etc.
Diagram + photo mix	A hybrid combination of adjacent or superimposed diagrams and photographs.
Table+image mix	A hybrid combination of images (photos or diagrams) embedded in a table, for example, used together within one of the cells.
Concept Cartoons	While characters generate alternative ideas about the scientific aspect of a situation, students are invited to discuss with the character in the cartoon (Keogh et al., 1998).

Note. Revised from Distribution of visual representations across scientific genres in secondary science textbooks: Analysing multimodal genre pattern of verbal-visual texts by K. S. Tang (2022).

Table 2 Framework for the Coding of Scientific Genres with Which Representations in Textbooks Are Associated

Genre	Features
Information report	Purpose: Organizing information on events and objects Stages: Identification, explanation, and classification Linguistic features: • Frequent use of relation clauses • Sentences are often not in order
Explanation	Purpose: Explaining the underlying causes or processes of a known phenomenon Stages: Case identification, sequencing, and generalization Linguistic features: • Frequent use of conjunctions (e.g., because, if) • Sentences are ordered according to the temporal or causal logic of events
Experimental	Purpose: Presenting the stages and results of an experiment Stages: Goal, stages, and results Linguistic features: • Frequent use of behavioral sentences centered on the reader or experimenter (e.g., holding the apparatus, magnet, etc.) • Frequent use of a numeric system or bullet points • Sentences are ordered according to the procedural steps required to perform an experiment.
Argumentative	Purpose: Providing evidence that confirms or refutes an arguable claim Stages: thesis, proof, and discussion Linguistic features: • Suggesting predictions or hypotheses (e.g., believing, suggesting, etc.) rather than objective statements may suggest • In some sentences, the subject is clear (for example, scientists believe…) • Sentences are ordered according to the temporal or causal logic of events.
Technical Procedure	Purpose: Instructing readers on how to perform a task or procedure Stages: task and method Linguistic features: • Frequent use of reader- or practitioner-centered behavioral sentences (write, balance, etc.) • Frequent use of personal pronouns (you can, you will, etc.) • Sentences are ordered according to the procedural steps of an operation
Narrative	Purpose: Relating the biographies of past or contemporary scientists; stories of recent news or historical events Stages: Orientation and event recording Linguistic features: • Names of people are clear in most sentences • Frequent use of action phrases (seeking, performing, etc.) • Sentences are usually in chronological order.

Note. From Distribution of visual representations across scientific genres in secondary science textbooks: Analysing multimodal genre pattern of verbal-visual texts by K. S. Tang (2022).

Analysis Unit

The analysis unit was the "representations" and the texts with which they were associated. The analysis unit excluded decorative images, warnings about safety precautions, and the same cartoonish characters and their speech bubbles in the textbooks. This study focused on texts and their educational function to identify the representations' scientific genres. It was determined that one representation was used in some scientific genres, while more than one representation was used in others. In this case, the entire group of representations was regarded as one representation. In the third-grade textbook, the headings "Chapter," "What We Have Learned," and "Do You Know?" were assessed within the scope of the "main text" part. The titles "Let's Do It Together" and "It is Your Turn" were assessed within the scope of the "activity" part. The contents under the title of "Unit Evaluation Test" were assessed within the scope of the "measurement and evaluation" part. In the fourth-grade science textbook, "Chapter," "Let's Know This," "Shaping the Future," and "Let's Repeat What We Learned" were assessed within the scope of the "main text" part. "Let's Explore Together," "Think, Write and Share," "Let's Try Ourselves," and "If You Were the Narrator" were assessed within the scope of the "activity" part. The contents under the title of "Unit Evaluation Questions" were examined within the scope of the "measurement and evaluation" part.

Data Analysis

Descriptive statistics were used to analyze the representations and scientific genres in the textbooks. To check reliability, a researcher coded two randomly representative samples from each unit at the third and fourth-grade levels and the related text. The inter-rater reliability coefficient was calculated. The representations and scientific genres had a Cohen's Kappa coefficient of .936 and .819, respectively. According to the reference interval suggested by Landis and Koch (1977) for Kappa statistics, both representations and scientific genres had high reliability.

