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Research Article

Content analysis of cell division concepts in Senior High School Biology textbooks

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ABSTRACT

Content and accuracy evaluation of textbooks is important as it provides quality assurance to both teachers and learners, especially in the new normal where modular instruction is used. This research aimed at evaluating the biology textbooks used by Senior High School STEM Science teachers (n=15) in content, presentation, and learning strategies. Content analysis and Collaizzi's descriptive phenomenology approach were employed in this study. The results showed that all evaluated textbooks have unique, distinct content, presentation, and learning strategies. Most topics were also aligned with the minimum curriculum requirement for SHS STEM, but topics such as cyclin-dependent kinases (CDKs) and control checkpoints were not discussed in some books. Learning outcomes were not indicated in some books, and few textbooks did not reach synthesis and evaluation level. However, a comparative approach of cell division across the 5-kingdom system is observed but not explained well, and some misleading statements in the cell division mechanism were present. Considering that cell division precedes the discussion of cancer cell division and metastasis, content enrichment through learner-friendly visuals and diagrams is recommended to facilitate learning, improve retention, and avoid misconceptions.

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INTRODUCTION

Cell division is one of the most challenging lessons to teach and understand in Biology. Prior to this research, we found disturbing feedback from Senior High School (SHS) teachers referring to several misconceptions about cell division materials. Based on authors' experiences in teaching the topic, it is noted that there was poor understanding of the mechanism of cell division particularly the implementation on germ

cell formation. Students mostly rely on memorization of stages and their respective distinguishing attributes but failed to provide a comprehensive synthesis of the process when asked to differentiate how cell division occurs between prokaryote and eukaryote, and how fungi and protozoans divide compared to animal and plant cells. Moreover, published literature also noted confusion on the following topics: tracing chromosome and chromatid number, the difference between dividing versus non-dividing chromosomes, what governs anaphase in the absence of centrioles in plant cells, an independent assortment of genes, how to count the centromere, and how gametes are formed, to name a few (Chattopadhyay, 2012). Mitosis, meiosis, and mutations have the highest misconception and alternative conception among the students in Genetics (Kumandas et al., 2018). This problem is evidence in the Philippines, as noted by the study of Rogayan and Albino (2019), which stated that Filipino students' misconception level in Biology subject especially in genetics which includes cell division is high.

Functional Literacy, Education and Mass Media Survey (FLEMMS, 2019) noted that the functional literacy rate for 10 to 64 years old in the Philippines is increasing with 91.6%, 85.8% in MIMAROPA Region (Philippine Statistics Authority, 2019), and 95.7% in Palawan (Philippine Statistics Authority, 2016). The Filipinos age group population of 15 to 19 years old had the highest basic literacy rate at 98.6%, while the 5 to 9 age group had the lowest at 73.2% in the country (FLEMMS, 2020). On the contrary, the Philippine's quality of Math and Science education ranked 76th out of 137 countries (World Economic Forum, 2018). Meanwhile, the OECD (2018) showed that the Philippines ranked second to the last among all other participating countries, with 357 scores (below average) in science. Teachers and curriculum experts believe that the poor quality of science textbooks contributes to this problem (Irez, 2009).

Textbooks are essential for the educational enterprise (Okabe, 2013) because of the following reasons: (a) it is the most available teaching tool that provides essential information to students (Kashi et al., 2015); (b) convey knowledge to the learners (Tok, 2012); and (c) plays a crucial role in the teaching and learning process in many classrooms (Gok, 2012). Good quality textbooks also help to facilitate science teachers' development (Swanepoel, 2010). Although current online-based education technology has massively modified the learning platform of our students, textbooks are still widely favored because of their availability and ease of use. They are the most common instructional materials for students and teachers at all grade levels (Gok, 2012). In the Philippines, Rogayan and Albino (2019) revealed that some science reference learning materials contain misconceptions and errors that indirectly threaten science education quality. Many teachers have also reported that the books' content is obsolete and flooded with errors (Ambag, 2018). Considering that books' content quality and accuracy are crucial for educational effectiveness (Gok, 2012; Khine, 2013), evaluating science textbooks in terms of alignment of the book content with the curriculum, accuracy, and authenticity of the content is of paramount importance to ensure quality of science education. Similarly, attributes such as organization of instructional materials, readability, motivational strategies, explicit instruction, target assessment, and instructional strategies are also deemed essential (Gok, 2012), especially in the *new normal* where modular instruction is employed. However, the researches which are focused on content analysis still very limited. Hence, the current research conducted a content analysis of SHS Biology textbooks particularly in cell material.

This research provided the need for studies on science education literacy using reference materials in teaching cell division by employing content analysis of textbooks in terms of content, presentations, and learning strategies. It also explored teachers' experiences and insights using the textbooks used by SHS teachers in the province of Palawan. This study primarily intends to help improve the content understanding of science teachers and serve as a guide in crafting learning modules that can be used in different learning modalities, such as modular instruction.

METHOD

The study employed a mixed-method research design utilizing content analysis and Collaizzi's descriptive phenomenology approach. This is composed of two parts: the content analysis of the identified Biology textbooks using the criteria recommended by the Florida University Department of Education (2008) [see Table 1] and the teachers' insights using the identified textbooks to triangulate the study results (Swanepoel, 2010). Four (4) main Biology textbooks (coded as B1, B2, B3, and B4) published in the Philippines and authored by Filipino writers were identified in this study. These books were commonly used as main references in teaching General Biology 1 in Grade 12 SHS Level.

Teachers in SHS who teach Biology 1 in Science, Technology, Engineering, and Mathematics (STEM) strand in Palawan were the informants of this study, and a purposive sampling procedure using a semi-structured survey instrument was used. During the interview process, a Google form questionnaire was sent thru the e-mail of the informants, and a follow-up interview via cellular phone calls was employed to clarify and explain further the answers given in the survey. The study used descriptive statistics (i.e., mean and simple percentage) to analyze the quantitative data from the content analysis and employed thematic analysis to interpret the qualitative data based on the teacher participants' responses.

