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Visual Content Analysis of STEM-Related Content in Indonesian Vocational High Schools Biology Textbooks

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ABSTRACT This research aims to analyze the characteristics of STEM-related visual content in Indonesian Vocational High School biology textbooks. Biology textbooks have been adapted to the latest scientific and technological advances and curriculum demands and declared feasible. However, some distributed biology textbooks in Indonesia may need to be improved and have various areas for improvement and problems. This study used NVivo to perform a descriptive statistic comprising 197 visual samples from the two biology textbooks. The results have shown that the type of "sketch & comics" is the most common at 30.5%. In addition, the type of "representation" is the most visual function found in this study, with 44.7%. The study has seen all of the STEM domains appearing in biology textbooks. Most of the STEM domain with visual content relates to scientific content. Other components discussed in detail and essential to the development of the student learning unit are schematic views displaying biological processes and representation functions. Therefore, the authors of biology textbooks need to consider the types and functions of visual content holistically, particularly regarding the context of the topics that can represent effective visual content and develop student understanding.

Keywords Biology textbooks, STEM, Visual content, Vocational high school

1. INTRODUCTION

The way that textbooks are presented to students plays a part in the learning process as a source of information (Juwita, Ilmiyati & Maladona, 2017). The textbook is a teacher's support and a source of information for students during their learning process. The textbooks' quality enhances the teaching process (Asri, 2017). One subject that has a big influence on the ability to master science and technology while using textbooks is biology (Athiyah, 2018; Goba, 2020).

Students' ability to think critically and develop the ideas presented in textbooks should be increased through active thinking during the effective biology learning process (Irawati & Idrus, 2020). A high-quality biology textbook must adhere to guidelines for textbook evaluations based on four primary criteria: content, presentation, language, and graphics/visuals (Syahyani, 2018). However, Irani, Zulyusri & Darussyamsu (2020) claim that many high school students still struggle to comprehend the materials in biology textbooks since the visualization does not correspond to actual concepts.

Pictures, photos, diagrams, graphs, and tables can be used to visualize content in a textbook to help students better understand a subject that is occasionally still not given clearly in a learning material (Soesilo & Munthe, 2020). To improve students' comprehension, textbook visual content must adhere to a dynamic brain work system with various visual data, display modifications, and coloring (Suryanda, Azrai, & Anita, 2020). However, Permana, Degeng & Sihkabuden (2018) note that several secondary school textbooks do not adequately illustrate ideas. This makes it more difficult to demonstrate successful mastery of material notions. How logically students think, applying their information to real-world issues, and demonstrating advanced thinking abilities indicate their understanding of the topics (Andaresta & Rachmadiarti, 2021). Based on this issue, we require innovation in the learning process to help students think logically, use what they learned to solve everyday difficulties, and have advanced thinking abilities.

The term "STEM learning" refers to learning and teaching practices that emphasize problem-solving in the real world and integrate science, technology, math, and engineering knowledge with other subjects (Wahono, Lin

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& Chang, 2020). To meet the expectations of student skills in the twenty-first century, STEM learning can teach students how to combine knowledge from the classroom with real-world occurrences (Andaresta & Rachmadiarti, 2021). According to research by Wahono, Lin & Chang, (2020), STEM education is the most potential innovation for enabling students to develop higher-order thinking abilities and adapt to competitiveness in the twenty-first century. This statement is supported by research on socio-scientific issues using the STEM approach; this approach can improve student academic achievement and other students' self-awareness, motivation, and multi-perspective thinking (Wahono, Chang & Khuyen, 2021). Moreover, students need to be given real-world engineering challenges at the secondary education level to supplement science learning through project activities combining science, engineering, technology, and mathematics (Zulaiha & Kusuma, 2020). Indeed, STEM is considered to help students succeed in their academic endeavors at the high school level, particularly at vocational high schools.

In terms of vocational education institutions, vocational high schools provide students with knowledge and expertise to complement their academic abilities (Cahyani, Mayasari & Sasono, 2020). Aiming to train graduates to be productive members of society, work independently, fill job vacancies, prepare students for professions, be tenacious, persistent in their competence, and adapt to the selected skill program, vocational education institutions prepare students for careers (Atokilah, 2019). Each region's vocational school has a unique expertise program launched in response to the needs and demands of the local community (Kusuma et al., 2017). In some skill programs, biology is one of many scientific disciplines that becomes the fundamental science when studies are taken at the following level (Permana, Degeng & Sihkabuden, 2018).

According to the literature review findings, many students do not meet the Minimum Completeness Criteria in biology disciplines, as evidenced by their daily and general test scores, because they do not understand the subject material presented (Agnafia, 2019). According to Risma, Rahmayani & Handayani, (2019), the key teaching materials teachers select – in this case, biology textbooks, influence the learning outcomes of their students. The study by Sani, Sari & Harahap (2019) regarding the analysis of secondary school students' challenges in biology content found that students had difficulty visualizing the concepts they were learning. A good picture is one of the media for assisting students in identifying the appropriate biological topics in their biology textbooks (Suryanda, Azrai, & Anita, 2020). According to Sartika (2019), STEM education can help prepare human resources for the competencies of graduates required in the twenty-first century.