RESULTS

The Distribution of the Representations in Science Textbooks

The distribution of the representations in science textbooks was examined by grade level, subject area, and unit. Firstly, the distribution of representations by grade level was presented. Table 3 shows the distribution of the representations by grade level.

Table 3 Distribution of Representations by Grade Level

		Representations									
Grade Level	**f**	**Photograph**	**Iconic diagram**	**Symbolic diagram**	**Table**	**Network graph**	**Graph**	**Diagram + photo**	**Tables+ images**	**Concept cartoon**	**Map**
3	668 (60%)	384 57.5%	204 30.5%	22 3.3%	17 2.5%	14 2.1%	2 0.3%	14 2.1%	3 0.4%	3 0.4%	5 0.7%
4	449 (40%)	251 55.9%	87 19.4%	28 6.2%	38 8.5%	24 5.3%	1 0.2%	14 3.1%	6 1.3%	0 0.0%	0 0.0%
Total	1117	635 56.8%	291 26.1%	50 4.5%	55 4.9%	38 3.4%	3 0.3%	28 2.5%	9 0.8%	3 0.3%	5 0.4%

The textbooks had 1117 representations (Table 3). The most common representations were photographs (56.8%) and iconic diagrams (26.1%), followed by symbolic diagrams, tables, network graphs, graphs, diagrams + photographs, tables + images, and concept cartoons. However, the textbooks had no scientific images or equation representations.

The third-grade textbook had more than half of the total representations (60%). The third-grade textbook had 384 photographs (57.5%), while the fourth-grade textbook had 251 photographs (55.9%). The third-grade textbook (30%) had more iconic diagrams than the fourth-grade textbook (19.4%). On the other hand, the fourth-grade textbook had more symbolic diagrams (6.2%), tables (8.5%), network graphs (5.3%), diagrams + photographs (3.1%), and tables + visuals (1.3%) than the third-grade textbook. The third-grade textbook had three concept cartoons and five maps, whereas the fourth-grade textbook had none. Table 4 shows the distribution of the representations by subject area and unit.

Table 4 Distribution of Representations by Subject Area and Unit

Subject area	Units	f	%	Photograph	Iconic diagram	Symbolic diagram	Table	Network graph	Graph	Diagram + photo	Table + image	Concept cartoon	Map
Earth and Universe	Let's get to know our planet	49	4.3%	29	7	6	0	1	1	1	0	1	3
	Earth's crust and Earth's movements	46	4.1%	17	13	6	2	4	0	0	4	0	0
Creatures and Life	Our five senses	70	6.2%	48	15	3	0	0	1	1	1	1	0
	Our Food	49	4.3%	29	9	2	4	2	0	2	1	0	0
	Journey to the living world	84	7.5%	39	33	4	3	1	0	2	2	0	0
	Human and environment	58	5.1%	43	3	9	1	1	0	1	0	0	0
Physical phenomena	Let's get to know the force	77	6.8%	43	22	2	4	3	0	1	0	0	2
	Effects of the force	67	5.9%	32	20	5	5	4	0	1	0		
	Light and sounds around us	106	9.4%	75	19	2	2	4	0	4	0	0	0
	Lighting and sound technologies	87	7.7%	67	8	3	3	5	1	0	0	0	0
	Electric vehicles	173	15.4%	83	78	5	4	3	0	0	0	0	0
	Simple electrical circuits	32	2.8%	14	10	2	1	1	0	3	1	0	
Matter and Nature	Let's get to know the substance	109	9.7%	67	30	0	4	2	0	5	0	1	0
	Properties of Matter	110	9.8%	49	24	1	22	7	0	7	0	0	0

The unit of "electric vehicles" in the subject area of "physical phenomena" had the highest number of representations (15.4%). The unit had 83 photographs and 78 iconic diagrams (Table 4).

The Distribution of Representations by Scientific Genres

The distribution of representations and scientific genres in science textbooks was presented in two ways. Firstly, what scientific genres were associated to representations used in science textbooks were presented. Then scientific genres used in science textbooks were examined in terms of multiple representations. Table 5 shows the findings regarding what scientific genres were associated with representations used in science textbooks.