Table 1. Textbook evaluation criteria used in the study

Criteria*	Subcategories	Units of Measure
Content	Alignment with the curriculum requirements	The competencies found in the identified books are aligned with the required competencies set by the Department of Education (DepEd).
	Level of treatment of content	The method used is the inductive or deductive method. The terms used are appropriate for the learners, and the time allocation is adequate.
	Accuracy of the content	The book is objective and factual, free of misleading statements and mistakes, biases of interpretation, and inconsistencies.
	Authenticity of the content	The use of real-life connections and diversity of interdisciplinary connections.
Presentation	Number of pages for each topic	Comparison of the number pages for each topic.
	Organization of the textbooks	The topics are organized according to: a) introduction for each topic; b) labelled reviews or summaries; c) index; d) glossary; and e) bibliography.
	Comparison of typography	Comparison of the typographical presentation and visual features of the books.
	Numbers and types of visuals used	Comparison of the number and types of visuals used.
Learning strategies	Motivational strategy	The book contains thought-provoking problems, various hands-on activities in a concrete context relevant to learners' lives, and various assessment forms.
	Explicit instruction	The introduction of the topics is presented well. Textbooks' activities and experiments have clear instructions on how to perform the activities and experiments.
	Guidance and support	Comparison of the analogies found in the textbooks, status of the terms used, the number of activities and experiments found in the textbooks.
	Targeted instructional and assessment strategies	Comparison of the number of questions, the types of question used, and the cognitive levels of questions used in the textbooks.

*Adopted from Florida Department of Education (2008)

RESULTS AND DISCUSSION

A textbook is a major source of information in teaching and translates the curriculum's intent into classroom practice by reflecting the science learning goals (Altbach & Kelly, 1998). The content's quality and accuracy are crucial for their educational effectiveness (Khine, 2013). Quality textbooks significantly impact the quality of instruction (Lemmer et al., 2008), and the availability of high-quality textbooks is one of the critical factors in the successful implementation of curricular reform (Khine, 2015; Liang & Cobern, 2013; Swanpoel, 2010). The following findings were presented in three (3) major clusters [content, presentation, and learning strategies] and their corresponding subcategories.

Content

Table 2 shows the alignment of the content of the textbooks in the curriculum requirements. All books contain facts and data based on the curriculum requirements.Based on the analysis conducted, all books have learning outcomes at the beginning of each chapter. Learners' learning outcomes must contain cognitive, affective, and psychomotor characteristics expected to be mastered at the successful culmination of an entire educational program (ISCED, 2012). Learning outcomes aligned in the national curriculum indicate that the textbook is good in quality (Education Bureau the Government of the Hong Kong Administrative Region, 2016), and it also gives background information to the learners on the goals in every chapter.

Table 2. Alignment with curriculum requirements

Learning Competency	B1	B2	B3	B4
Characterize the phases of the cell cycle and their control points (STEM_BIO11/12-Id-f-6)	√	√	√	√
Describe the stages of mitosis/meiosis given 2n=6 (STEM_BIO11/12 Id-f-7)	√	√	√	√
Discuss crossing over and recombination in meiosis (STEM_BIO 11/12 Id-f-8)	√	√	√	√
Explain the significance or applications of mitosis/meiosis (STEM_BIO 11/12 Id-f-9)	√	√	√	√
Identify disorders and diseases that result from the malfunction of the cell during the cell cycle (STEM_BIO 11/12 Id-f-10)	√	√	√	√

Table 3 shows the content of the textbooks in line with learning competencies. Cell cycle phases were discussed in all books. Also, the control checkpoints were mentioned in B1 and B3 but not explained well. In B2, control checkpoints were not mentioned and explained, while B4 control checkpoints were mentioned and explained well. In addition, B1, B2, and B3 mentioned the signaling system and actions of Cyclin-dependent kinase (CDKs) but were not explained well. Lastly, in B4, signaling systems and CDKs were discussed and explained. This implies that B4 met the intended learning competency based on the curriculum guide, and all topics in the books presented have corresponding examples and illustrations.

Table 3. Content of the textbooks in line with learning competencies

Learning competency	B1	B2	B3	B4
Characterize the phases of the cell cycle and their control checkpoints (STEM_BIO11/12-Id-f-6)	Phases of the cell cycle were discussed, while control checkpoints and CDKs were mentioned but not explained well.	Phases of the cell cycle were discussed, control checkpoints were not mentioned and explained, while CDKs were mentioned but not explained.	Phases of the cell cycle were discussed, while control checkpoints and CDKs were mentioned but not explained well.	Phases of the cell cycle were discussed. Control checkpoints were mentioned and explained well. CDKs were mentioned and discussed.
Describe the stages of mitosis/meiosis given 2n=6 (STEM_BIO11/12 Id-f-7)	Stages of mitosis and meiosis were explained with corresponding illustrations. Plants also undergo cell division.	Stages of mitosis and meiosis were mentioned but not explained well.	Stages of mitosis and meiosis were explained with corresponding illustrations. Plants also undergo cell division.	Stages of mitosis and meiosis were explained with corresponding illustrations. Plants also undergo cell division.
Discuss crossing-over and recombination in meiosis (STEM_BIO 11/12 Id-f-8)	Mentioned and discussed with corresponding examples and diagrams.	Mentioned but not explained.	Mentioned but not explained.	Mentioned and discussed with corresponding examples and diagrams.
Explain the significance or applications of mitosis/meiosis (STEM_BIO 11/12 Id-f-9)	Significance and applications of mitosis/meiosis were discussed	Significance and applications of mitosis/meiosis were discussed	Significance and applications of mitosis/meiosis were discussed	Significance and applications of mitosis/meiosis were discussed
Identify diseases and disorders that result from the malfunction of the cell cycle (STEM_BIO 11/12 Id-f-10)	Discussed and explained with corresponding illustrations. Mentioned cancer but not explained.	Discussed and explained with corresponding illustrations.	Discussed and explained with corresponding illustrations.	Discussed and explained with corresponding illustrations. Cancer was introduced.