Moreover, based on Le et al. (2019) research regarding work interest and academic achievement of high school students in Vietnam, student scores tend to be higher in STEM-related subjects, including Mathematics, Physics, Chemistry, and Biology, which is also related to textbooks that students at school use. Therefore, STEM education is a practical and holistic approach to achieving inclusive, equal, and quality education and promoting lifelong learning opportunities. Innovation is also needed for vocational schools that can maintain new skills on a broad scale, including by implementing STEM education in one of its aspects, which can be started in the textbooks used in learning (Wolf et al., 2021). As a result, analyzing STEM-related visual content is essential. However, no new research regarding STEM-related visual content in vocational high school biology textbooks has been discovered.

1.1 STEM-related Content Text Book Analysis

Students are currently using a wide range of textbooks. Some textbooks have been approved for use because they have been updated to reflect the most recent advances in science and technology and the curriculum demands. However, some textbooks with insufficient content, flaws, and problems have been distributed. Previously, there were studies on textbook analysis and its relationship with STEM-related content. In a previous survey of textbook analysis for vocational schools, (Kusuma, Rohman & Syamsuri, 2018), examined the readability of physics textbooks for students in the 10th grade at a vocational high school. Ramda (2017) has also analyzed the suitability of the textbook materials. They did not, however, look into the connection between the STEM content in the analyzed textbooks. Nunun, Wirza & Noorman (2020) conducted a study on visual content analysis, but their analysis did not discuss STEM content.

Furthermore, Artobatama, Hamdu & Giyartini (2020) investigated STEM-related learning designs based on 4C skills for elementary schools. Meanwhile, (Viyanti, Suyatna, & Naj'iyah, 2021) conducted analytical research in STEM-based learning, examining how physics learning strategies were developed to account for different learning styles and past knowledge. In addition, Artobatama, Hamdu & Giyartini (2020) studied STEM-related learning designs based on 4C abilities in elementary schools. Meanwhile, a content analysis study on five editions of biology books by (Yu, Li & Li, 2022), shows that the authors pay more attention to high-level cognitive abilities but do not yet have an accurate picture of how to improve skills and requirements for them to apply them in K-12 education. Based on research trends on science education textbooks from the results of a systematic literature review by (Vojíř & Rusek, 2019), research on textbooks mostly concerns three main topics related to content, conception, and presentation (content, learning concepts, concept integration, and non-textual explanation of the content of learning). In contrast, topics related to student activity, use of textbooks, possible problems, and evaluation of textbooks by teachers and students were discussed less

often. There has to be more research is needed on biology textbooks, especially in vocational high schools.

Other research on the visual content analysis of STEM-related material in Indonesian vocational high school biology textbooks is required based on the context of the issues discussed. It is now easier for teachers and students to choose biology textbooks that include STEM-related visual content. According to Lodge & Reiss (2021), analyzing the content analysis of textbooks can generate numerical data and statistical analysis that can be used to draw inferences from the content effectively and efficiently. As a result, this research is expected to be incorporated into the development of teaching materials, particularly for biology textbooks with STEM-related visual content in vocational high schools. Furthermore, this research can aid in developing human resources for the twenty-first century. Visual content analysis linked to STEM can also be used to prepare biology textbooks with STEM-related visual content to assist students in vocational high schools in imagining the material and comprehending biology principles.

2. METHOD

2.1 Research Design

This study performed a type of descriptive research method. Nassaji (2015) explained that descriptive research describes a phenomenon and its characteristics. This research concerns what rather than how or why something has happened. Therefore, observation and survey tools are often used to gather data. Moreover, in this study, the description of the sample analyzed is connected to visual content related to STEM (Science, Technology, Engineering, and Mathematics) in the most often-used biology textbooks in vocational high schools. This research conducted document analysis techniques. This technique is generally used for research, leading to a content analysis approach.

2.2 Research Population and Sample

The population in this study was the Indonesian Vocational High School biology textbooks for the 11th grade. The research in this current study included the Biology textbooks for 11th-graders used in Indonesian vocational high schools in health expertise programs. In this case, the textbooks chosen are those that vocational students utilize the most frequently as a source of teaching materials. The teaching materials are under the direct management of the Directorate of Vocational Development of the Ministry of Education and Culture of the Republic of Indonesia. The textbooks used in this study can be accessed at the following link: https://s.id/Biologi_KesehatanXIsmt1 for the first semester and https://s.id/Biologi_KesehatanXIsmt2 for the second semester.

2.3 Research Instrument

The instrument performed in this study was a non-test instrument in the form of a document analysis sheet. This document analysis sheet is a tool for evaluating the appearance of visual content based on several aspects, namely types, functions, and relevance of STEM content. The document analysis sheet used in this study is as shown in Table 1.

Table 1 was created to map occurrences for each aspect examined with different codes easily. After each visual content is grouped according to each code, it is entered into a document analysis sheet for later recapitulation. The recapitulation results are analyzed using qualitative software data analysis.

2.4 Research Procedure

The research procedures were divided into three stages: preparation, implementation, and final. Details of each research stage are as follows:

The preparation stage includes:

a. Research would be done before choosing the X textbooks as vocational high school biology textbooks. The X textbooks selected are from the 2013 revised 2017 edition for the 11th-grade vocational high schools in health expertise programs.
b. Preparing research instruments in the form of analysis sheets that include the aspects under the study, such as visual content types and visual content function, and STEM content in vocational high school biology textbooks.
c. Prepare the research instruments by requesting the supervisors' approval.