Table 5 Representations by Scientific Genres

Representation	Grade Level	N	Information report	Explanation	Experimental	Argumentative	Technical procedure	Narrative
Photograph	3rd	384	29	342	1	2	4	6
	4th	251	21	199	0	11	0	20
	Total	635	50 (7.8%)	541 (85.1%)	1 (0.1%)	13 (2%)	4 (0.6%)	26 (4%)
Iconic diagram	3rd	204	34	135	8	10	14	3
	4th	87	10	30	16	11	20	0
	Total	291	44 (15%)	165 (57%)	24 (8%)	21 (7%)	34 (12%)	3 (1%)
Symbolic diagram	3rd	22	10	8	0	1	3	0
	4th	28	18	8	0	1	1	0
	Total	50	28 (56%)	16 (32%)	0	2 (4%)	4 (8%)	0
Table	3rd	17	3	10	1	-	3	0
	4th	38	7	24	2	4	1	0
	Total	55	10 (18%)	34 (61.8%)	3 (5.4%)	4 (7.2%)	4 (7.2%)	0
Network graph	3rd	14	6	8	-	-	-	0
	4th	24	12	12	-	-	-	0

	Total	38	18 (47%)	20 (53%)	-	-	-	0
Graph	3rd	2	0	-	2	-	-	0
	4th	1	0	1	-	-	-	0
	Total	3	0	1 (33%)	2 (67%)	-	-	0
Diagram + photo	3rd	14	6	7	1	-	-	0
	4th	14	2	11	0	1	-	0
	Total	28	8 (28.5%)	18 (64.2%)	1 (3.5%)	1 (3.5%)	-	0
Tables + images	3rd	3	1	2	-	-	-	0
	4th	6	2	4	-	-	-	-
	Total	9	3 (33%)	6 (67%)	-	-	-	-
Concept cartoon	3rd	3	-	1	-	2	-	-
	4th	-	-	-	-	-	-	--
	Total	3	-	1 (33%)	-	2 (67%)	-	-
Map	3rd	5	1	3	-	-	1	-
	4th	0	0	0	0	0	0	0
	Total	5	1 (20%)	3 (60%)	0	0	1 (20%)	0
Total		1117	162 (14%)	805 (72%)	29 (3%)	43 (4%)	49 (4%)	29 (3%)

Most representations were used in relation to "explanation" (72%), followed by "information report" (14%), "technical procedure" (4%), "argumentative" (4%), "experimental" (3%), and "narrative" (3%). Most photographs were associated with "explanation" (85.1%). More than half of the iconic diagrams were associated with "explanation" (57%), and the majority of the symbolic diagrams were associated with "information report" (56%). The larger part of the network graphs was associated with "explanation" (52.6%), and the graphs were associated with "experimental" (67%). While the diagrams + photographs were associated with "explanation" (64.2%); the tables + visuals were associated with "explanation" (67%). The greater part of the concept cartoons was associated with "argumentative" (67%). More than half of the maps were associated with "explanation" (60%). Figure 1 shows the distribution of the representations of the scientific genres in the textbooks.