Stages of mitosis and meiosis were discussed and explained in three books (B1, B3, and B4), such as mitosis in body cells and meiosis in sex cells with corresponding illustrations. It was indicated that mitosis produces two daughter cells, and meiosis produces four daughter cells. Only B4 mentioned that mitosis produces two diploid daughter cells, and meiosis produces four haploid daughter cells. B1, B3, and B4 also discussed mitosis and meiosis in plants but not in other kingdoms that undergo the same process. All books mentioned that crossing-over and recombination, but B1 and B4 discussed the process with corresponding diagrams. This means that B1 and B4 satisfied the learning competency for this topic. Thus, all books met the learning competency assigned in terms of the significance and applications of mitosis and meiosis.

Finally, diseases and disorders resulting from malfunctioning the cell cycle were discussed in all books with corresponding illustrations. However, the concept of cancer was only mentioned in B1 and B4. In addition, B4 further introduced the concept of cancer. This revealed that all books met the learning competency. Therefore, B1 and B4 are books that add supplementary information than what is prescribed by the learning competency.

The study affirms Bansiong and Wan's (2019) findings that texts in science textbooks used for grade three (3) Filipino learners are aligned with national science standards. Similar results of Nugroho et al.'s (2017) study showed that two books, integrated Science and Science textbooks used in grade seven, are aligned with core competencies and standards based on the 2013 curriculum's basic competence and book standard. A well-aligned textbook is essential for curriculum reform (Lu & Liu, 2012) and implementation (Bhatti et al., 2015; Fan, 2010). If the textbooks were associated with the curriculum, the classroom instruction is more likely to be aligned to the curriculum (Khine, 2015; Park et al., 2005; Shah, 2012), and the students can perform well (Fan, 2010) because they are guided and to ensure that all learners will learn the same lessons as part of the national standard for science education despite their different locations in the country.

Level of treatment of the content

In terms of content's treatment level (Table 4), all books used the inductive method. B1 and B3 discussions are brief but concise, while only B4 discusses the topics comprehensively. Terms used in the book are also appropriate to the level of learners. The inductive/discovery method was presented in the books, which allows the learners to practice the science skills. This method will enhance the learners' critical thinking as they understand how things work around them.

Table 4. Level of treatment in the study

Level of Treatment of the Content	B1	B2	B3	B4
Use inductive method	√	√	√	√
Appropriateness of terms used for learners	√	√	√	√
Adequacy of time allocation	X	X	X	X

Considering the students' development, understanding, and experience with science concepts at previous schooling levels are the most important criteria for a good Science textbook (Khine, 2013). These findings show that authors and publishers adhere to presenting the lesson. The inductive method, sometimes referred to as the discovery method, allows the learners to practice the science skills that a learner must possess now that we are in the digital era. This method will enhance the learners' critical thinking as they understand how things work around them. Since adequacy of time is one of the criteria in evaluating science books, it is better if authors and publishers indicate time allocation for each topic in consonance to the budget of work to give an idea to the learners on how long the topic is going be discussed.

Accuracy of the content

The accuracy of content was analyzed based on the following criteria: factual and objective in text and visuals, inconsistencies and biases of opinion, and misleading statements. Table 5 shows the accuracy of the content in the textbooks. All books discussed the topics in cell division, which are aligned with the learning competencies based on the taught curriculum. The books analyzed are based on facts and show objectivity in text and visuals, following the guidelines on textbooks publishing set by the DepEd. The content is consistent with important terms and reflects the learning competencies of the K to 12 Program stated in the curriculum guide. No bias and inconsistencies have been observed in the four books analyzed since textbooks are one of the primary sources of lessons in the classroom, accuracy of the content adhere to curriculum standards as stated in the curriculum guide (Macasawang et al., 2019).

The National Book Development Board (NBDB, 1994) is mandated to scrutinize the content of the textbooks published in the Philippines goes through a textbook review service to ensure the accuracy of the textbooks' content (Office of the President of the Philippines, 1999). Based on the analysis of the four books, three out of four books were found to be accurate in terms of content.

Table 5. Accuracy of the content

Accuracy of Content	B1	B2	B3	B4
Factual and objective in text and visuals	√	√	√	√
Consistent and no bias	√	√	√	√
Misleading statements	X	√	√	√

However, there were misleading statements found in B1 (Table 6). Campbell Biology (twelve edition) serves as reference material to correct the inaccurate terms and statements found in B1.

Table 6. Misleading statements from B1

Misleading Statements	The Authors should use the correct terms and statements
Page 39, lines 4-5: ***"Meiosis** is what produces the gametes, sperm, and eggs that fuse after two organisms have sex."*	Meiosis reduces the number of chromosomes sets from diploid to haploid.
Page 40, line 25: *"The normal 46 chromosomes will result in the fetus."*	The normal 46 chromosomes will result in a human organism.

Misleading and inadequate descriptions of science may lead to serious implications for promoting science literacy and negatively affect students' ideas (Irez, 2016). Oakes and Saunders (2002) agreed that poor quality textbooks constitute a significant factor in students' low achievement in external examinations. Some reviewed textbooks in Biology have insufficient content (Nomoto et al., 2011), while other books have some information that is not always accurate and out-of-date health information (Clifford, 2002; Nomoto et al., 2011). Furthermore, the misleading statements found in the book could lead to misconceptions of the content to the readers (Novitasari et al., 2019). With this, the books should be reviewed and evaluated carefully to check for misleading statements to avoid students' misconceptions.

Authenticity of the content

Table 7 shows the authenticity of the textbook content. The authenticity of the textbook content was presented in all books and evaluated based on two criteria: real-life connections and diversity of interdisciplinary connections.

Table 7. Authenticity of the content of the books

Authenticity of the Content	B1	B2	B3	B4
Real-life connections	√	√	√	√
Interdisciplinary Connections	√	√	√	√

Real-life connections

All books have their respective real-life connections (Table 8). Real-life connections communicate theoretical concepts into students' everyday lives (Gamble & Gamble, 2013).