Analysis Stage

a. Every chapter of the X (selected textbooks) textbooks includes visual content analysis. The units analyzed are visual content types and function, and STEM-related

Table 1 Coding framework

Types of Visual Content	Code	The function of Visual Content	Code	STEM Content	Code
Sketch-Comics	SC	Representation	R	Science	S
Clips & Scraps	CS	Decoration	D	Technology	T
Photos	P	Interpretation	I	Engineering	E
Tables	T	Organization	O	Mathematics	M
Graphics	G	Transformation	T	Others	O
Schematic Views	SV	Extention	E		
Concept Maps	CM				

*Modified from: Fotakopoulou, 2008 & Wolff, 2013.

visual content. The visual content types analyzed cover sketches-comics, clips and scraps, photos, tables, graphs, schematic views, and concept maps. Moreover, the analyzed visual content function include representational, decorative, interpretive, organizational, transformational, and extension functions. The STEM-related visual content analyzed includes science, technology, engineering, and mathematics.

b. On the document analysis sheet that contains all aspects of visual content, each visual content of the textbook is then analyzed and grouped with aspects of visual content types, visual content functions, and STEM-related visual content.
c. Describe and count the occurrences of each visual content aspect in each chapter.
d. Recapitulate the frequency of occurrence of each aspect analyzed as a whole.
e. Carry out inter-rater reliability tests to determine the validity of the obtained data.

Final Stage

a. Describe and count the occurrences of each visual content aspect in each textbook section.
b. Analyze the data obtained to obtain research findings.
c. Conclude the research results based on the virtual content analysis and discussion.

2.5 Data Analysis

Data analysis used in this study is a qualitative descriptive analysis technique using the Nvivo 11 qualitative software data analysis for Windows. Data analysis began by examining the grouping results of the visual content, first analyzed to determine categories in each aspect. After analyzing the data obtained from the grouping results, we will summarize the data and calculate the frequency in each chapter. The data recapitulation results function as a basis for analysis using NVivo software to determine the frequency shown in tables and graphs. Then, use this representation to complete the extensive data with a short description. An analysis is carried out for each frequently occurring aspect when examining the visual content type and function. On the other hand, since visual content includes multiple STEM content, it is unknown how many STEM aspects appear in the analyzed STEM content. Therefore, it is not possible to determine the most dominant STEM aspects.

The researchers performed an Inter-Rater Reliability test involving two researchers for data validity. The table of inter-rater reliability below shows the agreement and disagreement of each rater as validation in determining the visual content type representing the entire analyzed samples.

The inter-rater reliability test results are based on the percentage level of agreement and disagreement (Table 2). The higher and lower percentage of agreement and disagreement indicates a high level of validity of the analysis carried out by the principal researcher. Otherwise, the lower deal and the higher disagreement show that the researcher's analysis does not represent the other researchers. However, according to Belur, Tompson, Thornton & Simon (2021), this situation depends on various factors resulting from the samples analyzed; this includes task standardization, rater behavior during the observation process, and agreed and appropriate training on individual coder responses that vary according to personal idiosyncrasies to ambiguous or poor written abstracts. Finally, the ambiguity factors frequently enter into the research samples.

Table 2 Inter-rater reliability of the analyzed samples

Nodes	Agreement (%)	Disagreement (%)
Clips & scraps	91.11	8.89
Concept maps	96.79	3.21
Graphs	96.36	3.64
Photos	95.63	4.37
Schematic views	71.14	28.86
Sketches-comics	86.01	13.99
Tables	96.06	3.94

3. RESULT AND DISCUSSION

3.1 Result

The research "Visual Content Analysis of STEM-Related Content on Indonesian Vocational High School Biology Textbooks" has discovered visual content types, functions, and characteristics through in-depth analysis and seeks validation from other researchers to obtain data validity. Here are the research results:

Varying results were obtained for the three analyzed types, functions, and STEM content aspects. Visual content types, schematics, sketches-comics, and table results are the most commonly seen in this study. Representation and extension were the most seen visual content functions, and other functions were found in almost equal numbers. The STEM content analysis revealed that scientific content dominates compared to technology, engineering, and mathematics content.

Figure 1 shows that the visual content functions of extension and organization are found mainly in the first-semester biology textbooks. On the other hand, the visual content functions of interpretation, representation, and transformation are mainly found in the second semester. Meanwhile, it is no decorative function in this study. The visual content types of clips & scraps, photos, sketches-comics, and tables are commonly found in first-semester biology textbooks. Visible content types in graphs and schematic diagrams are common in second-semester biology textbooks. However, we also found that the visual content type of concept maps was well-balanced in both

