An analysis of activity section images in Greek secondary Physics textbooks

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ABSTRACT

An increasing number of studies emphasize the crucial role of visual representations in science education. Science textbooks are rich in visual content, which significantly contributes to facilitating the learning process. Although considerable attention has been given to the role of visuals in enhancing conceptual understanding within the main text of science textbooks, the educational value of images in the activity sections has received limited focus. This study investigates the images included in the activity sections of the physics textbook for the 1st grade of Greek secondary education (Gymnasium) in terms of image type and task type. Analyzing 150 images, we classified them by image type (e.g., photographs, diagrams, graphs) and task type (e.g., observation, drawing, text completion). The results show that the majority of images are photographs (76/150) and mixed photographs (42/150), while diagrams, drawings, and graphs are less frequent. Most images (146/150) are used to guide student observation or actions, while only few (4/150) involve drawing tasks, and none require text completion. Relevant literature and ideas for further research are discussed.

KEYWORDS

Physics textbooks, images analysis, secondary education

RÉSUMÉ

Un nombre croissant d'études met en évidence le rôle essentiel des représentations visuelles pour l'enseignement des sciences. Les manuels scolaires de sciences comportent une grande richesse de représentations visuelles qui contribuent de manière significative à faciliter le processus d'apprentissage. Bien qu'une attention considérable ait été accordée au rôle des figures dans la compréhension conceptuelle à l'intérieur du texte principal des manuels, la valeur pédagogique des images présentes dans les sections d'activités a été relativement peu explorée. Cette étude examine les types d'images et les tâches associées incluses dans les sections d'activités du manuel de physique utilisé en première année du secondaire grec (13 *ans). En analysant 150 images, nous les avons classées selon leur nature (par exemple, photographies, diagrammes, graphiques) et le type de tâche proposé (par exemple, observation, dessin, complétion de texte). Les résultats montrent que la majorité des images sont des photographies (76/150) ou des photographies modifiées (42/150), tandis que les diagrammes, dessins et graphiques sont moins fréquents. La plupart des images (146/150) servent à guider l'observation ou l'action des élèves, seules quelques-unes (4/150) impliquent des tâches de dessin, et aucune ne requiert de compléter un texte. Les résultats et des pistes pour de futures recherches sont également discutées au regard de la littérature sur le sujet.*

MOTS CLÉS
Manuels de physique, analyse d'images, enseignement secondaire

INTRODUCTION

Since the 15th century, graphical representations have played a central role in conveying scientific and technical information. In the 1400s, engineers often used notebooks that relied primarily on visuals, with text serving mainly to clarify the accompanying images. It has been argued that the advent of printing – and the resulting wider availability of illustrated scientific and technical texts – significantly contributed to the major technological advances that occurred between the 16th and 18th centuries (Ampatzidis & Armeni, 2019; Hegarty et al., 1991). Science images are playing an increasingly prominent role across a variety of contexts, including scientific inquiry, science reporting in the mass media and school science textbooks. This growing emphasis on visuals is influenced by shifts in publishing practices, advancements in technology, and the widespread use of visual content on the internet. As a result, modern school science textbooks have evolved in their design, adopting formats that resemble web pages and science trade books (Slough et al., 2010).

A growing body of research highlights the central importance of visual representations in science education (Cook, 2006, 2008; Dimopoulos et al., 2003). Science textbooks are abundant in visual content, which plays a significant role in supporting the learning process (Liu & Khine, 2016). Visual elements help simplify the complexity and abstraction of scientific concepts, making them more accessible to students (Devetak & Vogrinc, 2013). As natural extensions of the text, images serve as powerful tools for illustrating and conveying intricate scientific ideas effectively (Ampatzidis & Armeni, 2021; Liu & Treagust, 2013). Graphs, tables, maps, diagrams and photographs play a vital role in science education, as they help students understand concepts that words alone may not effectively convey (Lemoni et al., 2013). For instance, photographs can depict phenomena that are not directly observable, while graphs can illustrate spatial relationships that support and expand comprehension of accompanying texts. Well-designed science visuals contribute significantly to concept formation and integration, which are key to developing a deeper understanding (Ge et al., 2018).

