Types and Frequency of Visual Representations in Lebanese National Science Textbooks

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Abstract

The purpose of this study is to analyze the different types of visual representation in the Lebanese national science textbooks at elementary grade levels, in addition to the frequency of each visual representation, and their distributions in accordance with the grade levels. The study's sample consists of eight textbooks established by Lebanon's Ministry of Education (CRDP) for elementary science classes (1st, 2nd, 3rd, 4th parts 1 & 2, 5th parts 1 & 2, and 6th Grade). This thesis employs a document analysis style, which is one of the qualitative research methods. The data was analyzed using the descriptive analysis approach and the “Visual Representation Classification Model” proposed by Moline (2012). In this research, three results were deduced with accordance to the three research questions. The first result indicated that the analyzed science textbooks included all the types and almost all the subtypes except for personal maps, timelines, and Venn diagrams that Moline (2012) explained. The second result of this paper showed that the most frequent visuals among all grade levels were the photographs and realistic illustrations. The third result of this study revealed that the number and types of visual representations in the analyzed textbooks varied according to the grade level.

Introduction

Textbooks tend to have a major role in the academic field as they are considered one of the most essential educational resources used by teachers and students (Lee, 2010). According to a study conducted by Chiappetta et al. (2006), educators use textbooks at a mean of 90% while assigning homework to students. Since science textbooks are often used by teachers to facilitate learning, students must improve their ability to process and integrate all sources of knowledge, specifically texts and visual representations (Stylianidou et al., 2002). According to Vekiri (2002), the words visual displays, photographs, graphical displays, and graphical/visual representations all refer to displays that use symbols and their spatial arrangement to represent objects, concepts, and their relationships. Mayer (1989) highlighted that graphics are commonly used in science textbooks to help students concentrate on crucial details in the text, to encourage internal connections between ideas in the text, and to facilitate external connections between ideas in the text and the learners' prior knowledge. This paper will analyze the types and frequency of the visual representations that exist in the Lebanese national science textbooks in elementary grade levels as an approach to answer the questions of this research: What are the types of the visual representations that exist in the Lebanese national science textbooks? What is the frequency of the visual representations found in the analyzed textbooks? How are the visual representations distributed in accordance with the grade levels?

Rationale

While conducting research within this framework, the authors of this study found that there is a gap in previous literature with regards to examining the visual representations in science textbooks within the Lebanese context. Within the Turkish context, Inaltekin and Gukso (2019) presented a similar research regarding the types of visual representations found in science textbooks at the primary and secondary levels. In addition, they researched the variations and similarities in the distribution of visual learning representations across grades in science textbooks (Inaltekin & Goksu, 2019). Moreover, in the United States, two research studies were conducted; the first, conducted by Guo et al. (2018), examined visual representations found in science and social studies textbooks through third and fifth grade, and the second, conducted by Coleman et al. (2011), analyzed the different types of visual representations found in science trade books. Furthermore, in the state of Texas, Slough et al. (2010) conducted their research based on quantifying the types and quality of visual representations in science texts. In Fingeret's (2012) study, she looked at the various types of graphics that appear in children's social studies and science trade books, as well as the defining characteristics of the different graphics. However, when it comes to the Lebanese context, none of the studies considered this aspect, knowing that the current study checked for similar research within English and Arabic resources.

Significance

The significance of this research is highlighted through several aspects. First, this paper may benefit other researchers who are examining this discipline, as it would provide them with contextual findings to perform cross cultural studies. After reviewing the various frameworks and research on visual representations in various countries, none of the studies in the Lebanese context considered this aspect. Hence, this study will assist other authors to conduct research in this discipline- the types of visual representations in science textbooks- within the same context. Second, it makes the educators aware of the different types of visual representations that are found in science textbooks, thus this would help them plan their lessons accordingly. Educators may consider specific instructional strategies to assist the learners in better understanding the visual representations they encounter within their textbooks, hence enhance their learning. Furthermore, this research would make authors aware of the types of visual representations they include in their publications while developing science textbooks. Hence, this paper may contribute to improving the quality of the Lebanese science textbooks in the upcoming years.

The aim of this study was to look at the different types and frequency of visual representations used in the Lebanese national science textbooks published by the Ministry of Education (CRDP). We chose to examine this discipline as there was no research with regards to this field done in Lebanon. Within the following section we review the literature which guided our study and start first by addressing the challenges that students face while reading science textbooks. Next, we discuss the importance of visual representations in enhancing the learners' conceptual understanding while reading science textbooks. After that, we cover the different frameworks found, used, and revised by different researchers that covered the field of types of visual representations found in science textbooks, including Moline, whose framework was adopted in this study. Consequently, the way the data was collected will be presented along with the guidelines which were considered to analyze the collected data. The results and main findings are then explained with the interpretations of each result. Finally, an action plan will be presented that shows the different ways this study will be helpful for future use.

Literature review

Students' Challenges while Reading Scientific Textbooks

While reading textbooks, students may face different challenges when it comes to retrieving the information presented (Inaltekin & Goksu, 2019). To begin with, learners may encounter an obstacle while reading science textbooks known as text complexity. Amendum et al. (2017) referred to the negative association between the text's complexity and learners' reading comprehension. The authors explained that as the text becomes more complex, the learners' comprehension of the text declines. One of the features that contribute to increasing the complexity of a text is the used vocabulary words, specifically the amount of difficult words and new terminologies (Amendum et al., 2017). According to Standsfield (2006), main ideas are often buried in superfluous and insignificant material, making it difficult for readers to comprehend the information presented in science textbooks. When it comes to the terminologies, Graesser et al. (2002) explained that as a result of sophisticated jargon, science textbooks tend to be more complex to comprehend by students. Thus, the learners' acquisition of scientific concepts may be affected by the complex vocabulary words due to the relationship between both variables (Fitzgerald et al., 2017**)**.