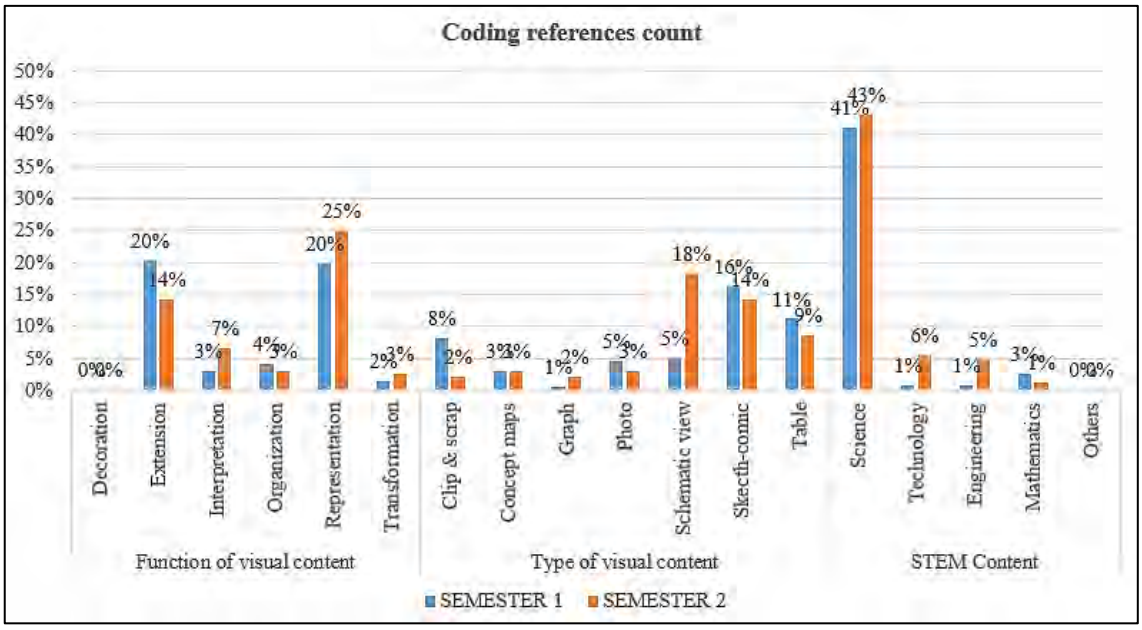


Figure 1 Comparison graphics of the visual content found in the different textbooks

biology textbooks analyzed in this study. Based on the STEM content, the second semester has mainly science, technology, and engineering content, while the first semester has mostly mathematics content. No other content was found in the analyzed biology textbooks.

Visual content types in Indonesian vocational high school biology textbooks

Below are the data obtained from the analysis results presented in table form. A total of 197 visual content spreads over all chapters of a biology textbook. Each image analyzed in this study represents all aspects of the visual content types.

Based on Table 3, the distribution of visual content types in Indonesian biology textbooks is known. The dominant visual content types were sketches & comics at 30.5%, followed by schematic views at 23.4%, tables at 19.8%, clips and scraps at 10.2%, photos at 7.6%, concept maps at 6.1%, and graphs at 2.5%. Examples of each visual content type analyzed in this study can be seen in the Figure 2.

Functions of visual content in biology textbooks at Indonesian vocational high schools

In this study, we analyzed six functions of visual content. The functions of visual content encompass representation, extension, interpretation, organization, transformation, and decoration, as shown in Table 4. From Table 4, the most common visual content function found from the study was representation (44.7%), followed by extension (34.5%), interpretation (9.6%), organization (7.1%), transformation (4.1%), and decoration (0%). The total visual content functions found in the textbook amount to 197 samples. Table 5 shows each example of visual content functions analyzed in this study.

Table 3 Types of visual content count

Analysis		Chapter												Number of Visual content	Visual count (%)
		1	2	3	4	5	6	7	8	9	10	11	12		
Types of Visual Content	Clips & scraps	7	1	0	1	5	2	3	1	0	0	0	0	20	10,2%
	Concept maps	1	1	1	1	1	1	1	1	2	0	1	1	12	6,1%
	Graphics	0	0	0	0	1	0	0	1	1	2	0	0	5	2,5%
	Photos	1	0	0	5	1	2	2	0	2	0	0	2	15	7,6%
	Schematic views	2	2	2	1	2	1	4	5	2	4	10	11	46	23,4%
	Skecth-comics	23	0	0	3	3	3	16	4	5	2	0	1	60	30,5%
	Table	5	4	4	4	3	2	4	3	3	2	1	4	39	19,8%
Total of visual content count														197	100%