Within science textbooks, images are presented in a variety of contexts and fulfil diverse educational purposes (Koutsikou et al., 2021). A key distinction lies in the placement and intended function of these visuals – specifically, whether they are embedded within the main body of the text or located in designated activity sections. The latter refers to clearly demarcated parts of textbooks that are separate from the main explanatory content and are designed to foster learner engagement through tasks such as practice, exploration, or reflection.

Images embedded in the main narrative often aim to support the reader's understanding by illustrating key concepts, processes, or phenomena described in the written content. They typically serve explanatory or descriptive roles, helping to clarify abstract ideas or making invisible or complex phenomena more accessible (Jee et al., 2022; Lee, 2010). In contrast, images included in activity sections are more interactive in nature. Rather than simply supporting comprehension, they are designed to actively engage students in learning tasks. These tasks may include interpreting data, identifying patterns, drawing conclusions, or even completing missing elements within the visual itself. Such images encourage learners to apply their knowledge, think critically, and develop scientific reasoning skills. Thus, the role of images in textbooks extends beyond mere decoration, functioning as integral tools that contribute to both the presentation and the active construction of scientific knowledge (Postigo & López-Manjón, 2019).

Despite the extensive attention given to the role of visuals in supporting conceptual understanding within the main text of science textbooks (Leivas Pozzer & Roth, 2003; Lenzner et al., 2013; Upahi & Ramnarain, 2019), relatively little emphasis has been placed on the pedagogical potential of images found in activity sections. As discussed above, these images are not merely illustrative; they are often designed to provoke student engagement through inquiry-based tasks, data interpretation, or problem-solving (Postigo & López-Manjón, 2019). Given their potential to enhance higher-order thinking and promote active learning, a closer examination of these images is warranted. In the case of Greek secondary education, where (a) the same government-mandated textbooks are used across all public and private schools, and (b) the national curriculum is closely tied to these textbooks, which serve as a primary instructional resource for teachers at all grade levels, it becomes particularly important to understand how visual elements function within the learning environment. Considering the above, this paper is part of a study that aims to analyse the images (i.e. photographs, drawings, graphs, diagrams etc.) included in the activities' sections of Greek secondary education science textbooks. Here, we report on results of the analysis of the physics textbook for the 1st grade of Gymnasium because it is designed to support a teaching approach rich in laboratory activities and, therefore, it includes a large number of images related to these activities. Thus, the research question addressed is the following: what are the types of images of activities section of Greek physics textbook for the 1st grade of Gymnasium and what are students asked to do with them?

METHODS

We investigated the images included in the physics textbook for the 1st grade of Gymnasium (12-13 years old, Kalkanis et al., 2013) in Greece. As explained above, this textbook is designed to support a teaching approach rich in laboratory activities therefore all the images may be considered to be associated with activities. We identified 150 images in 58 pages and coded them in terms of image type and task type in mutually exclusive categories formed drawing on a coding scheme modified from Postigo & López-Manjón (2019) as shown in Table 1. The authors coded independently all the images and the percentage agreement (Gisev et al., 2013) was calculated about 93%. The cases of disagreement were reviewed and discussed by the coders until consensus was reached.

In order to define our codes, we note the following. Photographs are images that depict objects in realistic representations. Moreover, drawings are images that typically preserve the morphological characteristics of objects while incorporate a degree of abstraction. Furthermore, diagrams are structured visual representations which use graphical elements alongside written text to illustrate relationships, processes, or systems. Graphs, encompassing charts, plots, and other schematic representations, are images that depict quantitative data, patterns, or relationships (Pantidos et al., 2022). Finally, mixed photographs are photographs that have been retouched (e.g. some lines have been highlighted). Concerning the task types, we looked in the relevant captions and surrounding text for guiding addressed to the students (e.g. "what do you see in the image?") and coded the images in terms of whether students are asked to look the images, complete text on them or draw a part of them.