From another perspective, science texts include conceptually dense information (Adams, 2010) which places a barrier in the face of the learners' acquisition of new scientific concepts (Nagy et al., 1987). In their article, Inaltekin and Goksu (2019) asserted that much information in science textbooks is found to be conceptual, complicated, and difficult to process by the students. Students find it difficult to comprehend complex concepts, as such concepts are abstract and not "readily accessible to mental imageability" (Reilly & Kean, 2007). Fitzgerald et al. (2017) concluded that students may find learning a challenging task as a result of the textual implementation of complex concepts in core science program textbooks.

To help students grasp the many complex concepts posed in science textbooks, it is important to combine these texts with the appropriate visual representations (Inaltekin & Goksu, 2019). The authors asserted that including visual representations that correspond to scientific texts in science textbooks would make it easier for students to connect, understand, and remember knowledge.

Visual Representations

When the findings of Inaltekin and Goksu's (2019) study are considered, it can be concluded that many visuals in the relevant literature are restricted in order to support the books' texts. However, with recent technological advancements, there is a greater presence and variety of graphical knowledge in science texts, which adds to the students' challenges of reading the texts (Martins, 2002; McTigue, 2009). Martins (2002) asserted that the evolution of technology has also added an obstacle for learners when it comes to perceiving science texts. However, when evaluating graphics in textbooks, Guo et al. (2018) concluded that with the improvement of publications throughout the years, an increase in both difficulty and frequency of visual representations has been detected. As a result, visual complexity must be considered, similar to the way text complexity has been analyzed (Fisher & Frey, 2013).

Marlen et al. (2018) defined visual complexity as the visual features, the diversity in colors, and the contrast variety found within an image. In a study conducted by Stylianidou (2002), students faced some difficulties in recognizing the visual elements that acquired the most meaning in science textbooks. As found by Hannus and Hyönä (1999), the students' awareness of graphics was limited to only 6% of the total time when studying scientific texts that include visual representations. Thus, when visuals in textbooks become denser and more complicated, this may result in cognitive overload among students and hence, they ignore the visual representations presented (Guo et al., 2018). In short, while graphics can provide useful details, they can also make understanding and comprehension more complex (McTigue & Flower, 2011).

These causes, combined with a reader's lack of scientific understanding, lead to misconceptions regarding science and, as a result, make it difficult to learn new details (Graesser et al., 2002) As a result, readers' confidence and attitudes are unlikely to be positive, adding to the difficulty of processing the texts.

Importance of Visual Representations

When looking at extensive research about visuals in science textbooks, one of the concepts that most researchers agreed on was the importance of visual representations in understanding the scientific content that students study (Guo et al., 2018; Inaltekin & Goksu, 2019; Lee, 2010). As mentioned by Inaltekin and Goksu (2019), in science textbooks, visual representations are essential for conveying to students the right message associated with the text. The authors asserted that science textbooks must have a variety of visual elements to help students understand the content of the subject in addition to the scientific texts they encounter (Inaltekin & Goksu, 2019).

Based on this premise, Vekiri (2002) highlighted that efforts should be exerted to make visual representations accessible to students. Specifically, science textbooks must be properly supported with visual learning representations in order to accomplish their purpose effectively (Inaltekin & Goksu, 2019). Hannus and Hyönä (1999) argued that it is essential that these visual representations be well- designed in order to improve the learners' understanding. Therefore, the organization of the visual representations should be taken into consideration when science textbooks are being prepared (Inaltekin & Goksu, 2019). As a result, much more attention should be paid to the arrangement of visual representations when science textbooks are being prepared (Inaltekin & Goksu, 2019).

Cognitive Role of Visual Representations

When examining Paivio's (1990) dual coding theory in terms of how learning instructional materials are interpreted, students' long-term memory becomes more durable and grasps more detailed information when dealing with illustrated texts than when dealing with verbal texts only.

Many science textbooks incorporate visual representations to assist the students in understanding the text they are reading and enhancing learning by improving their memory (Hannus & Hyönä, 1999). The researchers deduced that the human's memory becomes enriched when both a verbal and a pictorial representation of the stimulus can be constructed. They affirmed that, when the same information is displayed using different forms, i.e words and images, more complex semantic processing will occur in the students' brains, resulting in improved comprehension and memory of the illustrated text material (Hannus & Hyönä, 1999).

Visuals Display Concrete Examples for Abstract Scientific Concepts

Because of the abstract nature of some science principles, visual representations can be highly useful in demonstrating and explaining science to beginners by using visual examples that contribute to making abstract concepts more concrete (Coleman et al., 2011). As mentioned by Clark and Paivio (1991), associating abstract concepts that students are introduced to with concrete examples may assist in the comprehension and recollection of recently learned information. In the study conducted by Mayer (1989) on problem-solving transfer tests, students who read a text that is associated with illustrations achieved at least 50% better than students who read a solo text. Mayer (2002) also found that students who engaged with an illustrated text were able to give 79% more answers on problem-solving transfer tests in comparison with learners who engaged with a text without illustrations.

Other Thoughts on Visual Representations

Although much literature acknowledged the importance of visuals in enhancing the students' learning, some research has other inferences regarding the effectiveness of visual representations (Guo et al., 2018). The stated advantages and benefits of visuals may differ from one student to another. According to Hannus and Hyönä (1999), illustrations found in science textbooks may be non-beneficial and harmful to students of lower learning levels. This was because such students were diverted from the main task which requires linking the texts with the visuals presented by being distracted with the visual representations. Therefore, due to the learners' insufficient processing of visual representations, their advantages could become unfortunate (Peeck, 1994).