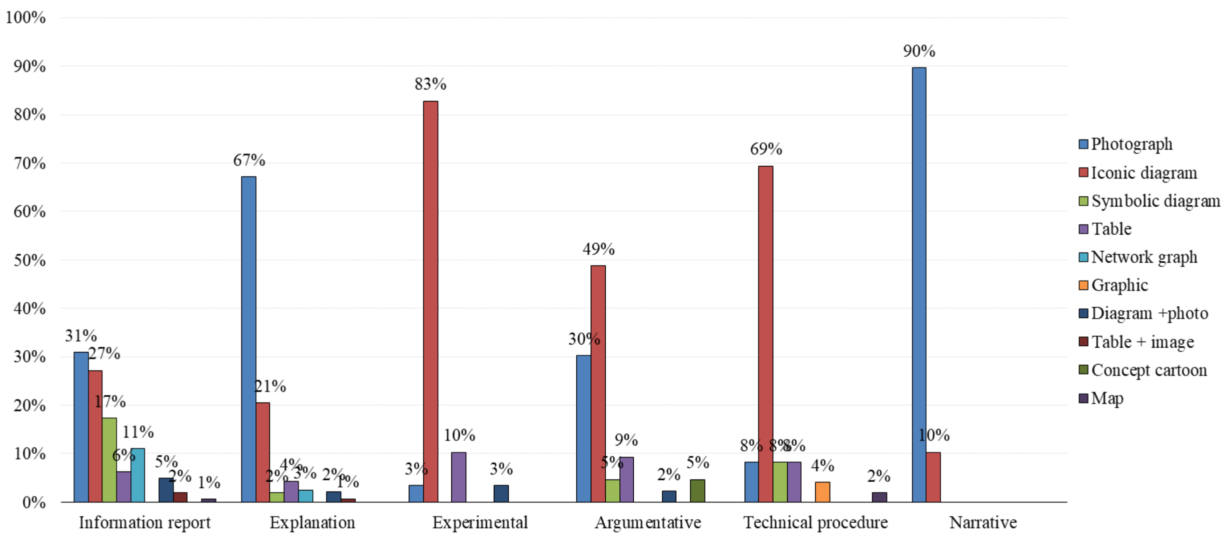


Figure 1 Distribution of Representations of Scientific Genres In Textbooks

"Information report," "explanation," and "narrative" were associated with photographs and iconic diagrams. "Experimental" was primarily associated with iconic diagrams and tables. "Argumentative" was predominantly associated with iconic diagrams and photographs. "Technical procedure" was mainly associated with iconic diagrams, followed by photographs, tables, and symbolic diagrams (Figure 1).

The Distribution of Representations and Scientific Genres by Section

The distribution of representations and scientific genres by section was examined regarding use in the main text, activity, assessment and evaluation. Table 6 shows the distribution of the representations and scientific genres by section.

Table 6 The Distribution of Representations and Scientific Genres by Section

Representation	Grade Level	Scientific Genre						
		Information report	Explanation	Experimental	Argumentative	Technical procedure	Narrative	Total
Photograph	Main text	50	442 (84%)*	-	10	-	25	527 (83%)
	Activity	-	51	1	-	4	1	57 (9%)
	Assessment and evaluation	-	48	-	3	-	-	51(8%)
Iconic diagram	Main text	24	103 (74%)*	-	9	-	3	139 (48%)
	Activity	19	42	24	10	34	-	129 (44%)
	Assessment and evaluation	1	20	-	2	-	-	23 (8%)
Symbolic diagram	Main text	10 (48%)*	10 (48%)*	-	1	-	-	21 (42%)
	Activity	5	-	-	1	4	-	10 (20%)
	Assessment and evaluation	13	6	-	-	-	-	19 (38%)
Table	Main text	4	-	-	-	-	-	4 (7%)
	Activity	2	19 (66%)*	3	1	4	-	29 (53%)
	Assessment and evaluation	4	15		3			22 (40%)
Network graph	Main text	6	4	-	-	-	-	10 (26%)
	Activity	6	14 (70%)*	-	-	-	-	20 (53%)
	Assessment and evaluation	6	2	-	-	-	-	8 (21%)
Graph	Main text	-	-	-	-	-	-	-
	Activity	-	-	-	-	2 (100%)*	-	2 (67%)
	Assessment and evaluation	-	1		-	-	-	1 (33%)
Diagram + photo	Main text	8	10 (56%)*		-	-	-	18 (64%)
	Activity	-	6	1	-	-	-	7 (25%)
	Assessment and evaluation	-	2		1			3 (11%)
Tables + images	Main text	3 (60%)*	2	-	-		-	5 (56%)
	Activity	-	2	-	-	-	-	2 (22%)
	Assessment and evaluation	-	2		-			2 (22%)
Concept cartoon	Main text	-	-	-	2 (100%)*	-	-	2 (67%)
	Activity	-	-	-	-	-	-	-
	Assessment and evaluation	-	1		-			1 (33%)
Map	Main text	1	1	-	-	-	-	2 (40%)
	Activity	-	2 (67%)*	-	-	1	-	3 (60%)
	Assessment and evaluation	-	-	-	-	-	-	-
Total		162	805	29	43	49	29	1117