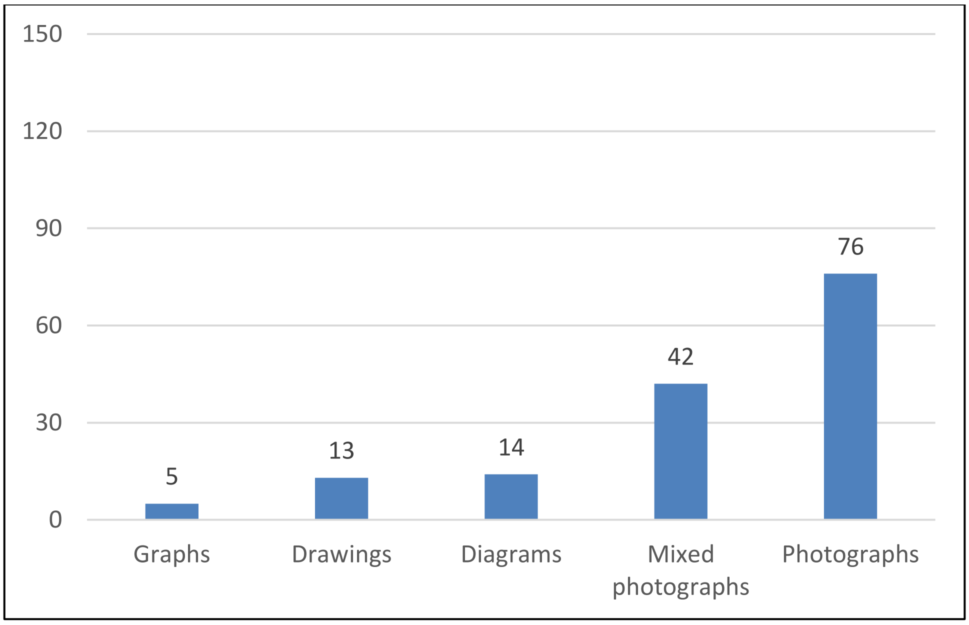
TABLE 1
The coding scheme

	Category
Image type	Photographs
	Drawings
	Diagrams
	Mixed photographs
	Graphs
Task type	Look at the image
	Complete text
	Add a drawn element

RESULTS

The analysis showed that the majority of images are photographs (76/150), while there are also many mixed photographs (i.e. photographs that have been edited) (42/150). On the other hand, diagrams, drawings and graphs appear few times (14/150, 13/150, and 5/150 respectively) (Figure 1).