Visual Representations in Science Instruction

Visual Literacy Skills

Guo et al. (2018) explained that science communication relies heavily on graphical representations. They asserted that understanding science depends on the way science is communicated using linguistic and visual information. Accordingly, Yeh and McTigue (2009) reported that 79.5% of the questions proposed on science examinations require visual literacy skills, as students should interpret the graphics so that the questions can be answered correctly. Furthermore, in the study conducted by Guo et al. (2018), 73.4% of visual representations that added new details to the informational text lacked clear information that links the verbal texts to the visual representations presented. As a result, students should pay attention to visuals and extract information that is not included in the text (Guo et al., 2018). As such, the illustrations are not easily interpretable, and they often necessitate a substantial amount of mental effort on the part of the learner (Hannus & Hyönä, 1999). Thus, understanding visual representations necessitates the use of certain skills which are not innate **(**Kress & van Leuween, 2006).

Theoretical Framework: Types of Visual Representations

The classification of the types of visual representations differ from one framework to another, whether in the number of types or subtypes or the way the types are classified. One of the difficulties while researching the types of graphical representations is that there is no unique classification scheme for graphics (Vekiri, 2002). Looking at previous reviews of literature on the types of visual representations of science textbooks, some researchers adapted previous frameworks done to continue their studies (Coleman and Dantzler, 2016; Guo et al., 2018; Inaltekin & Goksu, 2019), whereas others developed their own coding frameworks that better suit the purpose of their research (Fingeret, 2012; Moline, 2012; Slough et al., 2010; Vakiri, 2002).

In Inaltekin and Goksu’s (2019) research, the data was analyzed by using Moline's (2012) Visual Representation Classification Model. They categorized the visuals into seven categories: simple diagrams, synthetic diagrams, analytical diagrams, graphics, maps, tables, and timelines. Moreover, the coding method used for Coleman and Dantzler’s (2016) study on science trade books was also based on Moline's (2012) *I See What You Mean*, which is considered a teacher-friendly text that provides a framework and graphical examples to support students' graphical communication development.

Another framework that was adapted by researchers was Fingeret’s (2012) framework. Some implemented the coding scheme as it is, and some revised his work and added their modifications to fit their study. Fingeret’s (2012) study proposed a coding scheme that classified the types of visual representations into eight types: diagrams, flow diagrams, graphs, timelines, maps, tables, images, and simple photographs. These eight types branch into 59 discrete subtypes. Similar to Fingeret’s (2012) framework, Roberts et al. (2013) classified eight types of visual representations. These types are graphics, diagrams, flowcharts, graphs, insets, maps, tables, and timelines. Guo et al. (2018) based their work on Fingert's (2012) comparative approach and developed their revised list of subtypes using his coding scheme. Guo et al. (2018) classified visual representations into nine main forms, which branch into 54 subtypes. Guo et al. (2018) also focused on analyzing the functional aspect of the visual representations found in the textbooks they interpreted. For their purpose, they used the coding scheme proposed by Levin et al. (1987) who classified the visual representations into five categories based on their functions. Their categorization included decorative, representational, organizational, interpretational, and transformational visuals (Guo et al., 2018).

A different framework that was concerned with the issue of visual representations in science textbooks was Vekiri's (2002) framework. Vekiri (2002) developed a framework that summarized four types of visuals, each comprising unique communication conventions: diagrams, graphs, maps, and network charts.

McTigue et al. (2007) established a developed framework that can be used by researchers to analyze the types of visual representations. In Slough et al.'s (2010) study, visual representations in each textbook were analyzed using the developed Graphical Analysis Protocol (GAP). According to the researchers' established coding key, the visual representations were divided into 13 categories: Photograph, naturalistic drawing, stylized drawing, picture glossary, scale diagram, cycle flowchart, sequence flowchart, cutaway/cross section, maps, tables, graphs/histograms, enlargement, hybrids.

The earlier section examined previous literature and research about different systems designed to classify graphical representations. Despite the comprehensive classification that Fingeret (2012) has presented, her coding system did not explicitly differentiate between some subtypes (Guo et al., 2018). The revised coding scheme adopted by Guo et al. (2018) requires additional research to validate it as it modified Fingeret's coding classification system for the purpose of analyzing the textbooks they were using in their research (Guo et al., 2018). Regarding Levin et al.'s (1987) functional classification system, this paper focuses on the types of the visual representations rather than the functions of visuals, hence it would be more appropriate to follow another classification system. Vekiri (2002) established her classification based on the common features present in previous literature. Although her coding scheme is similar to Moline's Visual Representation Classification Model (Coleman & Dantzler, 2016), we will follow Moline's (2012) system, as it is the only one that is designed for the educators' use (Guo et al., 2018). Moreover, most of the presented examples in Moline's framework were based on scientific concepts and topics (Moline, 2012) which is one of the central themes in our research. Finally, Moline's (2012) framework focused on the elementary grade levels (Inaltekin & Goksu, 2019), hence we will adopt his framework as it serves the purpose of our study the most.

Methodology

In this study, we analyzed the visual representations found in the Lebanese national science textbooks at the elementary level to answer our research questions concerning the different types of visual representations and their frequencies. This paper included document analysis which is one of the qualitative research designs. As emphasized by Bowen (2009), document analysis is a method for systematically analyzing and assessing records, both written and electronic. Furthermore, document analysis is a useful tool for conducting in-depth investigations into the research subject (Bowen, 2009). The analysis in this study covered the Lebanese National Science textbooks at the elementary grade levels. It covered eight textbooks for six grade levels: 1st, 2nd, 3rd, 4th parts 1 and 2, 5th parts 1 and 2, and 6th. The examined textbooks were published by the national Centre for Educational Research and Development (CRDP) in the year 2000.

Data Collection and Analysis

The elementary science textbooks were downloaded from the CRDP (CRDP, 2000) website and analyzed using Moline's (2012) updated version of his coding system, which is summarized in Table 1 in Appendix A. The whole textbooks were analyzed in order to attain more reliable and comprehensive results. The researchers examined each of the visual representations separately and referred to their features to categorize these visuals among Moline's (2012) types and subtypes. The analyzed data, being the Lebanese national science textbooks at the elementary level, was documented on separate Excel sheets according to the different grade levels. However, while analyzing the textbooks, the researchers encountered a new type that was not classified by Moline (2012). Thus, the researchers added to Moline's seven types and 22 subtypes another categorization that was labeled as "Realistic Illustration" which was introduced and explained by Fingeret (2012). Fingeret demonstrated that the latter could be a computer graphic, hand-drawing image, or a painting. As shown in Appendix B below, samples from the different subtypes of visual representations are given. When the researchers confronted any challenge while examining some visual representations in the science textbooks, they referred to the teachers' guide to accomplish their aim. Accordingly, the researchers associated the purposes of the visuals mentioned in the teachers' guide with those explained by Moline (2012) in his book *I See What You Mean*. The data was then discussed by the researchers in order to come up with an inter-rater reliable analysis.