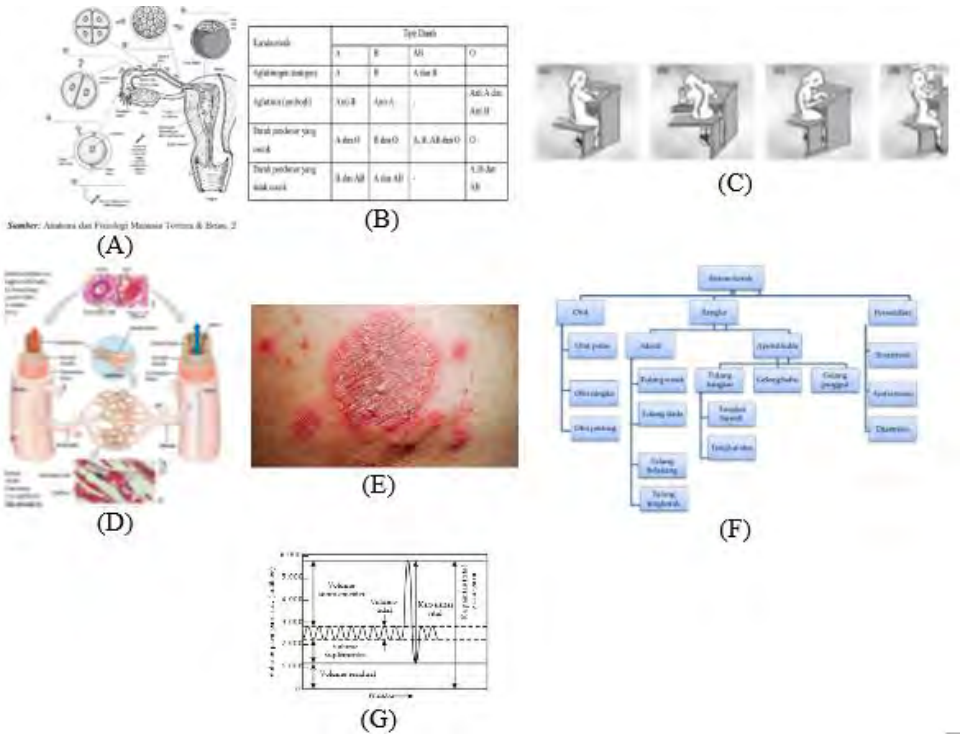


Figure 2 Examples of visual content types. (A) schematic views, (B) tables, (C) sketches-comics, (D) clips & scraps, (E) photos, (F) concept maps, (G)

Table 4 Function of visual content count

Analysis		Chapter												Number of Visual content	Visual count (%)
		1	2	3	4	5	6	7	8	9	10	11	12		
Functions of Visual Content	Decoration	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
	Extension	13	4	4	7	8	4	11	3	2	4	4	4	68	34,5%
	Interpretation	1	0	0	1	3	1	2	0	2	4	1	4	19	9,6%
	Organization	3	1	1	1	1	1	1	1	2	0	1	1	14	7,1%
	Representation	21	3	0	6	4	5	14	8	9	2	6	10	88	44,7%
	Transformation	1	0	2	0	0	0	2	3	0	0	0	0	8	4,1%
Total of visual content count														197	100%

Characteristics of STEM-related visual content found on Indonesian vocational high school biology textbooks

The data from the visual content analysis in Indonesian vocational high school biology textbooks are presented in the table below. The study discovered 234 STEM content because one visual content can contain more than one STEM content.

From Table 6, the characteristics of visual content found in Indonesian vocational high school biology textbooks dominate with science content at 100%, technology at 7.6%, engineering at 6.6%, and mathematics at 4.6%. Other than STEM content, it is not found in this study at 4.6%. The types and functions of STEM-related visual content in the Vocational High School biology textbooks studied had no effect. Table 7 shows some examples of STEM content analyzed in this study.

3.2 Discussion

The research is based on the descriptive analysis of 197 visual content samples. The researchers took the 197 visual content samples from the two first-semester and second-semester biology textbooks for the eleventh grade. Through this research, we can evaluate the visual content of Indonesian vocational high school biology textbooks to meet the needs of students and the demands of the twenty-first educational development. However, according to

Table 5 Example of the function of visual content

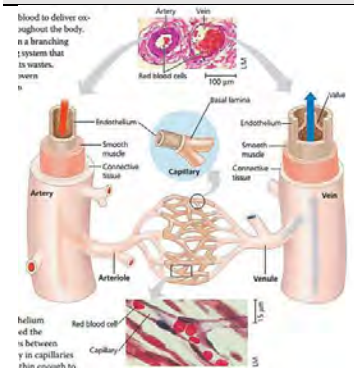
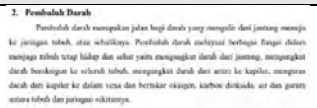
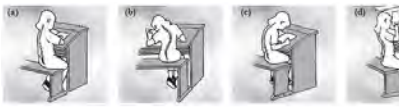
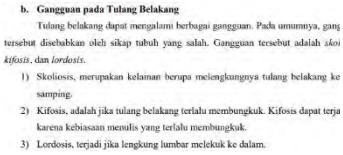
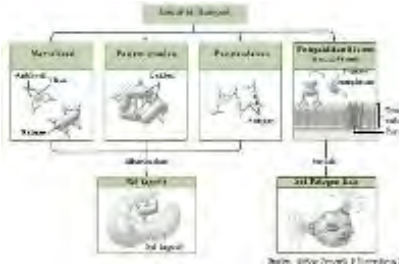
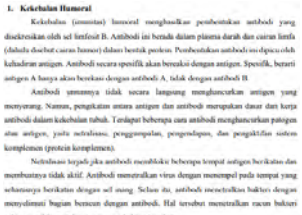
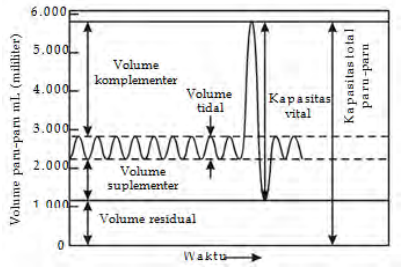
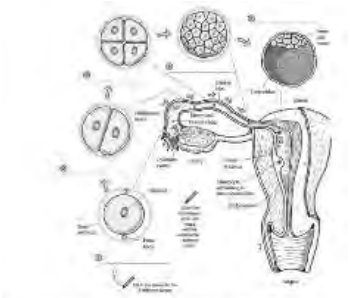
Visual Content	Visual Content Description in The Textbook	Function of Visual Content
		**2. Blood Vessels** Blood vessels are the pathways through which blood flows from the heart to the tissues of the body and vice versa. Blood vessels carry blood from the heart, carry oxygenated blood throughout the body, carry blood from arteries to capillaries, discharge blood from capillaries to veins, exchange oxygen, etc., to keep the body alive and healthy. It performs various functions to keep Carbon dioxide, water, and salt between the body and surrounding tissues.	Extension
		**b. Vertebrae disorders** Vertebrae can experience a variety of disorders. The disoders are generally caused by the wrong posture. These disorders are scoliosis, kyphosis and lordosis. 1) Scoliosis is a sideways curvature of the spine. 2) Kyphosis is an excessive curvature of the spine. Kyphosis can occur due to the habit of writing too bent. 3) Lordosis occurs when the lumbar arch bends inward.	Representation
		1. Humoral Immunity Humoral immunity (immunity) leads to the formation of antibodies secreted by B lymphocytes. These antibodies are present in the form of proteins in plasma and lymph (previously called humoral fluids). The presence of antigens triggers the formation of these antibodies. Antibodies react specifically with antigens. Specific means that antigen A reacts only with antibody A and not with antibody B. Antibodies do not normally destroy invading antigens directly. However, antigen-antibody binding is fundamental to antibody action in immunity. Antibiotics destroy pathogens or antigens in several ways: neutralization, aggregation, deposition, and activation of complement system "complement proteins".	Organization