FIGURE 1

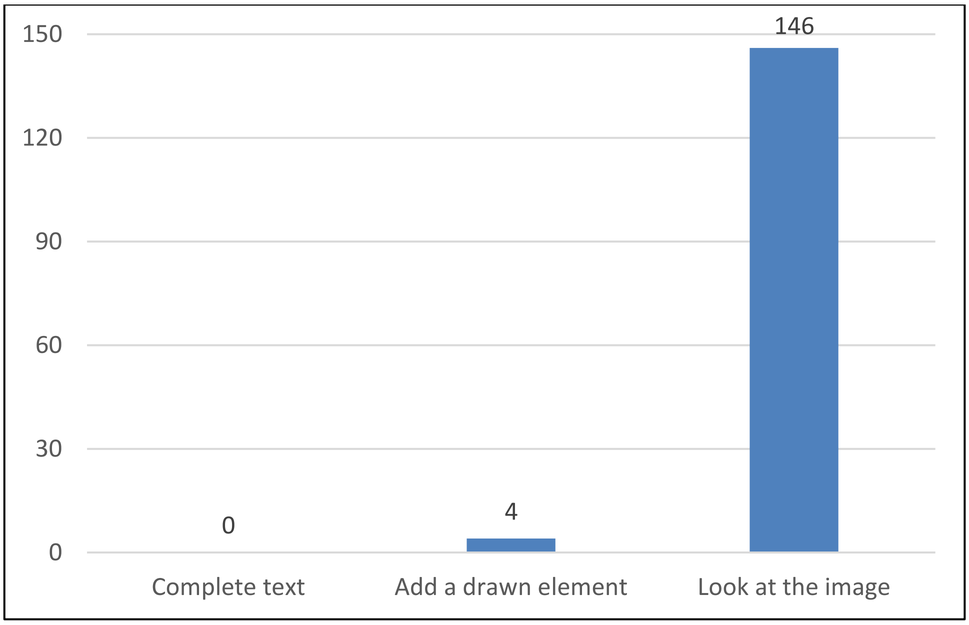


Frequencies of image types

Concerning the task type, for the large majority of images (146/150) students are asked to observe them in order to interpret their content or to use them as guidance for performing an activity. Two examples are the following: "Tie a small and heavy object (e.g., a ball made of modelling clay) to one end of a thin rope (about half a meter long), and hang it by tying the other end to a high point, making sure it doesn't touch anything and can swing freely. Let it come to rest in a vertical position, as shown in the adjacent image (Kalkanis et al., 2013, p. 6), "Look at the adjacent images of the same lake in summer and in winter. Observe the indicated temperatures. Explain these temperatures in summer and winter based on your conclusions. Why doesn't the whole lake freeze in winter?" (Kalkanis et al., 2013, p. 32). There are very few images (4/150) for which the students are asked to draw a part. Two examples are the following: "With the help of your teacher, record your measurement values on the 'temperature-time' graph, using the symbol 'x' for each pair of values. Draw a line that passes exactly through or between the points marked with the symbol 'x'" (Kalkanis et al., 2013, p. 26), "Plot the measurement values from Experiment 1 and Experiment 2 on the 'temperature-time' graph, using different symbols for the values from each experiment (e.g., 'x' for the temperature values without carbonated water, vinegar, and baking soda; 'o' for the temperature values with carbonated water, vinegar, and baking soda). Draw two curves by connecting the same symbols" (Kalkanis et al., 2013, p. 41). No images were identified for which students are asked to complete text on them (Figure 2).

Finally, we noted that most of the images prompting students to draw a part of them are graphs. Specifically, three out of the four images that include such a task are graphs, while the remaining one is a mixed photograph. This observation highlights the fact that the majority of the graphs identified (three out of five) are designed to engage students in an active task, namely, to draw a component of the graph themselves. In contrast, the remaining graphs (two out of five) serve a more interpretive purpose, requiring students to examine them in order to extract meaning.

FIGURE 2



Frequencies of task types

DISCUSSION

We may argue that the textbook investigated includes more photographs than expected; the number of photographs in textbooks of secondary education is anticipated to be limited, since more abstract images are usually found in textbooks used in secondary education (Dimopoulos et al., 2003; Liu & Khine, 2016). A reason for this may be that many photographs serve as guidelines for students to perform laboratory activities which require a certain level of details. An interesting observation is the presence of mixed images, i.e. images that are based on photographs but are treated in a way to manually increase emphasis in specific parts. This practice may be driven by a necessity to set the focus on certain details of the image in order to help students effectively perform the laboratory activities they depict. On the other hand, it appears that only few graphs are included in the textbook we investigated. This result aligns with Liu & Treagust's (2013) assertion that the representation of quantitative data is mainly found in textbooks for higher grade levels.

Concerning task types, we noticed that for the large majority of images students are asked to observe them which agrees with Postigo & López-Manjón's (2019) results concerning the science textbooks of secondary education in Spain. Drawing images is a learning activity that is rarely used at either educational level. However, tasks that involve creating an image or part of it can enhance deeper learning about the represented object. When students are encouraged to create visual representations themselves, they must understand and reorganize the information, which can lead to a deeper understanding of the concepts being represented (Mathai & Ramadas, 2009). Moreover, such creative tasks can be important in promoting higher-order thinking skills. In the context of science education, for example, drawing or creating images can support problem-solving, enhance critical thinking, and help students make meaningful connections between abstract concepts and real-world phenomena (Postigo & López-Manjón, 2019).

The preliminary data presented here highlight interesting patterns that appear to be associated with the types of images and corresponding tasks found in the physics textbook we researched. Our study will continue with the aim of analysing the activity-related images across all science textbooks used in Greek secondary education. This extended analysis aims to identify whether similar patterns exist across disciplines and grade levels. Moreover, we plan to analyze the activity-related images of science textbooks by implementing other analytical frameworks in a subsequent phase, such as the classification of images into narrative, analytical, classificational and metaphorical representations proposed by Dimopoulos et al. (2003) and the classification of images in terms of the processing level of the corresponding activities proposed by Postigo & López-Manjón (2019). As a final remark, we should note that although it seems to be a common place that visual representations play a significant role in facilitating learning of science by breaking down the inherent complexity and abstract nature of scientific concepts (Devetak & Vogrinc, 2013; Liu & Khine, 2016), we do not claim image types or task types having a direct impact on student learning. Although our observations raise important questions about the pedagogical use of visuals, further empirical research is needed to explore whether and how specific variables are connected to improved student learning.

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