Table 8. Real-life connection statements

Books	Page	Real-life connection statements
B1	page 34; lines 16-18	Why and how your hair and nails are growing? What makes your wound heal? How does it happen? How do the cells in your body multiply?
B2	page 49; lines13-17	You are applying for admission and a scholarship for a doctoral degree in Health sciences. As part of the application process, you have to submit a project proposal on a specific type of cancer and risk factors associated with it, focusing on your future project proposal to your prospective supervisors and the scholarship review panel.
B3	page 128; lines 15-17	Important applications of mitosis and meiosis may be found in plant research. Bigger and better varieties of plants are produced modifying chromosomes like growing bamboo using tissue culture.
B4	page 76; lines 1-9	Cell division is associated with growth and development; even humans are products of numerous cellular divisions, as life begins only with one single cell from the fusion of the parents' sex cells. In about nine months, that cell becomes trillions of cells due to the numerous cell divisions during embryonic development. The image in figure 3-2 shows a picture of an onion root tip. It shows an area in the onion plant that rapidly produces new cells, making the onion elongate and grow in size.

Studies of Atilla (2012) and Bernardo (2013) found that students' understanding of essential learning concepts could be improved, making the learning experience meaningful by providing real-life situations in their daily lives. Another feature of real-life connections is by featuring well-known scientists with works related to genetics. B2 and B4 have separate sections to showcase real-life examples by featuring science experts. In addition, B4 featured both foreign and Filipino scientists. This will expose and motivate the students to pursue science-related courses someday as they aspire to become experts mentioned in the book.

In textbook development, it must be carefully planned and reviewed by experts to avoid textbook fatigue. This could be avoided if examples or situations are related to students' everyday lives (Lent, 2012). Lubis and Sahyar (2021) stated that the development of textbooks must be contextualized, integrating culture and students' daily experiences to be meaningful using appropriate examples based on their cognitive level.

Interdisciplinary connections

Interdisciplinary connections allow the discussions in cell division to be related to other disciplines. For example, a combination of science and mathematical skills was employed to discuss cell cycle phases, mitosis and meiosis, and binary fission. The relationship between the phases and the context of the time was applied in the lesson. The concept of cancer and its treatment relates to medicine, while mitosis in plants was significantly related to agriculture. Also, B2, B3, and B4 have additional web links that lead to further research related to different fields of science at the end of the chapters. It could reinforce and supplement teachers' discussion to save instructional time. Dikenli (2009) mentioned that the teachers need to see how the lessons connect to student's everyday lives and other fields. Mitchell and Miller (1995) found that interdisciplinary connections through lesson integration could improve both mathematical and science achievements. Duerr (2008) stated that students could become more involved in their learning, and teachers can eliminate discipline lines in class using interdisciplinary instruction. As a result, students will become independent and confident and develop lifelong learning skills.

Presentations

Number of pages for each topic

Table 9 shows the number of pages allotted per topic. B4 has a greater number of pages, while B1 has a lower number of pages allotted in cell division. This table also shows that the meiosis topic has the greatest number of pages among all the textbooks. Books limit the number of pages to achieve space economy. The fewer pages, the cheaper the book would be. Therefore, the number of pages in a book will affect the book pricing (Barnes et al., 2005; Clerides, 2002). This economy of space may give insufficient learning from the end of the students. With this, it is recommended that the books have enough pages for discussion to provide students with sufficient information about the science concepts (Driscoll et al., 1994).

Table 9. Number of pages for each topic

Topics	B1	B2	B3	B4
Cell Cycle	6	6	4	18
Mitosis	4	8	8	12
Meiosis	5	9	12	33

Organization of the textbooks

Cell division topics were organized in all books according to a) introduction for each topic; b) labelled reviews or summaries; c) index; d) glossary; and e) bibliography (Table 10). Cell division topics were introduced in all books. However, only B3 and B4 have labelled reviews or summaries after each topic. Based on the data, parts of a book like an index, glossary, and bibliography were not found in the cell division chapter in all the books studied. These four books put the index, glossary, and bibliography at the last part of the book. Publishers of these books usually do this to economize the space. Barrus (2018) noted that index, glossary, and bibliography after each topic are important since it helps students recall information from the lessons discussed in a chapter or unit through the chapter summary. Yager (1983) believed that the glossary part in a science textbook where scientific terms or words are defined or described enriches students' learning. Hence, the inclusion of these parts is suggested to support students' learning and understanding of science topics.

Table 10. Organization of the textbooks

Parts of the Book	B1	B2	B3	B4
Introduction for each topic	√	√	√	√
Labeled reviews or summaries	X	X	√	√
Index	X	X	X	X
Glossary	X	X	X	X
Bibliography	X	X	X	X

Comparison of the Typography of the Textbooks

Table 11 shows the comparison of the typography of the four textbooks. All textbooks have strong bookbinding and cover, use A4-size, off-white, uncoated matte paper, and a single-column portrait type layout. B1 uses Calibri with 11 font size, B2 and B3 use Arial with 11 font size, and B4 uses Times New Roman with 11 font size. Font styles like Calibri and Arial were considered *sans-serif* font, and the Times New Roman is a *serif* font.

Table 11. Comparison of typography of the textbooks

B1	B2	B3	B4
Book bind and cover are strong	Book bind and cover are strong	Book bind and cover are strong	Book bind and cover are strong
Printed in off-white, uncoated matte paper	Printed in off-white, uncoated matte paper	Printed in off-white, uncoated matte paper	Printed in off-white, uncoated matte paper
A4 page size	A4 page size	A4 page size	A4 page size
Single-column layout, portrait type	Single-column layout, portrait type	Single-column layout, portrait type	Single-column layout, portrait type
Calibri font with 11 font size	Arial with font 11 font size	Arial font with 11 font size	Times New Roman font with 11 font size
The illustrations are not colored drawings.	The illustrations are not colored drawings.	The illustrations are not colored drawings.	The illustrations are colored drawings.
All are in monochromatic grayscale.	All are in monochromatic grayscale.	All are in monochromatic grayscale.	-
The illustrations are placed close to the text, referring to it.	The illustrations are placed close to the text, referring to it.	The illustrations are placed close to the text, referring to it.	The illustrations are placed close to the text, referring to it.

