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VISUAL REPRESENTATIONS ANALYSIS OF SENIOR HIGH SCHOOL BIOLOGY TEXTBOOKS ABOUT THE HUMAN MOVEMENT SYSTEM

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ABSTRACT

The objective of this research was to examine the functions and forms of visual representations in selected textbooks and to evaluate their alignment with principles of effective visual representation. Employing a qualitative content analysis approach, four textbooks, KM, BA, YT, IP, were analyzed using a classification framework that classified the visual representations by their function (decorative, illustrative, explanatory, complementary) and by their form (e.g., illustrations, diagrams, tables, maps). The results revealed that visual representations were predominantly illustrative in both function and form across all Biology textbook samples. Among the samples, the YT textbook demonstrated the highest quantity and diversity of visual content, while KM had the fewest. These findings suggest that the textbooks have not fully adhered to the principles of effective visual representation, potentially limiting students' understanding of complex biological concepts. It is recommended that future editions increase both the quantity and variation of visual content to enhance pedagogical effectiveness and promote deeper learning.

INTRODUCTION

Textbooks serve as one of the primary learning resources that present curriculum-aligned scientific concepts, facts, and theories, while playing an essential role in facilitating the learning process and the achievement of instructional goals, particularly at the secondary education level (Gultom, Napitupulu, Sirait, Lubis, & Harahap, 2024; Khairunnisa & Rasyidah, 2024).

The distinctive characteristic of biology education presents its own pedagogical challenges, including foreign terminology, scientific nomenclature, and abstract concepts that often make learning more difficult for students (Samaduri, 2022; Wahid, 2020). One example of this challenge is understanding biological mechanisms within the human organs, as these mechanisms cannot be directly observed and are difficult to grasp without appropriate instructional support (Raida, 2018).

One topic perceived as difficult due to its conceptual complexity and limited visualization is the human Movement system (Lutfha & Sumarno, 2020; Telaumbanua, Halawa, & Lase, 2024). This difficulty hinders students' ability to establish conceptual connections, leads to a lack of conceptual understanding, and impedes the overall learning process (Novitasari & Susantini, 2021). In such cases, visualization plays a crucial role in bridging the cognitive gap in understanding biological mechanisms that cannot be directly observed. Comprehensive and diverse visualizations in biology learning materials can support students' understanding of biology content by clarifying objects and phenomena at both symbolic and macroscopic levels (Khairunnisa & Rasyidah, 2024; Maduratna & Jayanti, 2022).

The use of visual representations has proven effective in making abstract concepts more concrete, thus enhancing students' comprehension (Ozara et al*.,* 2024). Visual representations also provide constructive feedback that reinforces accurate conceptual understanding throughout the learning process, thereby contributing to the achievement of learning objectives (Utami & Subiantoro, 2021). These representations can be classified into figurative types, such as photographs, illustrations, and icons, and into abstract types, such as graphs, tables, diagrams, charts, maps, and networks (Suyatna, Anggraini, Agustina, & Widyastuti, 2017).

The integration of visual representations in science textbooks has become increasingly relevant in recent years, aligning with research trends that highlight the growing emphasis on visualization in science education. A systematic review of 33 studies published between 2011 and 2021 reported that visualization has been a significant focus in K-12 science learning, particularly in supporting students' conceptual understanding (Kim & Jin, 2022). This evidence is further reinforced by a meta-analysis of 14 studies published in high-quality science education journals indexed in SCImago Quartiles 1 to 3, which reported a pooled effect size of 0.78, indicating a

substantial positive impact of visualization on students' scientific concept development (Suknarusaithagul, Puengnoi, & Pongsophon, 2020). Visual elements in textbooks also serve as essential learning resources that facilitate understanding of biological concepts (Papatheodosiou et al., 2020) and act as conceptual mediators, reducing ambiguity in textual explanations of scientific phenomena and helping students avoid scientific misconceptions (Parthasarathy & Premalatha, 2022). The appropriate use of visual representations in learning media, such as textbooks, serves as a pedagogical tool that not only supports scientific communication but also increases engagement, facilitates comprehension, and creates a more meaningful learning experience (Sudiarti, Wulandari, & Bukhori, 2024).