Table 5 Example of the function of visual content *(Continued)*

Visual Content	Visual Content Description in The Textbook	Function of Visual Content
	Tujuan utama dari proses bernapas adalah memasukkan oksigen segar ke di paru-paru (alveoli) secara terus-menerus. Volume udara yang masuk dan keluar p paru dapat berbeda-beda. Ketika istirahat, volume udara yang masuk dan keluar dari p paru hanya sedikit. Akan tetapi, ketika berolahraga, volume udara yang masuk dan ke dari paru-paru bertambah besar sesuai dengan kebutuhan. Volume udara di dalam p paru dapat dibagi menjadi beberapa macam: a. Volume tidal (500 mL): volume udara yang dihirup dan dikeluarkan pada kea istirahat. b. Volume suplemen (±1.500 mL): volume udara yang masih dapat dikelua setelah ekspirasi biasa (tidal). c. Volume komplemen (±3.000 mL): volume udara yang masih dapat dihirup set inspirasi biasa (tidal). d. Volume residu (±1.200 mL): volume udara yang tersisa setelah melaku ekspirasi maksimal. Volume residu tidak dapat dikeluarkan dengan ekspirasi b Volume residu disebut juga dengan udara cadangan. e. Kapasitas vital (±5.000 mL): jumlah volume total dari volume tidal, vol suplemen, dan volume komplemen. Dengan kata lain, kapasitas vital ad volume maksimal udara yang dapat dihembuskan setelah inspirasi maksimal. Kapasitas total paru-paru: jumlah volume residu ditambah kapasitas vital paru-paru.	The crucial purpose of breathing continuously brings fresh oxygen into the lungs (alveoli). The amount of air entering and leaving the lungs varies. At rest, only a small amount of air moves in and out of the lungs. During exercise, however, the amount of air moving in and out of the lungs increases as needed. The amount of air in the lungs can be divided into several types a. Tidal volume (500 ml): The amount of air inhaled and exhaled at rest. b. Additional volume (± 1500 ml): The amount of air that can be exhaled after a normal (tidal) expiration…	Interpretation
	6. *Dermatitis* adalah suatu peradangan yang terjadi di kulit, yang berulang-ulang d sering kambuh. Contoh dermatitis yang umum adalah eksim.	6. Dermatitis is inflammation of the skin that occurs repeatedly and frequently. A common example of dermatitis is eczema.	Representation
 *Sumber:* Anatomi dan Fisiologi Manusia Tortora & Brian, 2011	Zigot yang dihasilkan dari proses fertilisasi bersifat diploid dan memiliki kromos sebanyak 23 pasang, dan 46 pasang kromosom yang berasal dari perpaduan kedua or tuanya. Kromosom-kromosom tersebut terdiri dari 44 kromosom tubuh dan 2 kromos reproduksi. Di dalam 46 kromosom ini terdapat semua rumus untuk membentuk seor manusia. Selanjutnya, zigot tersebut akan mengalami pembelahan secara mitosis den pembelahan ganda dari yang semula satu sel menjadi dua, lalu menjadi empat, delapan seterusnya. Pembelahan itu berlangsung di sepanjang saluran tuba fallopi, sambil berja menuju uterus. Di sepanjang tuba fallopi terdapat rambut-rambut getar yang selalu berge melambai ke arah uterus yang berfungsi untuk memudahkan pergerakan zigot men uterus.	The zygote resulting from the fertilization process is diploid and has 23 pairs of chromosomes and 46 pairs resulting from the fusion of the parents. These chromosomes consist of 44 somatic chromosomes and 2 reproductive chromosomes. Within these 46 chromosomes are all the formulas for forming a human being. In addition, the fertilized egg undergoes mitosis by double fission, from the original her one cell to two, then into four, eight, and so on. Division occurs along the fallopian tubes to the uterus. Along the fallopian tubes are vibrating hairs that constantly undulate toward the uterus, facilitating the movement of the zygotes toward the uterus.	Transformation

Anagnostopoulos, Parganas, Chadwick & Fenton (2018), visual content can convey the author's message to the readers. The visual content of the textbook helps shape the perception. Therefore, it is necessary to ensure that the visual content is relevant to the supplementary ones so that the audience can clearly understand the textbook content.