The single-column portrait type layout helps the readers read the reading passages fast. Tarasov et al. (2015) cited Poulton's findings (1959) that a single-column layout can read faster than in double-column layout. However, a single-column layout with lengthy lines is not easy for the reader to precisely find the start of new lines (Bouma, 1980). Researchers reviewed serif fonts, like Times New Roman, more legible due to their serifs that put more information on the readers' eyes (Geske, 1996). These serifs also improve the text's legibility by assisting the readers to distinguish the words and letters easily (McCarthy & Mothersbaugh, 2002). Font size 10 or 11 is the smallest font size that must be utilized for books, according to the majority of the publishers (Tarasov et al., 2015). Therefore, increasing the font size can help improve the legibility of the texts (Beidler 2006; Subbaram, 2004).

Number and types of visuals used in the textbooks

The number and types of visuals that are used in the four textbooks are shown in Table 12. B4 has the most visuals, while B1 has a smaller number of visuals. The significance and application of mitosis and meiosis were also discussed in all books with illustrations and diagrams. Illustrations and images in the textbook appeal to the books and help the readers understand the content clearly (Rakes, 1995). In Iran, it has been found out that the insertion of images is one of the most effective tools in teaching and textbook designs (Kashi et al., 2015). Only B4 has colored illustrations and not monochromatic grayscale. Colored drawings or photographs are crucial for secondary school science textbooks that help motivate students to read and understand science concepts (Leivas & Roth, 2003).

Textbooks' visuals can enhance students' creativity and improve comprehension (Hibbing & Rankin-Erickson, 2003; Kasmaienezhadfard et al., 2015). Textual explanation with diagrams, graphics, illustrations, and pictures will enrich the textbook content, as it arouses the student's attention and increases student's retention when they see pictures, according to Dale's Cone of Experience. Visual literacy is one of the necessary skills a secondary student should have (Rakes et al., 1995). Visuals or illustrations helped the students learn about meiosis only by describing the phases and labeling structures but not comprehending the

overall and exact purpose of meiosis (Cook, 2008). Teachers can use different learning materials such as models, diagrams, pictures, laboratory activities, and videos to assist them in teaching cell division, and these materials could be utilized to increase learning potential among students (Chattopadhyay, 2012).

Table 12. Number and types of visuals used in the textbooks

Types of Visual	B1			B2			B3			B4		
	CC	Mi	Mei	CC	Mi	Mei	CC	Mi	Mei	CC	Mi	Mei
Drawings	2	3	1	1	6	3	1	1	4	6	9	15
Photographs	-	-	-	-	1	-	1		-	1	1	7
Photomicrographs	-	-	-	-	-	-	-	2	-	-	-	-
Graphs	-	-	-	-	-	-	-	-	-	2	-	-
Tables	-	1	2	-	-	-	-	-	1	1	-	1
Computer graphics	-	-	-	-	-	-	-	1	-	3	1	2
Total	2	4	3	1	7	3	2	4	5	13	11	25

where: CC is Cell Cycle; Mi is Mitosis; Mei is Meiosis

Learning strategies

Motivational strategy

The motivational strategy of all textbooks has differences and similarities. B1, B3, and B4 use active voice, while B2 uses passive voice. All books use less technical language. For example, B4 orderly stated and described the details on the cell cycle phase, the stages of the cell division, and the disorders/ diseases caused by the cell cycle's malfunction. Motivational strategies indicate that most of the textbooks use less technical language and an active voice. Using a passive voice in textbooks may hinder students from getting meaningful information (Luo, 2018), while an active voice promotes an easy and straightforward understanding of the texts (Sainani & Harwell, 2015). Learners might experience complexities understanding the information when there is no agent by phrase, and the subject must be assumed (Kline & Demuth, 2010). Identifying who the agent in a sentence, together with all other grammatical and linguistic challenges, is very hard for many students (Neilson, 2016).

Summative assessments were present in the four textbooks, but only B1 did not use any formative assessments. However, formative assessment is essential in identifying student progress and understanding, and the teachers can prepare to meet the diverse needs of the students (Clark, 2011). Therefore, using different assessments in textbooks to assess students' learning and guide and direct students in learning the topics. B2, B3, and B4 discussed the new updates on research. B3 explained the tissue culture and emphasized the importance in the Philippines (p.136). Science updates and research achievement in textbooks can be a good approach to motivate and encourage students (Gok, 2012). Therefore, textbooks are encouraged to put a section for updates on the latest research or famous researchers' achievements.

Explicit instruction

All books presented explicit instructions. The introduction of the topics was presented well, and emphasizing the topics with bold letters was also evident. B1, B2, and B4 presented the lesson objectives. Textbooks' activities and experiments have clear instructions on how to conduct the activities and experiments. B3 started the lesson with an overview of the cell cycle and ended with cytokinesis, followed by the full details of the cell cycle and cell division stages. Textbooks are helpful when explicit instruction is clear since it supports readers' learning success in understanding the lessons and topics. Explicit instruction's inclusion increases students' engagement in performing higher-order thinking activities (Boone, 2010). Researchers suggest using explicit instructions in textbooks to guide and aid students in achieving the learning objectives

Guidance and support

Textbooks should give guidance and support to aid students in becoming independent thinkers. This can be achieved by considering the analogies used in the textbooks, clear illustrations and instructions, various activities, and types of questions (Gok, 2012). The books were evaluated on how the textbooks guide and support students' understanding and learning. Table 13 shows the analogies found in the textbooks. Only B2 and B4 exhibited few analogies. Analogies can speed up understanding and learning science concepts by relating one idea to another. The analogy used in instruction will significantly better understand science concepts and eliminate misconceptions or alternative conceptions (Dilber & Duzgun, 2008).

Table 13. Analogies found in the textbooks

B1	B2	B3	B4
-	1. One gene in linked pair serves as a *marker*… (p. 38)	-	1. DNA is loosely organized like a *scattered spaghetti* on a plate (p. 78 and 97). 2. The chromosome now appears to be similar to *letter X* (p. 79). 3. Tiny strands of protein actin called microfilaments like a *drawstring* (p.87).

Status of terms used in the textbooks

Table 14 presents the status of the terms used in the textbooks. All textbooks presented the new biological terms to support and aid students in learning and understanding the concepts and emphasizing immediately defined terms that boost easier reading, understanding, and comprehension. In contrast, terms that are later-defined or undefined hinder students' learning (Gok, 2012). With this, terms should be immediately or earlier defined to help students understand the concepts.