Some commonly used Biology textbooks still demonstrate shortcomings in their use of visual representation, despite the increasing integration of visuals in secondary science textbooks. Previous studies have found that visual elements remain limited in depth and rarely connect biological material to real-life contexts (Ayu, 2015). Nevertheless, given the critical role of visual representation in scientific learning and the absence of focused studies on the visual representations of the Human Movement System, there is a pressing need for more in-depth analysis of the visual elements in commonly used Biology textbooks.

This study aims to identify the proportions and types of visual representations used in Grade XI Biology textbooks through a content analysis. The research questions leading this study are: What types and proportions of visual representations are employed, and to what extent does the design of Grade XI Biology textbooks—especially on the topic of the Human Movement System—reflect the principles of visual representation?

MATERIALS AND METHODS

Materials

This study used primary data from Grade XI Biology textbooks selected based on their relevance to the Kurikulum Merdeka. Through preliminary research using surveys and interviews with biology teachers at 14 senior high schools in Yogyakarta, four textbooks were identified as the most commonly used and subsequently selected as research samples. For analytical clarity, each book was assigned a code: KM, BA, YT,

and IP. The analysis focused specifically on the Human Movement System, with the material characteristics outlined in Table 1.

Table 1. Content Structure of the Human Movement System Topic

Book Characteristic*			
Book Code	Title	Page	N
KM	Structure, Functions, and Disorders of the Human Movement System 1. The Human Skeleton as Organ of Movement 2. Structure of Striated Muscles 3. Mechanisms of Motion	184 – 206	10
BA	The Human Movement System 1. The Skeleton as a Passive Organ of Movement 2. Muscles as an Active Organ of Movement	300 – 311	15
YT	A. Structure of the Human Skeleton 1. Types of Bones 2. Joints 3. Types of Skeletal Structure B. Structure of Muscles 1. Types of Muscles 2. Structure and Functional Properties of Skeletal Muscles 3. Classification of Skeletal Muscles 4. Mechanism of Muscle Contraction 5. Types of Body Movements C. Disorders of the Human Movement System 1. Disorders of Bones and Joints 2. Disorders of Muscles	39 – 65	36
IP	A. Bones Composing the Human Skeleton 1. Functions of the Human Skeleton 2. Arrangement of Bones in the Human Skeleton 3. Classification of Bones by Shape 4. Classification of Bones by Composition 5. Process of Bone Formation 6. Joints or Articulations 7. Disorders or Abnormalities of the Human Skeleton B. Structure and Functions of Muscles 1. Classification of Muscles 2. Mechanism of Muscle Contraction and Relaxation 3. Properties of Muscle Movement 4. Disorders or Abnormalities of Muscles	20 – 35	14
Total Number of Visual Representations			75

*) Content originally in Bahasa Indonesia

Methods

This study employed a descriptive research design using a content analysis approach to identify and evaluate specific components of the textbooks' learning materials (Maduratna & Jayanti, 2022). Content analysis is a method for deriving replicable and valid inferences from various forms of representation—such as text, images, maps, symbols, sound, and numbers—that carry social meaning and communicative intent and whose interpretation depends on their context of use (Gheyle & Jacobs, 2017).

The data analysis combined quantitative and qualitative techniques. The quantitative analysis focused on recording the frequency of visual representations found in each textbook. The qualitative analysis involved coding visual elements according to predefined categories. These representations were classified into two main dimensions: (1) by function and (2) by form, as outlined in Table 2 and Table 3.

Table 2. Visual Representation Classified by Function

Function	Operational Definition
Decorative	The visualization displayed is not related to the text or description.
Illustrative	The visualization displayed does not provide additional information or other information, and only explains the object or phenomenon based on the text.
Explanatory	The visualization displayed is provided with additional information or other information about the object based on the text.
Complementary	The visualization displayed contains other information not stated in the text.

(Utami & Subiantoro, 2021)

Table 3. Visual Representation Classified by Form

Category	Operational Definition	Form
Figurative	Visual representation is not abstract, similar to the real object/phenomenon	Photography/Naturalistic Technical Drawing Illustration Icon
Abstract	Visual representation with a higher level of abstraction/ also shows quantitative relationships between variables	Graph Table/Layout Map Diagram/Chart Network

(Papatheodosiou et al., 2020; Suyatna et al., 2017)

The analytical procedure involved the following steps: 1) Identification and quantification – Each visual representation in the Human Movement System topic was

identified and counted; 2) Classification – Visuals were categorized according to their function and form, based on the operational definitions adopted in this study.

This approach was designed to provide a comprehensive overview of the distribution of visual content across each Biology textbook and to examine how visual representations relate to the conceptual material to support students' understanding of the Human Movement System.