The interrater reliability was calculated using the formula [Agreement / (Agreement + Disagreement)] x 100. It was found to be 96% based on the analysis of the 8 science textbooks at the elementary level. The researchers referred to Moline's framework and revised the visual representations that were classified differently by both researchers based on the types, features of the visual representations, and examples that Moline provided for each. Following this process, both researchers used the Microsoft Excel features to attain some statistical numbers related to the analyzed visual representations. Finally, the results of the study were summarized in one table (Table 2).

Results

This section presents the findings after examining the Lebanese National Science textbooks and classifying the visual representations that exist in them. The results are summarized in Table 2 entitled *Findings of the Descriptive Analysis of the Visual Representations Found in the Elementary National Science Textbooks*.

After organizing the data, it was found that there are 2052 visuals distributed among the eight analyzed textbooks. When Table 2 is examined, it can be seen that the number of photographs and realistic illustrations is the highest in most elementary grade levels, having a frequency of 792 and 676 visuals respectively from the total of 2052 visuals. According to the findings, the percentage of photographs and realistic illustrations totaled more than 70%, with about 39 % and 33% distributed respectively, as shown in Graph 1. When looking at the other visual representations - all visuals except for photographs and realistic illustrations- it can be deduced that their number increased according to the grade level, as can be seen in Graph 2. Concerning the distribution of visuals by type among the grades, it can be seen that in the grades of the first cycle grades 1, 2, and 3, realistic illustrations and photographs formed around 80% of the visual representations; however, in the grades of the second cycle grades (4, 5 and 6) they formed about 64%. Nevertheless, “Graphs” only started to exist in the second cycle of elementary grade levels. Moreover, 3 subtypes of visual representations were not found at all among all 8 analyzed textbooks. The 3 subtypes were “Personal maps”, “Timelines”, and “Venn Diagrams.”

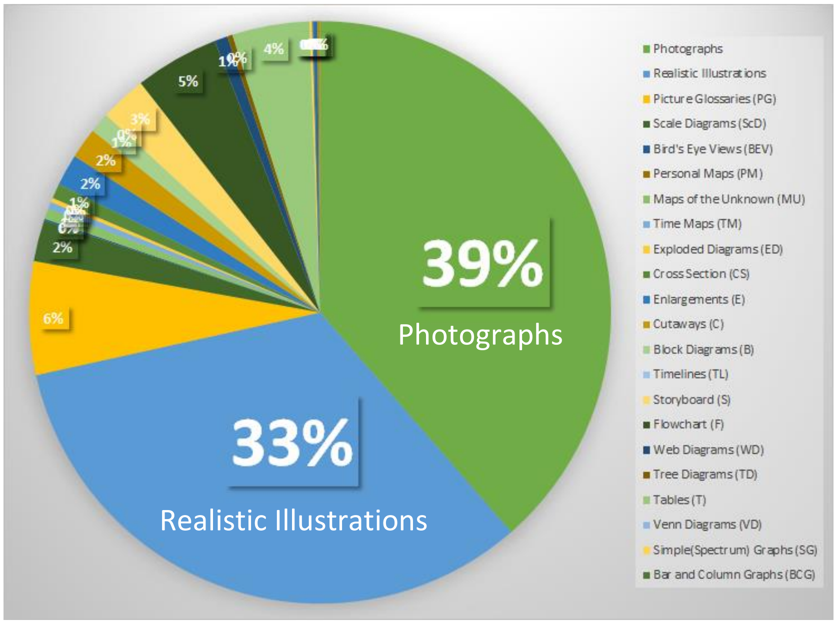
Table 2

Findings of the descriptive Analysis of the visual representations found in the elementary national science textbooks.

Grade Level	Unclassified	Photograph	Simple Diagram		Maps				Analytic Diagram					Process Diagram			Structure Diagram				Graphs				Total Number of Visual Representation
	Realistic Illustrations		Picture Glossary	Scale Diagram	Birds Eye View	Personal Map	Maps of the unknow	Time Maps	Enlargements	Exploded Diagram	Cutaways	Cross Sections	Block Diagram	Timelines	Storyboards	Flowcharts	Web Diagram	Tree Diagram	Tables	Venn Diagram	Simple Graphs	Bar & Column Graph	Line Graph	Pie Chart	
1	197	-	3	1	-	-	-	-	-	1	-	1	-	-	27	2	4	1	11	-	-	-	-	-	248
2	161	131	39	1	-	-	-	1	-	1	-	-	-	-	4	2	1	-	14	-	-	-	-	-	355
3	76	170	22	7	2	-	2	2	-	1	5	-	1	-	4	4	3	-	16	-	-	-	-	-	315
4	107	228	16	10	-	-	1	2	9	2	15	2	4	-	2	11	2	3	20	-	1	1	-	-	436
5	91	124	26	8	-	-	6	-	4	-	8	6	9	-	4	43	5	2	7	-	2	-	-	3	348
6	44	139	23	20	-	-	3	3	23	-	7	8	9	-	12	34	-	-	20	-	-	-	5	-	350
Total	676	792	129	47	2	-	12	8	36	5	35	17	23	-	53	96	15	6	88	-	3	1	5	3	2052