Table 14. Status of terms used in the textbooks

Categories	B1	B2	B3	B4
Terms immediately-defined	14	9	5	39
Terms earlier-defined	3	6	15	19
Terms later-defined	1	1	0	2
Terms undefined	1	0	0	0

Activities found in the textbooks

Activities found in the four (4) textbooks are shown in Table 15. B1, B2, and B4 have activities in the cell cycle and cell division. However, B3 does not have any activities regarding the topics. This may affect how students learn and understand the cell cycle and its subtopics since activities can help students develop and advance their learning and stimulate higher-order thinking skills. Mathai (2014) highlighted those activities must be incorporated in the textbooks to let students cope with complex concepts. Textbooks activities aids students grapple with complicated lessons. More activities are encouraged to be incorporated in the textbooks to better support students learning and understanding of the science concepts.

Table 15. Activities found in the four textbooks

B1	B2	B3	B4
1. Learning cell songs from websites (p.56)	1. Reflect on something that has changed… (p. 34)	-	1. Watch video tutorials on Mitosis and Cytokinesis, and Cell Cycle and Mitosis (p. 97)
-	2. Cell cycle (p.46)	-	2. Visit the following learning sites about Meiosis, Cells Alive, and Virtual Cell (p.123)

Experiments found in the textbooks for mitosis and meiosis

Table 16 shows the experiments found in the textbooks. B3 and B4 have suggested activities/experiments in mitosis, while only B4 has suggested activities/experiments in meiosis. B4 is better and more helpful in increasing students' engagement and involvement in learning science concepts than other books. Books that incorporate experiments in the lesson helps to motivate and increase students' understanding (Townsend, 2012).

Table 16. Experiments found in the four textbooks for Mitosis and Meiosis

	B1	B2	B3	B4
Experiment for Mitosis	-	-	1. Observing Mitosis (p.126)	1. Locating the Stages of Mitosis (p.96A)
	-	-		2. How long is each stage of the cell cycle? (p. 96E)
	B1	B2	B3	B4
Experiment for Meiosis	-	-	-	1. Modelling Meiosis (p.122a)
	-	-	-	2. Stop Motion Meiosis (p.122g)

Targeted instructional and assessment strategies

Types of questions, tests, and learning activities for identifying the targeted instructional assessment strategies were assessed and evaluated based on the context of Bloom's taxonomy of learning objectives. The learning objectives are categorized into three (3) known as affective, cognitive, and psychomotor. The cognitive aspect involves knowing, comprehending, applying, analyzing, synthesizing, and evaluating (Gok, 2012). Figure 1 presents the cognitive level of learning objectives in the textbooks. B4 has knowledge, comprehension, application, and analysis, which shows the various levels of complexity.

Moreover, it was found that B3 has no learning objectives, which implies that it fails to guide students on what main ideas to be understood (knowledge), what skills to be master, and what attitude to learning. Furthermore, no learning objective reaches the synthesis and evaluation level in all textbooks, which requires higher-order thinking skills. Therefore, the cognitive level of learning objectives should not only stop on lower-order thinking skills, but it should also reach a higher level of thinking skills since learning goals and objectives address the students' core and fundamental learning skills, content mastery, and critical and analytical thinking skills (Mahajan & Singh, 2017). With this, science textbooks should ensure that objectives are incorporated to organize, clarify, and prioritize learning.

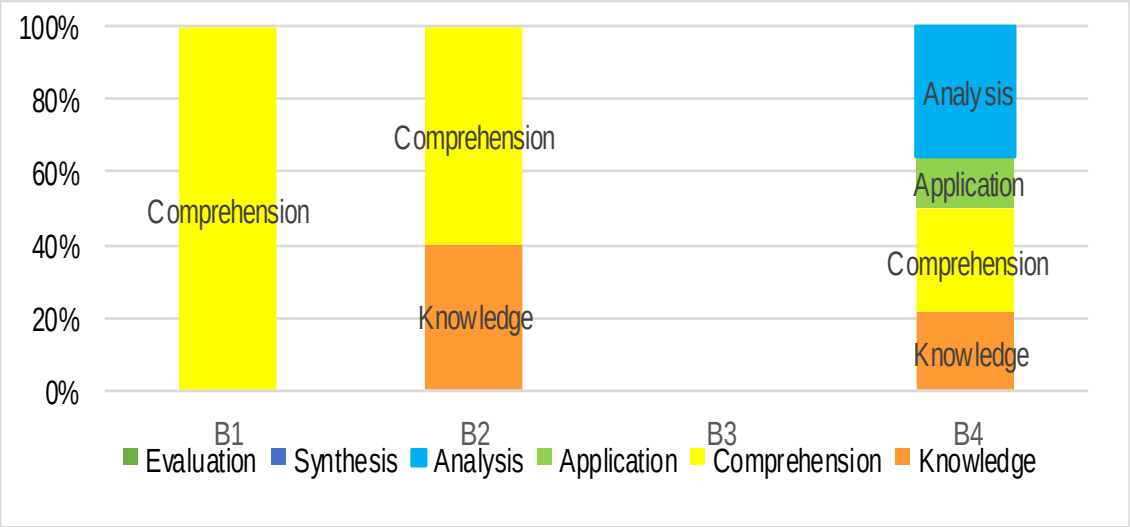

Figure 1. Cognitive levels of objectives

Comparison of number of questions in the textbooks

Table 17 shows the types and frequency of questions found in the textbooks. B2, B3, and B4 show the in-text questions, and B3 and B4 have after-experiment questions. All books have topic end questions for summative assessments. Furthermore, it can be observed that problems are not found in all four textbooks. Problem-solving questions stimulate students' deep and reflective thinking and understanding (Kim et al., 2018). By this, it is suggested to integrate problem-solving questions to develop students' higher-order thinking skills.