RESULTS AND DISCUSSION

Result

The availability of visual content in each sampled textbook varied in both quantity and type of representation. The distribution of visual representations by function in textbooks KM, BA, YT, and IP is presented in Table 4.

Table 4. Total Number of Visual Representations Classified by Function in a Sample of Grade XI Biology Textbooks

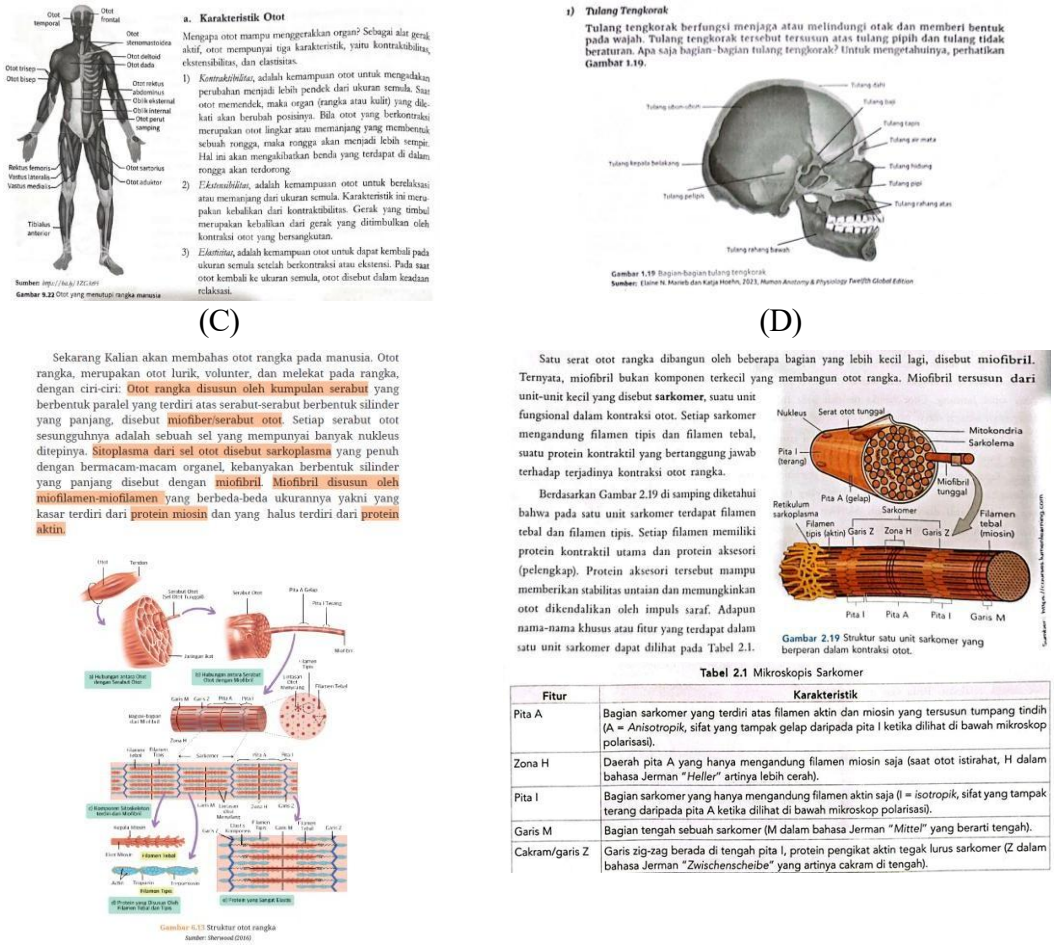
Function								
Book	Decorative		Illustrative		Explanatory		Complementary	
Code	Total	%	Total	%	Total	%	Total	%
KM	1	1,33%	5	6,67%	0	0	4	5,33%
BA	1	1,33%	13	17,33%	1	1,33%	0	0%
YT	0	0%	27	36%	4	5,33%	5	6,67%
IP	0	0%	13	17,33%	1	1,33%	0	0%
Total	2	2,67%	58	77,33%	6	8%	9	12%

The analysis revealed that illustrative visuals were the most dominant across all Biology textbook samples. Textbook YT had the highest number of visuals, with 27 (36%), followed by BA and IP, with 13 each (17.33%), and KM with 5 (6.67%). Complementary visuals ranked second in frequency. Textbook YT featured five visuals (6.67%), followed by KM with four visuals (5.33%), while BA and IP did not include this visual function in their presentations of Biology material. Explanatory visuals were found in limited numbers: YT featured four visuals (5.33%), BA and IP each featured 1 (1.33%), and none were found in KM. Meanwhile, decorative visuals were only present in textbooks KM and BA, with one visual each (1.33%).