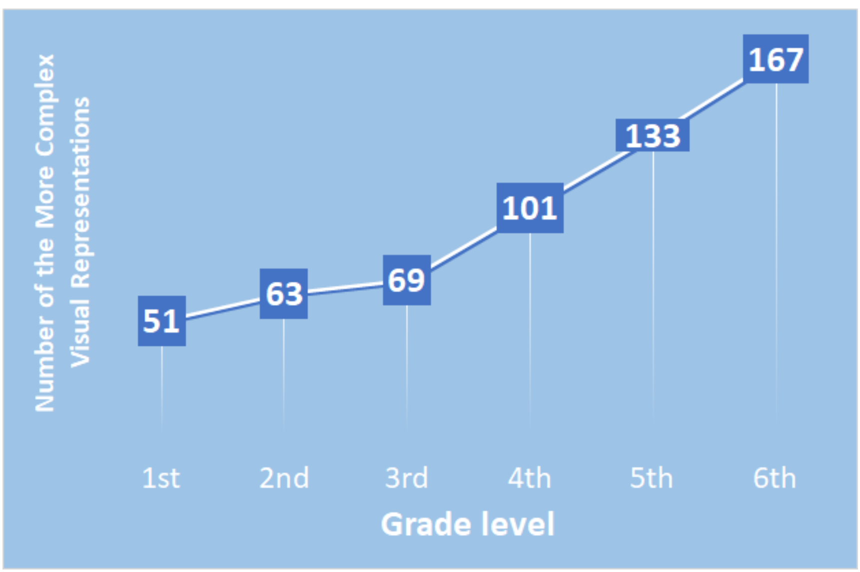
Graph 1

The Distribution of Visual Representations According to their Frequencies



Graph 2

The Distribution of More Complex Visual Representations According to Grade Levels.



Discussion

The first result of this study indicates that the analyzed science textbooks included all the types that Moline (2012) explained. Moreover, the textbooks included almost all the subtypes except for the following three; personal maps, timelines, and Venn diagrams. In her study, Fingeret (2012) reported similar results as she classified the visual representations present in the textbooks, she analyzed into 59 subtypes. Moreover, Slough et al. (2010) found that the graphical representations were distributed among 13 types. Having only three subtypes not being implemented from Moline's framework with a total of 7 types and 22 subtypes, this shows the diversity in visual representations that the Lebanese national science textbooks represent. The wide variety of visual representations may challenge the students' comprehension (Fingeret, 2012). Guo et al. (2018) further explained that the variety of visual representations poses difficulties for students as these visuals require certain skills so that they can be analyzed. McTigue and Flowers (2011) deduced that instruction for interpreting science visuals should be implemented. The absence of the three mentioned subtypes in the science textbooks could be explained by their use in other disciplines; Fingeret (2012) demonstrated that social studies involve more maps while science includes more diagrams. Coleman and Dantzler (2016) concluded that the distribution of visual representations varied with different disciplines.

The second result of this paper shows that photographs and realistic illustrations were the most frequent ones among all grade levels. Vekiri (2002) and Goodman (1968) classified the mentioned types of as non- notational graphics which lack discrete elements that can be easily identified. The findings of Guo et al. 's (2018) study about different types of visual representations in third and fifth grade levels indicate similar results to our current study. In their study, Guo et al. (2018) concluded that photographs and general images, which they labeled as cartoon illustrations and drawings, were the most recurring visual representations. Moreover, Fingeret (2012) found a compatible result as she revealed that simple photographs and images were the most prominent among other visuals. Additionally, Slough et al. (2010) reported that photographs were the most frequent, by which they represent about half of the visual representations present in the analyzed textbooks. In spite of their dominance, photographs were not incorporated in Inaltekin and Goksu's (2019) framework, as they have classified them under a broader type, labeled as simple diagrams.

The prominence of photographs and realistic illustrations in the analyzed textbooks could be explained by their contribution to enhancing the students' comprehension while reading science textbooks as they were classified as simpler visuals. Vekiri (2002) asserted that photographs are the most primitive and straightforward among other visual representations. On the other hand, McTigue and Flowers (2011) demonstrated that when dealing with information from several sources, young students face difficulties in processing and combining them. When it comes to photographs, Moline (2012) explained that the latter portray a single instant of the captured scene (Moline, 2012), which could reveal the reason behind their simplicity and intelligibility. Looking at the wide range of visual representations and at the high frequency of photographs and realistic illustrations, which was higher in the grades of the first cycle, should be considered when it comes to instruction. Fingeret (2012) explained that it would be beneficial to students that teachers start to concentrate their instruction during early grade levels on simple photographs, which was labeled as "photographs" in this study, and on images, which included "realistic illustrations", as they accounted for the majority of the visual representations. She added that it would be helpful to master them before learning the many other types and subtypes of visual representations.

The third result of this study shows that the number and types of visual representations vary according to the grade level. The frequency of all visual representations except for photographs and realistic illustrations, which were labeled by Vekiri (2002) and Goodman (1968) as notational graphics, increased with accordance to the grade level. The results found by Coleman and Dantzler (2016) indicate similar findings to our current study. In their study, they deduced that there was a difference in the distribution of visual representations, except for timelines, with accordance to the grade levels. On the contrary, Inaltekin and Goksu (2019) found in their research that the primary and secondary science textbooks that they have analyzed did not show any change with regards to the graphical representations according to the grade levels.

Regarding the types of visual representations, the data collected from this study shows that the textbooks of primary grade levels, that is grades 1, 2, and 3, did not include *Graphs*. However, they started to exist in the textbooks of secondary grade levels, grades 4, 5, and 6. Furthermore, the percentage of non-notational graphics, photographs and realistic illustrations, which were classified as simpler graphics by Vekiri (2002), decreased from 80% in primary grades to 64% in secondary grades. The change that exists in the mentioned types could be explained by the distribution of the visual representations on the grade levels according to their complexities. Fingeret (2012) explained that diagrams, flow diagrams, graphs, timelines, maps, and tables can be labeled as more complex visuals than images. Duke et al. (2012) asserted that students in primary grades may face difficulties in comprehending how visuals represent verbal text. Moreover, they demonstrated that learners may not understand that visual representations can extend verbal text until they complete the third grade.