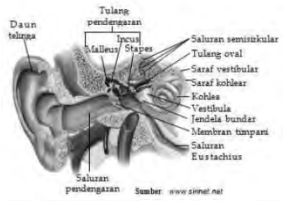
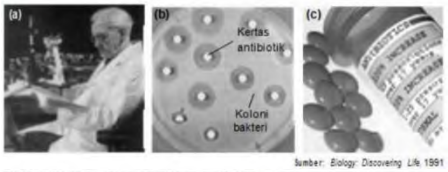
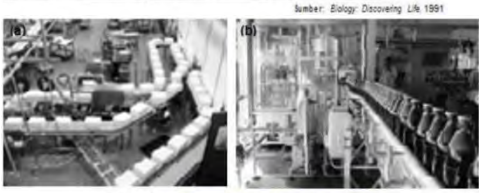
Types of visual content on biology textbooks at the vocational high school in Indonesia

Three common types of visual content are sketches and comics, schematic views, and tables. Based on the studies of Yu, Yu, Xiang, Fan & Tao (2018), the appearance of good visual content can help simultaneous understanding between textual content and visual content. The sketch and comic type is one type of visual content that can be difficult to access but can be a well-visualized image for readers.

Table 6 STEM content count in biology textbooks

Analysis		Chapter												Number of Visual content	Visual count (%)
		1	2	3	4	5	6	7	8	9	10	11	12		
STEM Content	Science	39	8	7	15	16	11	30	15	15	10	12	19	197	100%
	Technology	0	0	0	0	1	1	0	0	0	0	0	13	15	7,6%
	Engineering	0	0	0	0	1	1	0	0	0	0	0	11	13	6,6%
	Mathematics	4	0	0	0	2	0	0	2	0	1	0	0	9	4,6%
	Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Total of visual content count														234	

Table 7 Examples of STEM content

Visual Content	Description
	Contains **science content** about parts of human ear
	Contains **science and technology** content regarding the manufacture of biotechnology products in the health sector
 ***Sumber :*** www.rondAmerica.com	Contains **science, technology, and engineering** content on industrial-scale production of biotechnology products in cheese and beer factories
	Contains **science, technology, engineering and mathematics** content on how bronchoscopes work

Most illustrations and comics are described in the text, and readers can easily visualize the phenomena mentioned in the biology textbooks. The visual content type of sketches and comics is dominant because visualization is easy to clarify. This study frequently shows schematic views because various biological processes occur in living organisms. It is difficult to understand through textual descriptions alone and requires proper visualization. The type of schematic views is a factor that can influence the formation of human perception. The visual type cannot be described in text alone, so readers need a visualization aid to show process change (Zhang et al., 2018). At the same time, tables are one of the visual types that present challenges to creating appropriate representations for readers to understand the text and how to create tables according to natural conditions. Therefore, it is easy to understand and usually uses informative words from tables that enter high and low frequency, such as entity names and numbers that make up sentences (Bao et al., 2018).

The visual content types include clips, scraps, photos, concept maps, and graphs. The researchers did not often find the visual content types in this study. The visual content type of clips & scraps displays pictures of parts that comprise the material concepts. Therefore, clips and scraps become integral to any biology textbook so readers can understand comprehensively. (Inaltekin & Goksu, 2020), Asserts that relevant and comprehensive visual content can help students develop higher-order thinking abilities. So far, students use visual content to solve complex scientific problems to understand knowledge deeply. At the same time, visual content in a kind of photos has a greater impact on readers' memory but is not often found in textbooks because it is difficult to describe the text in detail (Zhang et al., 2018). However, Fan et al. (2018) state that the visual

content type of photos can influence the real-life vision of the phenomena described in the material of each chapter.

Since concept maps help readers understand the material by directing their thinking according to the order or hierarchy of the material described in a chapter, authors frequently put concept maps at the beginning. In contrast to visuals in the object category, (Fu, Xiang & Jiang, 2018), claim that visual concept maps can have a much more complex relationship. Attributes and adjectives are essential to visual concepts when used outside objects or nouns. When combined with the same attributes, attributes and adjectives frequently have different meanings. Authors guide readers to understand each process based on various paths with the concept map.

On the other hand, graphs are a visual type that shapes a display and provides specific data in connected lines. Romanov, Ivanov & Succi (2020) assert that for a graph to be beneficial, it must meet some requirements, such as the presence of hierarchy, clarity, multiple usages, and connectivity. The graph should have a hierarchy to represent the function and model how the features are present. It is expected that the graph's clarity will enable viewers to determine the graph's intended purpose. It has multiple purposes, where the function should ideally be used from various codes. Otherwise, it becomes challenging for the statistical model to comprehend the function's goal. Aspects of connectivity show that the graph can be associated with various features. Graphs are still uncommon in biology textbooks since students need a thorough comprehension to understand the meaning of each part of the graph.

Through this research, teaching materials should be more effective and developed to meet the needs of students in Indonesia. In addition, this study can be used as a reference for book publishers to evaluate biology textbooks before publication. Visual content types that meet the needs of students help improve their comprehension and thinking skills. Different students may have different purposes for the visual content presented in textbooks. These differences can take the form of natural conditions, learning opportunities, levels of technology, and others. However, textbooks are still the dominant teaching materials widely used in education.