Overall, textbook YT contained the highest total number of visual representations, with 36 visuals (48% of all visuals), while KM had the fewest, with only 10 visuals

(13.33%). Examples of visual representations by function in the four textbook samples are shown in Figure 1.

(A) (B)



(C) (D)

Figure 1. Visual Representations Classified by Function. (A) Decorative function in BA; (B) Illustrative function in IP; (C) Explanatory function in KM; (D) Complementary Function in YT

The subsequent analysis examined visual representations by form, grouped into two categories: figurative and abstract. The figurative category includes photographic/naturalistic visuals and illustrations, while the abstract category consists of tables/layouts, maps, and diagrams/charts. The distribution of visual representations by form in textbooks KM, BA, YT, and IP is presented in Table 5.

The results show that figurative visuals were more prevalent than abstract ones, with illustrations the most dominant form, accounting for 78.67% of all visuals. This finding aligns with the functional analysis, which found that illustrative visuals accounted for 77.33%. YT contained the highest number of illustrations, with 25 visuals (33.33%), while KM had the lowest, with just nine visuals (12%).

Table 5. Total Number of Visual Representations Classified by Form in a Sample of Grade XI Biology Textbooks

Code Book	Category									
	Figurative						Abstract			
	Photographic/ Naturalistic		Illustrations		Tables/ Layouts		Diagrams/ Charts		Maps	
	Total	%	Total	%	Total	%	Total	%	Total	%
KM	1	1,33%	9	12%	0	0	0	0	0	0
BA	2	2,67%	11	14,67%	0	0	2	2,67%	0	0
YT	6	8 %	25	33,33%	3	4%	1	1,33%	1	1,33%
IP	0	0	13	17,33%	1	1,33%	0	0	0	0
Total	8	10,67%	59	78,67%	4	5,33%	3	4 %	1	1,33%

The abstract category was found in a more limited number. The tables/layouts form was absent in KM and BA; the diagrams/charts form was not found in KM or IP; and the maps form appeared only in YT. Thus, the textbook YT was the only sample that featured all three types of abstract visuals. Tables/layouts were most frequently found in YT (3 visuals or 4%), diagrams/charts were most common in BA (2 visuals or 2.67%), and maps appeared exclusively in YT (1 visual or 1.33%). Examples of visual representations by form in the four textbooks are shown in Figure 2.