Action plan

Looking at this study and other literature, it can be deduced that visual literacy skills, which are needed to comprehend graphical representations, are not innate **(**Kress & van Leuween, 2006) hence, science visuals instruction is needed (McTigue & Flowers, 2011). However, when it comes to real world implementations, it seems that there is a lack of such necessity. In Guo et al.'s (2018) article, 73% and 49% of teachers reported that they never or rarely taught students to draw and mark graphics, respectively. Consequently, students are unlikely to deepen their comprehension of multimodal text without clear guidance (Peeck, 1993). Stylianidou et al. (2002) came to the conclusion that teachers should spend time and effort discussing the visual representations with their students.

Stylianidou et al. (2002) asserted that in their science lessons, teachers are encouraged and/or required to include graphical representations and models of different forms. Moreover, teacher training and professional development should include visual literacy instructional approaches (Metros, 2008). McTigue and Flower (2012) explained that when teachers model the way visual representations are analyzed, they highlight the importance of visual representations. They also suggested further strategies such as defining visuals, producing and creating diagrams, and assessing the students about them.

Research explaining how visual complexity increases across grade levels in both textbooks, including this study, and trade books would be particularly useful in determining the scaffolding that students need to grasp graphics as they progress through the grades (Guo et al., 2018). Following the results of this study and other similar studies, it can be deduced that it would be helpful for teachers to focus their instruction on photographs and realistic illustrations at the elementary levels, and then start gradually by introducing more complex visuals at higher elementary levels. Fingeret (2012) explained that although the mastery of certain visual representation does not assure the mastery of others, mastering the visual features of graphics could support recognizing other types and subtypes.

When it comes to publishing science textbooks, it can be deduced that the visual representations in the textbooks should be consistent to the intended grade level. Pinto (2002) asserted that the features of the visual representations should vary in accordance with the learners' development level. Hence, it can be concluded that it would be helpful if publishers include simpler visual representations at early elementary grades, which are photographs and realistic illustrations, and include more complex ones in higher levels.

Limitations

While we selected the national science textbooks to analyze, we have no way of knowing how many schools have chosen to use these textbooks. Additionally, this study only analyzed textbooks; despite the fact that we did not examine interactive e-books or electronic visuals that students experience while online reading, the impact of this medium should be considered in future research. Moreover, for future research, interviewing teachers and students about the use of visual representations are thought to help enhance and enrich textbooks significantly.

Conclusion

This study provided an overview of the types and frequency of visual representations present in the Lebanese national science textbooks at elementary grade levels. Overall, we discovered that there were seven major types and nineteen subtypes of visuals, indicating that students are exposed to a wide variety of visuals on a regular basis. As a result of this deduction, we concluded that visual instruction should be embedded within teachers' guidance since visual literacy skills are not intuitive, as it was mentioned by other research (Kress & van Leuween, 2006;

McTigue & Flowers, 2011; Stylianidou et al., 2002). This study also found that science textbooks of different grade levels had different distribution of visual types and frequency. Thus, it was concluded that the visual representations in science textbooks should be distributed according to the intended grade level.

Appendices

Table A.1
Moline's (2012) Classification Model

Type		Subtype	
Photograph	They capture a single instant for an object or an individual.	-	
Simple Diagram	They include both illustrations and phrases. The illustration simplifies, generalizes, or symbolizes the actual subject.	Picture Glossaries.	Labeled pictures that help the readers to recognize the elements within the whole picture (also known as labeled pictures).
		Scale Diagrams	Images accompanied with a scale that shows the size of the presented object.
Maps	Special kind of diagram that represents huge scale objects into smaller ones.	Bird's Eye View	Maps that display the scene from an upward view.
		Personal Maps	Maps that assist the readers to position themselves within a certain context.
		Maps of the Unknown	Maps that help locating unknown regions and people.
		Time Maps	Maps that record processes and movement of people or things using arrows.
Analytic Diagrams	They zoom into a subject or portray its inner parts.	Enlargements	Magnified diagrams that show how an object is constructed or how it works through zooming in into its details.
		Exploded Diagrams	Diagrams used to separately portray the different parts of the whole that might be unclear when the whole picture is presented.
		Cutaways	Diagrams that show and explain the hidden parts of the presented object through removing its outer layer.
		Cross Sections	They expose the inside of the subject in a single plane, creating a two-dimensional surface which represents the subject's internal structure.

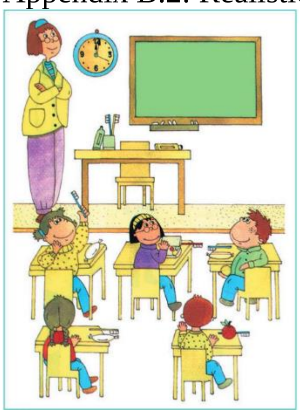
		Block Diagrams	They expose a segment of the subject in three-dimension, allowing a deeper understanding of the different parts of the subject.
Process Diagrams	They reflect sequence and chronology.	Timelines	Spectrum that organizes events in time intervals to represent the sequence of incidents.
		Storyboards	They are similar to timelines in the organization of events in time order, yet they are more pictorial and might include explanations.
		Flowcharts	Diagrams that represent the change that occurs within a process in accordance to time and space, with the use of arrows.
Structure Diagrams	They connect the elements presented in the diagrams and texts together.	Web Diagrams	They connect the presented ideas together and represent the relationship between them rather than showing a process.
		Tree Diagrams	Organizes information according to their hierarchy, including groups and subgroups.
		Tables	They organize the information in rows and/ or columns which helps in identifying patterns and interconnections.
		Venn Diagrams	To compare and contrast the elements within the presented subject.
Graphs	Diagrams that include words, numbers, or symbols for measuring and comparing data.	Simple (Spectrum) Graphs	They measure the size of an object by inserting marks within a spectrum i.e., equal scale intervals.
		Bar and Column Graphs	A column graph measures information in units vertically, from top to bottom. A bar graph measures information in units across the page horizontally, from left to right. Otherwise, they both serve the same purpose; they display data in a way that allows it to be calculated, compared, and rated.
		Line Graphs	They represent the change in the amounts in accordance with time intervals with the use of a line.
		Pie Charts	They represent data in the form of the degrees of the circle. They highlight the differences in the information collected, compare proportions, and assist in coming up with conclusions based on the differences.