*The highest percentage of scientific genres in the unit with the highest number of representations

The main text sections of the textbooks had 527 photographs (83%), 139 iconic diagrams (48%), 21 symbolic diagrams (42%), 18 diagrams + photographs (64%), five tables + images (56%), and two concept cartoons (67%). The high-level activity sections of the textbooks had 29 tables (53%), 20 network graphs (53%), two graphs (67%), and three maps (60%).

Photographs were the most common representations. They were mainly associated with "explanation" in the main text (84%). Figure 2 shows a photograph associated with the scientific genre of "explanation" in the main text section.

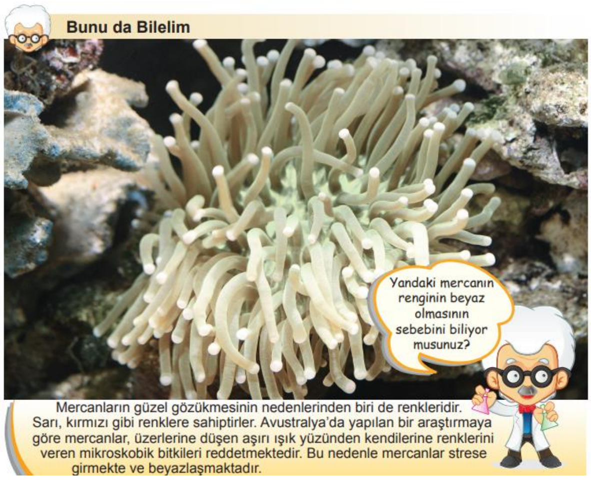


Figure 2 A Photograph Associated With The Scientific Genre of "Explanation" In The Main Text Section

Note. Primary School Science 4th Grade Textbook, Ministry of National Education (MoNE) Publications, Lighting and Sound Technologies Unit (Physical Phenomena subject area)

Figure 2 shows corals and explains why they are white. The photograph is used to show "what" is explained. The question of "what" about the learning object in the "main text" section is answered with a photograph representation since it is a real-life image. Most iconic diagrams were also associated with "explanation" in the main text (74%). They were also used extensively in the activity section following the main text. However, the scientific genres in the activity section had different functions than those in the main text. Figure 3 shows how an iconic diagram is used differently in the "main text" (explanation) and "activity" (technical procedure) sections.

a b

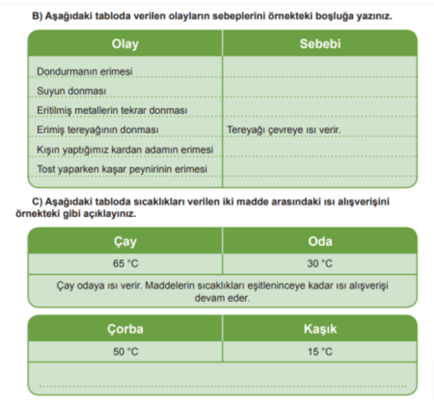
Figure 3 Example of the Use of an Iconic Diagram Differently in the Main Text and Activity Sections

Note. Primary School Science 3rd Grade Textbook MoNE Publications, [a] Electric Vehicles, and [b] Let's Get to Know Our Planet Units

In Figure 3a, the iconic diagram explains how the direct disposal of waste batteries affects living things. In this example, the iconic diagram is used to answer the question of "how," unlike the question of "what" in the photographic representation. In Figure 3b, the iconic diagram explains how to perform the steps of a process. Both iconic diagrams are used to answer the question of "how."

Symbolic diagrams were associated with “information report” throughout the textbooks. They were associated with “information report” (48%) and “explanation” (48%) in the “main text” section. Diagrams + photographs were associated with “explanation” in the “main text” section (56%). Tables (66%), network graphs (70%), and maps (67%) were associated with “explanation” in the “activity” section. All graphs were associated with “technical procedure” in the “main text” section. More than half of the tables + images were associated with “information report” in the “main text” section (60%). All concept cartoons were associated with “argument” in the “main text” section.