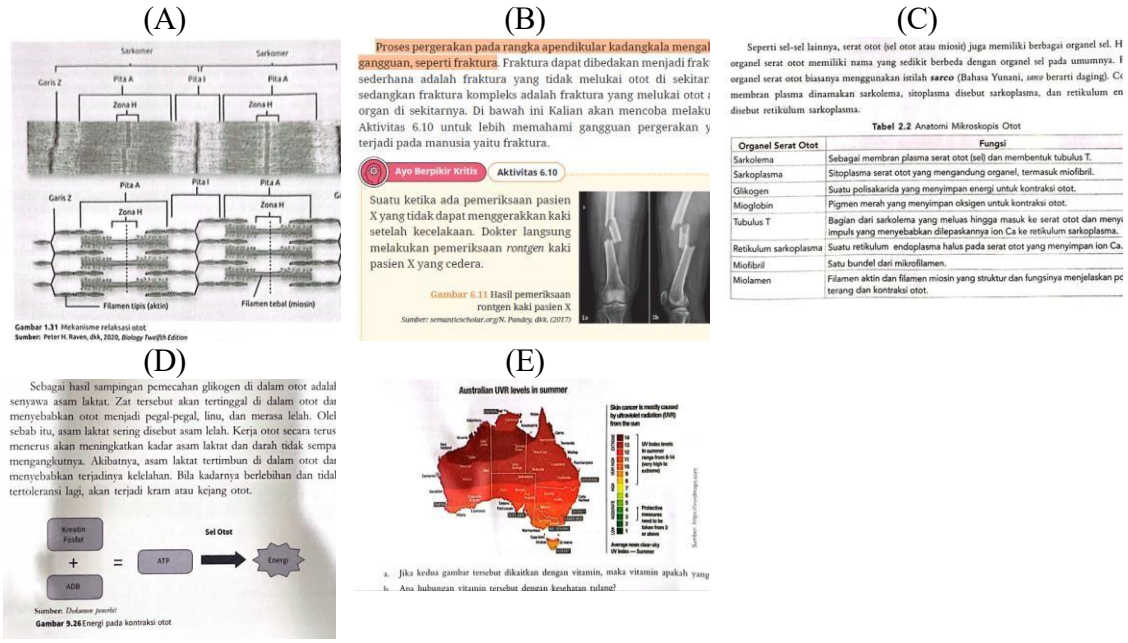


Figure 2. Visual Representations Classified by Form. (a) Illustrations form in IP; (b) Photographic/naturalistic form in KM; (c) Tables/layouts in YT; (d) Diagrams/charts forms in BA; (e) Maps forms in YT

Discussion

The dominance of illustrative functions and illustration forms in the textbooks indicates that visual content tends to serve primarily as textual support, rather than as a

source of new information. While illustrative images can enhance students' understanding of written content (Théophile, 2023), certain biological concepts require advanced forms of visualization to be explained in more depth.

The limited use of visual representations beyond the illustrative function or Illustration forms may reduce the overall effectiveness of content delivery. Explanatory and complementary visual functions can provide a more elaborate learning experience by introducing new information not directly presented in the text or by reinforcing implicit explanations of the material presented (Utami & Subiantoro, 2021; Wati, Chandra, & Mulyani, 2021). Meanwhile, abstract visual forms—such as tables, diagrams, and maps—help facilitate information access, identify patterns, and interpret data trends (Gerela, Mishra, & Vipat, 2022).

Integrating visual elements like tables, images, charts, or graphs in thoughtful ways can minimize the monotony of text-heavy content, offer cognitive pauses that support processing and connecting information, and foster more reflective learning activities (Divecha, Tullu, & Karande, 2023). Therefore, the addition and variation of visual content in school textbooks should be carefully considered, as visual representation offers a powerful means of explaining abstract biological concepts in greater detail through the synergy of text and imagery (Buckley & Nerantzi, 2020).

Textbook YT demonstrates superiority in both quantity and diversity of visual representations compared to the other three. These advantages include the use of more diverse abstract visuals, such as tables, maps, and diagrams, although their frequency remains limited. For example, maps appear exclusively in YT textbooks (see Figure 2D), and such visuals can support students' spatial reasoning and geographic interpretation, including demographic data analysis (Alabi, 2024). Besides that, the YT textbook features more visuals serving explanatory and complementary functions than the other textbooks, which supports elaborative learning as previously outlined. The variety of visual representation positions textbook YT as a potential pedagogical tool that fosters inclusive learning, deepens conceptual understanding, enhances student performance and memory retention, and enriches the overall learning experience (Alabi, 2024; Buckley & Nerantzi, 2020; Gerela et al., 2022).

The diversity of visual representations directly supports students in achieving the competencies stated in the Biology Learning Outcomes (Capaian Pembelajaran/CP) for

Phase F of the Kurikulum Merdeka, as regulated in the Surat Keputusan Badan Standar Kurikulum dan Asesmen Pendidikan *(2022) No. 033/H/KR/2022*. In the context of the human locomotor system, students are expected to analyze the interrelationships among its structural, physiological, and pathological aspects (abnormalities or disorders). These competencies can be optimally achieved when textbooks provide explanatory visual representations and abstract visual forms that clearly and comprehensively depict anatomical structures, bioprocess mechanisms, and pathological conditions. Limited variation in visual representations prevents students from receiving adequate visual support for understanding structure–function relationships and distinguishing between normal and impaired conditions of the locomotor system. Therefore, the presence of varied, informative, and elaborately designed visuals is essential for facilitating students' holistic understanding of the human locomotor system in line with the expectations of the Kurikulum Merdeka.

CONCLUSION

Based on a content analysis of Grade XI Biology textbooks on the Human Movement System, the findings indicate that the variety of visual representations remains limited and predominantly illustrative. Among the four textbooks analyzed, YT provides the most significant number and diversity of visuals, while KM offers the fewest. Overall, the textbooks have not fully aligned with the principles of effective visual representation. Therefore, enhancing the quality and diversifying the visual content in future editions is essential to better support students' understanding of this topic.

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