Appendix B

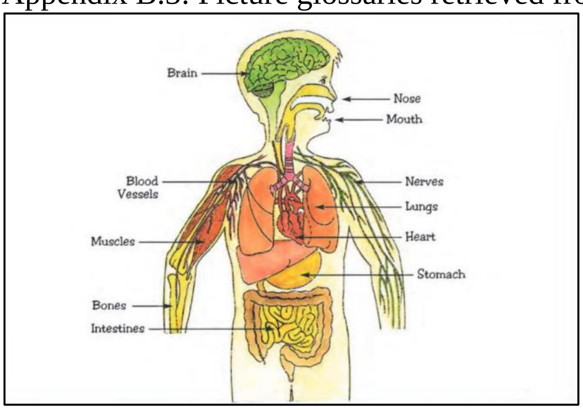
Sample of Each Subtype of the Included Visual Representations, Order in Frequency.

Appendix B.1: Photograph retrieved from *Science for life*, grade 4, part 1, p. 13.

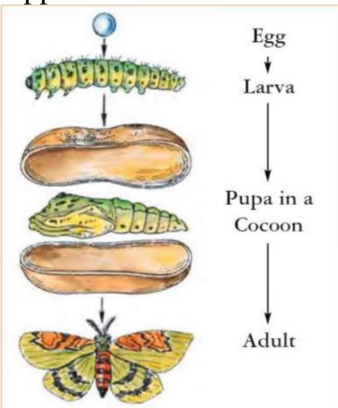
Appendix B.2: Realistic illustration retrieved from *My 1st Science book*, Grade 1, p. 24.



Appendix B.3: Picture glossaries retrieved from *My 3rd Science book*, Grade 3, p. 75.



Appendix B.4: Flowchart retrieved from *Science for life*, Grade 6, p. 43.



- Figure 9 -
Life cycle of a caterpillar.

Appendix B.5: Table retrieved from *Science for life*, Grade 6, p. 44.

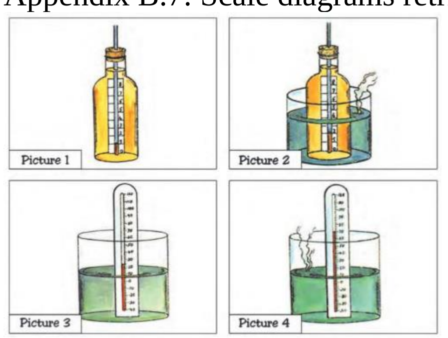
Animal	Number of days
Cat	65
Ewe	155
Mare	340
Cow	275
Elephant	625
Camel	410

- Figure 10 -
Gestation periods of some animals.

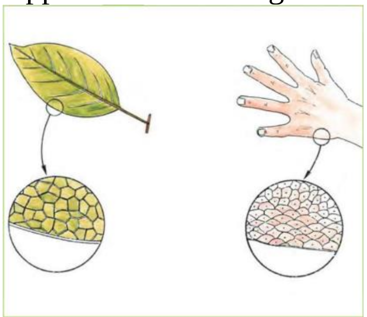
Appendix B.6: Storyboard retrieved from *Science for life*, Grade 5, part 1, p. 75.

Figure -2- Color camouflage in a lizard.

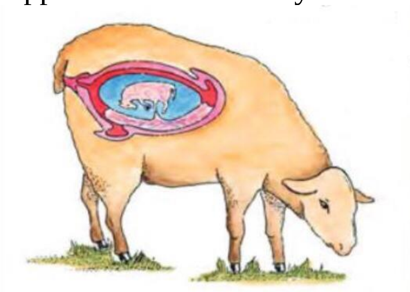
Appendix B.7: Scale diagrams retrieved from *My 3rd Science book*, Grade 3, p. 113.



Appendix B.8: Enlargements retrieved from *Science for life*, Grade 6, p. 15.

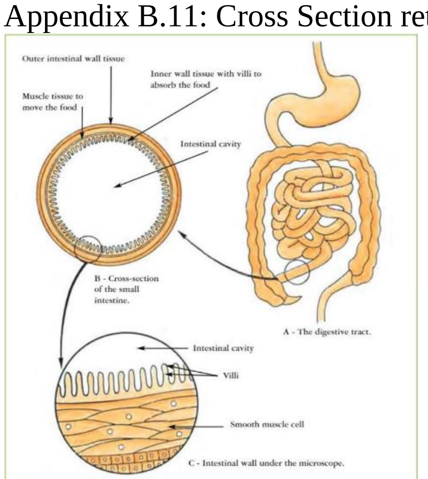


Appendix B.9: Cutaway retrieved from *Science for life*, Grade 6, p. 44.



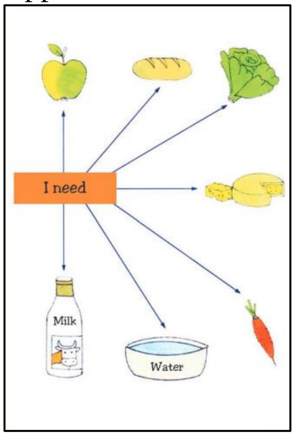
Appendix B.10: Block Diagrams retrieved from *Science for life*, Grade 5, part 1, p. 127.

Appendix B.11: Cross Section retrieved from *Science for life*, Grade 6, p. 26.