Tables were associated with “explanation” throughout the textbooks. They were primarily used in the “activity” section. Figure 4 shows a table associated with “explanation” in the “activity” section.


B) Aşağıdaki tabloda verilen olayların sebeplerini örnekteki boşluğa yazınız.

Olay	Sebebi
Dondurmanın erimesi	
Suyun donması	
Eritilmiş metallerin tekrar donması	
Erimiş tereyağının donması	Tereyağı çevreye ısı verir.
Kışın yaptığımız kardan adamın erimesi	
Tost yaparken kaşar peynirinin erimesi	

C) Aşağıdaki tabloda sıcaklıkları verilen iki madde arasındaki ısı alışverişini örnekteki gibi açıklayınız.

Çay	Oda
65 °C	30 °C
Çay odaya ısı verir. Maddelerin sıcaklıkları eşitleninceye kadar ısı alışverişi devam eder.	

Çorba	Kaşık
50 °C	15 °C
....	

Figure 4 Example of a Table Associated With Explanation in the Activity Section

Note. Primary School Science 4th Grade Textbook MoNE Publications, Properties of Matter Unit

In Figure 4, the table is used in an activity design where students are asked to explain the reasons for a scientific event through different examples. The table is used to reveal the cause-and-effect relationship.

DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

This study focused on the scientific genres and representations in third- and fourth-grade science textbooks. The results show that the textbooks use photographs, iconic diagrams, and tables as representations. Liu and Khine (2016) argue that primary school students need more photos and pictures showing how scientific facts and entities appear in science education. Primary school science topics involving abstract concepts are challenging to teach, especially when it is not visible (Preston et al., 2022). The dominant use of realistic images in the textbook is most likely aimed to help the learners easily correlate the abstract scientific concept with the objects that can be found in real life (Nur’graha & Hermawan, 2020). Pictorial representations clarify and improve oral texts and sometimes convey information more clearly than oral texts (Edens & Potter, 2001). Photographs are correct representations and a mechanical record of reality against subjective interference (Bastide, 1990; Myers, 1990). Photos sometimes offer much detail, while diagrams allow the author to select and manipulate pieces (Myers, 1990).

Realistic iconic diagrams help students recognize the structures of physical systems unsuitable for visual inspection (Hegarty et al., 1996; Novick, 2006). Dimopoulos et al. (2003) maintain that textbooks contain many photographs and iconic diagrams that present science subjects in a naturalistic, articulated, and contextualized way while remaining faithful to their real-life images. They also state that primary and secondary school textbooks have more realistic visuals than other representations because they are interested in introducing students to a familiar world to involve them in science education. Our result is consistent with the literature (Hatzinikita et al., 2008; Kurnaz et al., 2016; Liu & Treagust, 2013; Postigo & López-Manjón, 2019; Şantaş, 2017). For example, İnaltekin and Göksu (2019) found that primary and secondary school science textbooks in Türkiye mostly had diagrams. Akçay et al. (2020) also determined that secondary school science textbooks in Türkiye mostly used diagrams. Dimopoulos et al. (2003) reported that Greek primary school science textbooks had much more realistic visuals than other visuals. Tang (2022) also documented that secondary school science textbooks mostly contained photographs and diagrams. Similarly, Slough et al. (2010) found that the most common representations were photographs and diagrams. Lee (2010) focused on science textbooks taught in the USA between 1943 and 2005 and reported an increase in the number of iconic diagrams (especially photographs) in modern textbooks over the years (Lee 2010).

The third-grade textbook had more representations than the fourth-grade textbook. Besides, the third-grade textbook had more iconic diagrams than the fourth-grade textbook. However, the fourth-grade textbook had more symbolic diagrams, tables, network graphs, diagrams + photographs, and tables + visuals than the third-grade textbook. How many and what type of representations primary school science textbooks contain depends on the grade level. Research shows that first-grade science textbooks mostly contain iconic diagrams (Khine & Liu, 2017; Liu & Treagust, 2013). Dimopoulos et al. (2003) argue that there is a positive correlation between representations' number and abstraction level and the grade level, except for photographs and iconic diagrams. Older students are more ready to learn abstract concepts than their younger counterparts (Kapıcı & Savaşcı-Açıkalın, 2015).