Table 17. Comparison of the number of questions in the textbooks

Types of Questions	B1	B2	B3	B4
	Mitosis and Meiosis			
In-text questions	0	4	6	29
After-experiment questions	0	0	3	14
Problems	0	0	0	0
Topic end questions	12	26	11	36
Total	12	30	20	79

Question types used by the four (4) general biology textbooks

The types of questions used in the textbooks are shown in Table 18. Types of questions were classified as open-ended questions and close-ended questions. Most of the question types used in the book were short-

answer questions. B4 has the greatest number of questions, and B1 has the least number of questions presented.

Table 18. Question types used by the textbooks

Question Types	B1	B2	B3	B4
Short answer	0	7	9	52
Multiple choice	0	5	5	20
Data related	0	0	0	0
Fill in the blanks	0	0	0	0
Label the diagram/ draw and label	0	3	0	0
True-False	10	10	0	0
Draw a graph/ illustrate the process	0	0	0	4
Find the exit	0	0	0	0
Fill in the table	2	0	1	3
Matching type	0	5	5	0
Problem-solving	0	0	0	0
Total	12	30	20	79

Open-ended questions require critical analysis and higher-order thinking skills, which can aid learners in putting in words the knowledge gained, relating, and making relationships between the concepts learned and real-life scenarios. On the other hand, close-ended questions only need a low level of cognitive answers (Gok, 2012). With this, open-ended questions are recommended.

Cognitive levels of questions

Figure 2 shows the cognitive levels of questions. All books know the cognitive level, while only B4 uses most of the different levels of cognitive questions. This is because no question-level reaches the synthesis. Mahajan and Singh (2017) suggested that the cognitive level of questions should not only stop on lower-order thinking skills, but it should also reach a higher level of thinking skills in order to stimulate critical and analytical thinking skills.

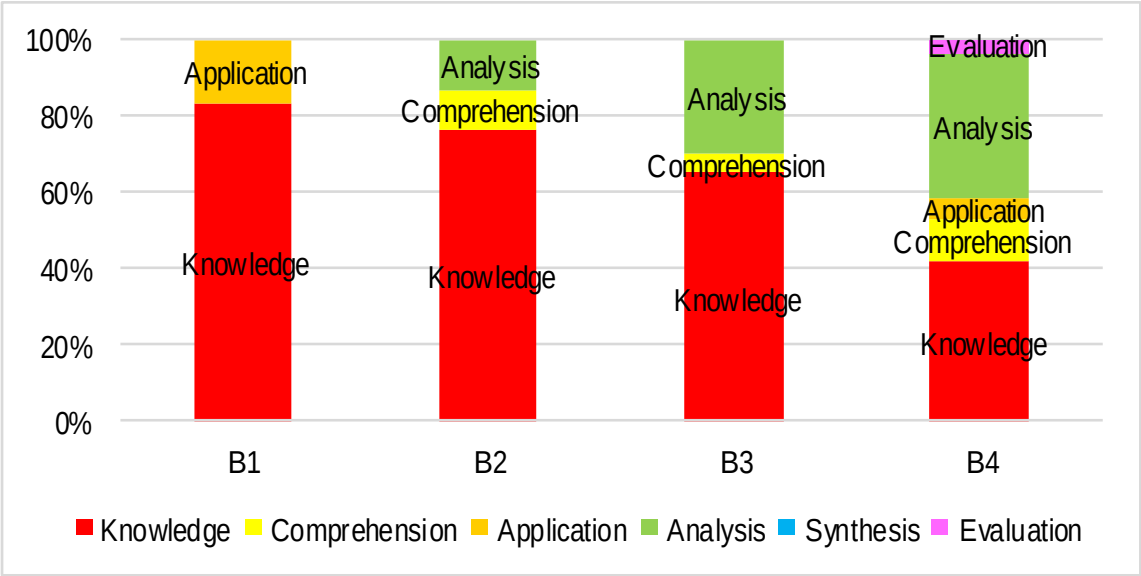

Figure 2. Cognitive levels of questions

Insights of biology senior high school teachers

Fifteen SHS teachers were the informants of this study, five SHS from Southern Palawan, six from Northern Palawan, and four from Puerto Princesa City. Results of insights serve as the validation to confirm the results of the researchers' content analysis. Insights of the teachers are vital because they are the ones who teach the students using the curriculum with the guide of the reference materials. Textbooks are essential to teachers and students who need to be prepared academically in all necessary competencies.

Content presented

Respondents stated that all books were aligned in the K to 12 Basic Education Curriculum Learning Guide (BEC-LG) in the content of cell division. In B1, crossing over and recombination on cell division were not further presented and emphasized contrary to the indicated BEC-LG. The content is accurately presented but not in detailed discussions, information is insufficient, and needs additional supplementary materials to teach the topic effectively. Activities such as minilab, reading check-in between discussions, and concepts in motion were included that are beneficial for in-depth learning. After each lesson, there are no other citations except the video links and optional video documentaries for further learning.

Respondents observed that some typographical errors and subject-verb agreement were presented in B2. In addition, the discussion is incomplete that needs other resources to expound on the concepts and give more examples.

In B3, teachers mentioned that there is lacking descriptions and explanations. Some teachers believed that using this book was enough. The discussion and illustrations are well-presented and well-explained. Every stage in the cell cycle is well-described, including the control points, errors, significance, mitosis, and meiosis application. However, some teachers use other references on illustrations and more in-depth discussions to discuss the topic.

Respondents evaluated B4 as a well-contextualized book. The objectives and activities match the competencies indicated in CG. The content was accurate, had no misconceptions, and was sufficient to discuss the SHS level topic. Key concepts in teaching cell division were also evident. Additional information was also provided related to the topic to motivate and make the readers aware of cell division. The order of main topics and subtopics was organized from simple to complex.

The teachers rated and recommended using B4 as the most helpful book in terms of content, next with B1, B2, and lastly, B3. A single manner of organizing the content of the books was used. The textbooks must be free from errors, inaccuracies, and misleading statements to convey the correct information as they learn cell division. The textbook is essential to improve quality education (Juwita et al., 2017) and can be used as teaching material for delivering curriculum content (Candra, 2020). The basic teaching contents in the textbook must be arranged and ordered used in delivering the curriculum (Ruhiat et al., 2016). Unfortunately, many inappropriate textbooks were used in teaching and schools, such as sync content (Behnke, 2018; Mariani & Usmeldi, 2019).