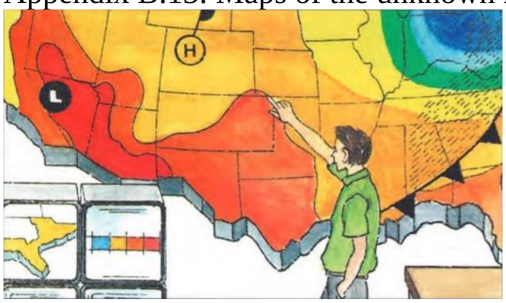


- Figure 15 - The structure of the digestive system.

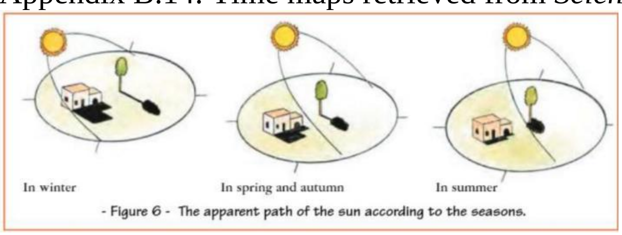
Appendix B.12: Web Diagram retrieved from *My 1st Science book*, Grade 1, p. 81.



Appendix B.13: Maps of the unknown retrieved from *My 3rd Science book*, Grade 3, p. 172.

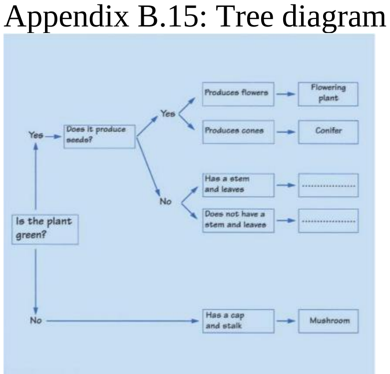


Appendix B.14: Time maps retrieved from *Science for life*, Grade 6, p. 191.

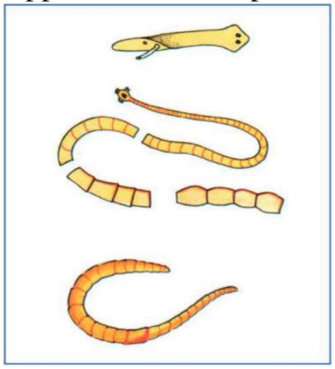


- Figure 6 - The apparent path of the sun according to the seasons.

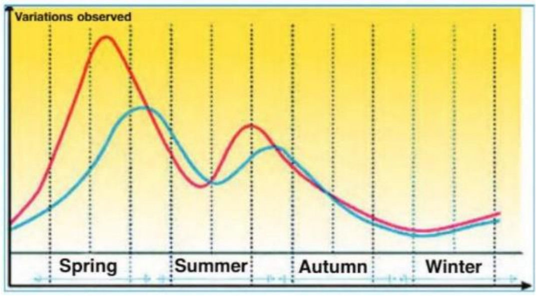
Appendix B.15: Tree diagram retrieved from *Science for life*, Grade 4, part 1, p. 124.



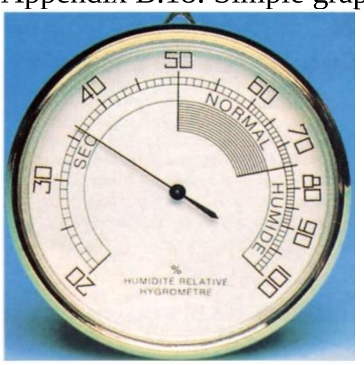
Appendix B.16: Exploded diagrams retrieved from *Science for life*, Grade 4, part 1, p. 75.



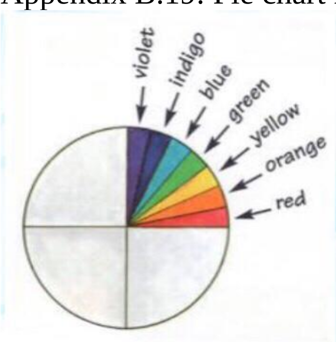
Appendix B.17: Line graphs retrieved from *Science for life*, Grade 6, p. 109.



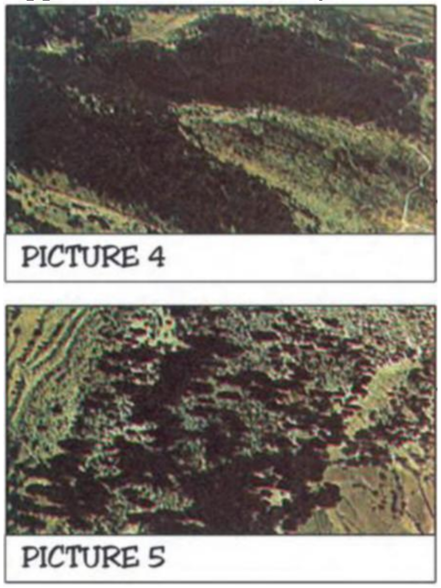
Appendix B.18: Simple graphs retrieved from *Science for life*, Grade 5, part 2, p. 211.



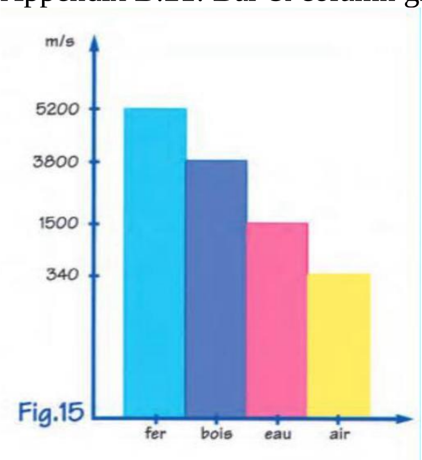
Appendix B.19: Pie chart retrieved from *Science for life*, Grade 5, part 2, p. 155.



Appendix B.20: Bird's eye view retrieved from *My 3rd Science book,* Grade 3, p. 29.



Appendix B.21: Bar & column graphs retrieved from *Science for life,* Grade 4, part 2, p. 198.



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