Moreover, the characteristics of representations depend on students' age or success level (Pinto, 2002). Abstract relationships are depicted in symbolic diagrams without considering natural physical properties, which causes novice learners to have difficulty interpreting representations and deciding what is essential and what is not (Butcher, 2006). Therefore, we should assess how ready students are before deciding on the form of scientific communication. Due to the relatively weak mathematical background of primary school students, it is recommended to compare them with figurative visuals and with symbolic visuals and technical representations as the grade level increases (Pinto, 2002). Symbolic expressions are essential for teaching abstract science concepts (Akçay et al., 2020). In this context, the negative correlation between the number of visual representations in textbooks and the grade level may be because students accumulate more academic and abstract knowledge over the years (Dimopoulos et al., 2003). Research also shows a positive correlation between the number of representations in science textbooks and the grade level (Postigo & López-Manjón, 2019).

On the other hand, Liu and Khine (2016) and Khine and Liu (2017) reported that science textbooks introduced fewer iconic representations and more schematics, graphs, and tables as students moved on to the next grade. Coleman and Dantzler (2016) concluded a positive correlation between the types of representations in science textbooks and the grade level. Therefore, our results are consistent with the literature.

The unit "electric vehicles" had the highest number of representations. The subject area "physical phenomena" also had the highest number of representations because it had more units than other subject areas. However, the other units in the same subject area also had many representations. This may be because those units are suitable for realistic visuals (photograph, iconic diagram). Coleman and Dantzler (2016) investigated the frequency of graphical representations in science textbooks for children and determined that physics textbooks had the highest number of representations. Research also shows that physics textbooks contain more representations than others (Qasim & Pandey, 2017; Şantaş, 2017).

Our results showed that the representations in the textbooks were mainly associated with “explanation” and “knowledge report.” The most common representations (photographs, iconic diagrams, and tables) were associated with “explanation.” Science is based on descriptive and explanatory understanding, which offers a meaningful way of "knowing" that helps us think flexibly and answer the question of "why" (Newton et al., 2002). Illustrative drawings facilitate the cognitive processes necessary for meaningful learning as they help students select, organize, and integrate words and images into a coherent mental model (Mayer et al., 1995). Textbooks and scientific texts with implicit images showing only certain aspects of a topic only represent information, or worse, cause students to misinterpret it (Evagorou et al., 2015). According to Pozzer-Ardenghi and Roth (2004), photograph titles in textbooks should go beyond describing phenomena represented in photographs and provide readers with enough information to help them make a connection between texts and photographs and distinguish necessary and redundant details. Evagorou et al. (2015) argue that if we explain which features of a topic a visual focuses on or omits, we make the role of representation in the learning process visible to students.

Annotated drawings help readers connect visual and verbal representations and approach the material from a causal perspective, allowing inexperienced students to benefit from representations (Mayer et al., 1995). Bryce (2013) maintains that the texts and language structure of primary school science textbooks focus most on the main idea and details and then adopt an understanding of cause and effect. Dimopoulos et al. (2005) documented that the descriptive scientific genre was the most dominant in science textbooks. According to Pozzer-Ardenghi and Roth (2004), students first notice the most central objects in photographs in textbooks and pay attention to the learning objects in the photographs through photo captions. They read the text to relate it to the photographs and then go further and recognize the message in the representation. The fact that the representations in the textbooks are primarily associated with “information report” and “explanation” indicates that they are used effectively. This result is consistent with the literature. For example, Tang (2022) found that the representations in secondary school science textbooks were associated with “information report” and “explanation.” However, she also reported that there were more representations associated with “information report” than with “explanation,” probably because she focused on science textbooks at different grade levels. Green and Green (2000) argue that primary school students have less difficulty understanding descriptive texts than explanatory texts. Newton et al. (2002) stated that descriptive understanding was more dominant than explanatory understanding in primary school science textbooks. We can talk about a change in the way textbooks are designed because students are familiar with different types of texts, and therefore, manage them in a way they can use them in their own learning processes (Bryce, 2013). Some studies point to the effectiveness of writing in various scientific genres in science education (Keys, 1999; Pelger & Nilsson, 2015).