Presentations to the reader

According to the teachers, the pictures and illustrations of B1, B2, and B3 were printed in black and white. In B2, teachers mentioned a need for enhancement by increasing the font size and having clear images. Additional pictures and illustrations were also recommended to understand the process and differentiate the mechanism of cell division. There are no misspelled words and grammatical errors in the discussions. The presentations of the diagram of the stages of meiosis should start in interphase to the formation of four granddaughter cells rather than the summary of the two meiotic divisions. The technological aspect should need enhancement and should be updated.

Respondents observed that B2 needs more aesthetics in images, figures, and the book's cover page. Some images and figures do not entirely complement the text. The authors used a simple English language that was easy to understand. Additional information on the website was also present. In B3, there was no typographical error. The linguistic style and tone of the textbook are right. It has links with learning strategies, which directs students to online interactive exercises and animations. However, some visuals are small and blurred. The images should improve with more informative visuals.

Lastly, B4 is highly recommended by the teachers and considered as user-friendly. The written language is legible, readable, and easy to comprehend. The illustrations appeal to the reader, and it provides texts and enough description of the process, diagrams, and illustrations. The linguistic style is formal and more on scientific discussions. The book has activities, videos, and exercise links on the internet. Additional articles, images, examples, video clips, and assessment tools were included and accessed from the internet. However, some examples with quick response (QR) codes cannot be accessed.

Textbooks largely determine what topics and ideas were taught in the classroom and presented to students. Therefore, textbooks affect learning and teaching in many different ways (Behnke, 2018). The presentation of material from the easy level to the difficulty level and from the simple level to the complex level textbook demonstrates effectiveness in designing systematic, gradual, and evaluable instructions that can enhance the learning experience (Dunlosky et al., 2013; Khalil & Elkhider, 2016; Sidek, 2012). Besides,

publisher editors who are not careful in editing textbooks from aspects of content, illustration, and design as sources of learning can cause errors that should be corrected (Muslich, 2010; Reynolds et al., 2012).

Students could relate easily to the delivery of words in the book. It is scientifically based but is user-friendly. Candra et al. (2020) concluded that the book's inaccuracies of concepts, principles, and illustrations in textbooks could be corrected by the teacher based on valid references. Colored images promote differentiating figures and understanding concepts to be a lot easier. Suitability of content, readability, and ease of getting feedback when using textbooks can improve students' attitudes and behaviors towards learning (Morales & Baker, 2018).

Learning strategies presented

Based on the teachers' responses, there are no inaccuracies and misconceptions regarding the strategies used in the presentation of the lesson. In B1, the learning strategies were correctly arranged. Incorporating additional activities concerning the topic was significant between sub-topics, but the activities were not enough to teach how cells grow, divide, and reproduce. Less interactive and technology-based activities in mitosis and meiosis were presented, although various learning checks were given at the end of the lesson to deepen students' understanding. The moving of chromosomes should be emphasized in the cell division process. Authors should consider the learning strategies for visual learners as well as the emergent technologies-based examples. The provision of minds-on and hands-on activities or performance tasks should be considered to allow the users to feel more engaged in learning the concept.

B2 uses examples and activities based on the topic discussed. In addition, some laboratory activities were given to reinforce the topic. The order of subtopics in learning strategies was organized and very informative. The learning strategies in B3 were modified and rearranged according to the K-12 DepEd SHS Curriculum's learning competencies. Some teachers claimed that the book was enough for teaching strategies. It has different exercises to check the students' learning. Some mentioned that there is still a need for other supporting references to engage more in learning strategies.

Lastly, in B4, informants mentioned that the book has some additional concepts that can help build the curriculum's foundation. The objectives, main ideas, essential questions, formative and summative assessments were evident and quickly done. The textbook can easily relay the concept and knowledge to the user. It encourages the readers to learn in mind and body through performance tasks. Some concepts were complicated, but the given main ideas, objectives, articles, essential questions, formative questions, summaries, and summative questions can pinpoint the topic's goals and objectives. The learning strategies in the subtopics were in order and well-organized. It follows the chronological order from the basic concepts to the more complicated strategies.

The evaluation of the teachers agrees with the content analysis that all books under review have clarity in terms of presentation and learning strategies. The topics were introduced and supported using various bold and standard letters with clear instruction in activities. Based on the content analysis results, there was some disagreement that B1 has misleading statements, wherein teachers mentioned that all books have no inaccuracies and misconceptions. The books must be reviewed regularly to check whether there were inaccuracies to avoid misconceptions to the readers. Teachers also shared their experiences strategies in the books that could not be performed because of the lack of equipment and materials, and the teachers need to localize the given activities.

Competence can be achieved through learning activities (Cebrián et al., 2020) and can encourage students to live and experience (Gu et al., 2015). Good media must support the science concepts to visualize learning (Rahmiwati et al., 2018) easily. The correct interpretation of knowledge structure turns misconceptions into learning strategies (Leonard et al., 2014). However, some concepts and illustrations were inaccurate in natural sciences textbooks (Nugroho et al., 2017).

CONCLUSIONS

Cell division topic in SHS identifies as least learned concept in science. Teachers commonly use textbooks as instructional material that can transfer the essential knowledge and information to the students. Accurate content and no misleading information, quality presentations, and aligned learning strategies in the curriculum and teaching-learning process are important features in the textbook to help the teachers and learners gain efficient and effective education. Using quality textbooks can positively affect students' learning and help the teachers in the science teaching and learning process.

Therefore, the role of an educational institution in choosing the best textbook is very vital. They should purchase, provide, and recommend updated books aligned in the curriculum guide with skeptical and keen scrutiny from the experts to avoid any misconceptions in the different topics. Moreover, the book publisher must have credible experts to review the books to avoid misleading statements and use technical and scientific terms to explain the science concepts accurately. Additional relevant activities and experiments with clear instructions are highly encouraged to explore and experience real-life applications of the concepts learned. Using higher-order questions and objectives is also recommended to encourage learners to think critically and expound on the concepts learned.

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