Functions of visual content in Indonesian vocational high school biology textbooks

Most visual content functions in this study are expression and extension. Representation is the most dominant feature found in visual content functions. The visual content with representation features present for those considered complex and require a presentation for the reader to achieve the intended learning goal. Goes, Chen, Nogueira, Fernandez & Eilks, (2019), state that the visual content functions of representation can help students reduce difficulties in interpreting different types of visual content and help them better understand the meaning of texts in the textbooks presenting concepts. Therefore, you should make sure that your visual content selection is perfect. Coherence between text and visuals is crucial because the presence of even modest visual content does not ensure that it will aid in understanding the textbook content. Extensions are the second most common visual content feature after representation features. The extension feature adds visual content to reading text that helps the reader comprehend the meaning of the textbook's material (Teterwak et al., 2019). Based on the research results, the extension feature can be present in all chapters of biology textbooks. Almost every chapter needs this feature to enrich the knowledge of the readers or students using biology textbooks.

Some functions of visual content found in this study include interpretation, organization, transformation, and decoration. The interpretation function is a function that has close relations with the illustrated content and can explain and help readers better understand concepts and ideas in the text. Chen, de Goes, Treagust & Eilks (2019a). In this study, the interpretation function, like the representation function, is not found in several chapters because chapters with material that is not too tricky or easy to understand do not always require it. Because the organization function only directs the readers' thoughts before entering the text, it is usually only found at the beginning of a chapter. Like the organization function, the transformation function is only shown in a few chapters. Elmiana (2019) asserts that decorative function develops textbooks' aesthetic value and attracts readers to read them despite not affecting their understanding. At the same time, the transformation function is visual content that can show movements or changes based on time and place, so textbook readers will understand the sequence of a phenomenon that changes over time with the transformation function. It is not strictly needed because the transformation function can be replaced with a detailed description of the text.

Finally, this study could be a reference for textbook authors who want to tailor the function of visual content in biology textbooks in Indonesia to the needs of students. Depending on the difficulty level, the visual content function in each chapter may vary. Appropriate visual content functions can assist students in comprehending even the most complex material. Finally, the proper visual content function can help students answer high-level questions frequently encountered in the learning process.

Characteristics of STEM-related visual content found in Indonesian vocational high school biology textbooks

Visual content found in this study has 100% science, 7.6% technology content, 6.6% engineering content, and 4.6% mathematics content (Table 4.4). According to the research, a single visual content can have multiple STEM content (Wahono, Hariyadi & Subiantoro, 2022). In

biology textbooks, science content has the highest share of all visual forms and functions. Only a few chapters contain technology content, including those on the respiratory system in humans, the excretory system in humans, the metabolism of living things, and biotechnology and its applications. Engineering content appears in the same chapter as engineering content. Simultaneously, the mathematical material is present in the chapters on the human movement system, respiration system, reproductive system, enzymes, and hormones. It demonstrates that technology and engineering content are inextricably linked. Because all STEM knowledge can be represented in multiple forms based on their respective functions, the characteristics of visual content in Indonesian vocational high school biology textbooks are not fixed on visual content types and functions. Only the STEM content has more than one STEM aspect and technology and engineering content are frequently connected. Furthermore, STEM content in textbooks is merely visual content comprising anything difficult or uncommon in everyday life to broaden students' knowledge.

Integrating STEM-related visual content in student textbooks refers to combining different types of content, subject matter, and knowledge disciplines for STEM learning. Because there is a subject-based curriculum, arranging subject knowledge in the learning process may be easier than integrating it cohesively. Integration in STEM subjects has become relevant and required for the early and continual stage of development (Cheng & So, 2020). STEM in teaching and learning entails learning material and pedagogy to develop the qualities and efficacy of the learning process. It may comprise a variety of pedagogical strategies or activities for STEM learning that can result in various experiences and student learning outcomes, such as visual content in textbooks (Chen, de Goes, Treagust & Eilks, 2019b). Furthermore, textbooks can be a bridge and an important area in education that helps students define the subject since textbooks provide both text and visual content to help students understand the material notion (Cheng & So, 2020). As a result, the characteristics of biology textbooks in Indonesian vocational high schools must be learned so that textbook authors can tailor the needs of students to the demands of future learning objectives.

The STEM-related characteristics identified in this study can reexamine Indonesian biology textbooks, specifically biology textbooks in vocational high schools. It is so because students in high school vocational programs must be able to apply their classroom learning to real-world situations. STEM is a strategy that can help students at vocational high schools meet the requirements for high school graduates in competency standards. Frequently used teaching tools, such as textbooks, are one method that can meet graduate competency standards

4. CONCLUSION

Based on the finding and discussions, sketches & comics are the types of visual content found in this study. Meanwhile, photo is the fewest one found in textbooks. In addition, the characteristics of visual content observed in vocational biology textbooks in Indonesia start from the most, particularly science content as great as 100%, technology at 7.6%, engineering at 6.6%, and mathematics at 4.6%. Besides, no other STEM content was found. In addition, the STEM-related visual content in vocational high school textbooks studied no longer depends on the types and functions of visual content. However, STEM content can include more than one aspect of STEM and are frequently interrelated.

Recommendations based on this research are for the researchers to conduct additional research to fully benefit from analyzing the visual content of Indonesian vocational high school biology textbooks. It can take the form of research on the relationship between types, functions, and STEM content on learning outcomes or critical thinking skills, so the benefits of this research are shown clearly. This study suggested that biology textbook writers should present appropriate visual content to improve students' understanding and learning outcomes by linking STEM visual content to adapt student innovation in the twenty-first century. Finally, vocational biology teachers can benefit from this research to select vocational biology textbooks that meet the needs of their students and graduate competency achievement targets.

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