The results showed that photographs were the most common representations associated with “information report,” “explanation,” and “narrative,” while iconic diagrams were the most common representations associated with “experimental,” “argumentative,” and “technical procedure.” Tang (2022) focused on middle school science textbooks and reported the following results. Most photographs are associated with “information report” and “narrative.” Diagrams and photographs are associated with “explanation.” Diagrams are associated with “experimental.” Photographs are associated with “argumentative.” Equality is associated with “technical procedure.” The differences in results may be because we focused on textbooks at different grade levels.

The results showed that the photographs and iconic diagrams were primarily used in the “main text” section. There were also many iconic diagrams in the “activity” section. However, the scientific genre associated with the “activity” section varied because some photographs were used to answer the question of "what," while others were used to answer the question of “how.” Our results also showed that most iconic diagrams were associated with “experimental” and “technical procedure.” Using real or realistic images to describe learning objects and explain causes and effects in the “main text” section makes sense. However, it is better to use realistic rather than real images in the “activity” section. The author or designer can have more control over diagrams than photographs and get the chance to emphasize different aspects of a topic (Tang, 2022). Akçay et al. (2020) determined that the images in science textbooks were primarily used in the "main text" section. Pozzer-Ardenghi and Roth (2004) maintain that the main text is an essential cognitive source that students use to interpret photographs.

The primary school third- and fourth-grade science textbooks have more photographs and iconic diagrams (realistic visuals) than conventional representations (graphs, network graphs, tables, maps, etc.), This result indicates that the textbooks do not contain diverse representations to improve representational fluency and visual literacy. İnaltekin and Göksu (2019) emphasize that teaching materials should help students develop visual literacy skills because they play a critical role in scientific literacy and international exams. Devetak and Vogrinc (2013) advocate that a good science textbook should encourage students to use different representations, especially conventional representations that activate high-level thinking skills. The realism, familiarity, and detail provided by photographs were utilized in association with "explanation" and "narrative" in the design process of the science textbooks. Iconic diagrams are modifiable representations that offer a perception of reality. This is why they were associated with the "experimental," "technical procedure," and "argumentative" genres. The results showed that different representations were used to construct the "information report" genre. Scientific genres and representations in textbooks can create a structure that includes multimodal types. Multimodal structures dominate the design of textbooks, which influence and are influenced by teacher-student interaction (Tang et al., 2022). Textbooks should contain different representations to help them synthesize information and use it in complex processes, such as scientific arguments (Donovan & Coleman, 2018). Therefore, science textbooks should be designed in such a way that they contain a variety of representations associated with scientific genres

RECOMMENDATIONS

The results are sample-specific and cannot be generalized to all textbooks. It is necessary to carry out researches examining the textbooks of different publishers. Primary school science textbooks mostly have photographs and iconic diagrams as representations. Researchers should examine the photographs and diagrams in textbooks from different classifications (simple, analytic-synthetic, etc.). Authorities should revise the current textbooks and integrate more representations and scientific genres into them. They should design scientific genres to utilize the advantages of different types of representations. In this study, there was no examination of the quality of representations used in textbooks, and it is recommended that new studies be conducted on this subject. Researchers should investigate how classroom teachers associate representations with scientific genres. They should also focus on the representations and scientific genres in mathematics, social studies, Turkish, and life studies textbooks.

Conflicts of Interest: No potential conflict of interest was declared by the author.

Funding Details: This study was not supported by any funding agency

CRediT Author Statement: Elif GÜVEN DEMİR: Conceptualization, Formal Analysis, Methodology, Investigation, Resources, Supervision, Validation, Writing – Review & Editing.

Ethical Statement: This study does not require ethics committee approval.

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