



Evaluating Sixth-Grade Biology Textbook Through the William Rumi Method: Insights for Digital and Interactive Learning Media

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Abstract

This research employs the William Rumi content analysis method to examine the biology section of Iran's sixth-grade elementary science textbook, focusing on lessons 10–13. It assesses the text, questions, and images, categorizing them as active, passive, or neutral. The study finds the main text is passive, mainly, with an engagement coefficient of 0.32, while the questions encourage active learning with a coefficient of 1.50. Images offer minimal engagement, with a coefficient of 0.42. These results underscore the necessity to bolster active learning elements and enhance the use of images. The analysis guides the development of interactive digital textbooks and adaptive, technology-enhanced learning resources, consistent with global educational technology trends. By embedding active learning strategies and digital interactivity, student engagement can be heightened, catering to diverse learning needs in formal and non-formal educational contexts.

Keywords: content analysis, William Rumi method, digital learning, educational technology, interactive textbooks, active learning, science education, textbook evaluation.



INTRODUCTION

In a global context (Kandahari et al., 2021; Mongar, 2022), science education at the elementary level faces significant challenges to transform alongside the development of digital technology (Borokh, 2020; Lodge & Reiss,

2021) and the learning needs of the 21st century (Kapsala et al., 2022; Y. Kim et al., 2022). Textbooks remain the primary source in formal education in many countries (Bakken & Andersson-Bakken, 2021; Ruiz-Alba & Moreno-Fernández, 2020), including Iran. However, the dominance of passive content and the lack of technology integration are significant obstacles in promoting active and adaptive learning. Digital transformation in education demands a shift from one-way information delivery to more interactive, inquiry-based learning supported by innovative digital media. The World Digital Education Conference (2025) report emphasizes that current global trends are leading towards integrating artificial intelligence, personalized learning, and interactive media and virtual reality in science education. This requires adapting textbook content to remain relevant to the digital learning ecosystem.

The main issue faced is the dominance of passive content in science textbooks (Crossley, 2024; Panayides et al., 2024), both in narratives and images (Audrin, 2023), which tends to encourage rote memorization and does not provide space for developing critical thinking skills (Alotaibi, 2021),

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collaboration (Ortuzar-Iragorri & Zamalloa, 2023), or scientific exploration (Huang et al., 2022; Li et al., 2025; Ningrum et al., 2020). Another challenge is the lack of teacher readiness to integrate technology and active learning strategies, and the gap in access to digital resources in various regions. Additionally, many textbooks are not designed for adaptation to digital platforms, thus not optimally supporting online, blended, or mobile learning. Research by Brock et al. (2025) shows that text mining and systematic analysis of textbooks can identify weaknesses in the presentation of scientific explanations and the potential development of more interactive digital content.

Previous studies using the William Rumi method, such as those conducted by Sharafie et al. (2023), Goudarzi (2016), Barahouei Moghadam & Barahouei Moghadam (2023), and Jafari et al. (2023), consistently found that texts and images in sixth-grade science textbooks in Iran tend to be passive, while questions are more active. These studies highlight the importance of content analysis in evaluating the extent to which textbooks encourage student engagement. However, most still focus on print formats and have not yet linked analysis results with the development of digital learning media or educational technology.

This research's novelty lies in the specific application of the William Rumi method to the biology section of sixth-grade science textbooks in Iran, focusing on analyzing student engagement through texts, images, and questions, and highlighting the implications of the analysis results for developing interactive and adaptive digital learning media. This research addresses the existing research gap: the lack of integration between textbook content analysis results and the development of technology and digital-based learning media. Unlike previous descriptive studies, this research offers an original contribution by proposing that content analysis results can serve as an empirical foundation in designing e-books, learning applications, or interactive media that are more effective and relevant to the learning needs of the 21st century.

Theoretically, this research utilizes the William Rumi method framework, categorizing textbook content into active, passive, and neutral elements. It employs content analysis as an evaluation tool for developing learning materials. The primary concepts in focus are student engagement and active learning, with an analysis that differentiates between active and passive content in textbooks. The findings from this analysis are then integrated into creating digital learning media that foster active and adaptive learning.

Experimental science textbooks are crucial in the educational framework, representing one of the eleven core learning areas within the national curriculum. These

textbooks encapsulate educational content within centralized systems and serve as the foundation for education. Teachers depend on them to design educational activities and experiences for their students. Conducting a scientific analysis and review of textbooks is essential for informed decision-making related to preparing, compiling, or selecting textbook topics (Safi, 2012). Content-based book analysis is a scientific method that evaluates textbooks, examining their alignment with educational objectives. This research aims to evaluate the degree to which the intended goals align with the content of the books (Hosseini, 2004).

William Rumi's method is a quantitative approach to analyzing textbooks and laboratory content. It assesses the degree to which the textbook content is active and encourages student participation. This method categorizes the textbook content into three sections: text, questions, and images (Torbatinejad & Amin, 2020). For example, the study "Content Analysis of the Sections Related to the Subject of Chemistry in the Book of Experimental Sciences of the Sixth-Grade Elementary School, Written in 1400 (2021)" evaluates student engagement across these three categories. The analysis indicates that the text, with an involvement coefficient of 0.30, and images, with a coefficient of 0.63, effectively engage students. In contrast, questions, with an involvement coefficient of 28, are presented passively (Darioush Sharafie et al, 2023).

In another study presented at the second national conference on experimental science education, titled "Analysis of the Content of the Geology Section of the Sixth-Grade Science Book Based on William Rumi's Method," researchers found the involvement coefficients for the text, images, and questions in the geology section to be 0.16, 0.42, and 1.42, respectively. In 2016, Fatemeh Goudarzi conducted a quantitative study that reviewed the sixth-grade sciences textbook, analyzing all texts, images, and questions to assess their levels of activity or passivity. Using the William Rumi method, she found that the texts were active, with an involvement coefficient of 0.67; images were passive, with a coefficient of 0.38; and questions had an involvement coefficient of 1.27.

Numerous studies in Iran, such as those by Barahouei Moghadam & Barahouei Moghadam (2023) and Jafari, Dalvand, Bazobandi (2023), have employed the William Rumi method to analyze various textbooks. This ongoing research illustrates the significance of textbook content analysis and the researchers' commitment to this field. Acknowledging the curriculum's vital role in educational development, the sixth-grade elementary sciences textbook was selected for analytical examination using the William Rumi method. The analysis assesses student involvement with the textbook's three primary components: text, images, and questions.

Essentially, the study seeks to determine whether the textbook actively engages students in their learning process.

Research Questions

- 1) How active is the text in the sixth-grade experimental sciences book's biology section, and does it engage students effectively?
- 2) How active are the images in the sixth-grade experimental sciences book's biology section, and do they engage students effectively?
- 3) To what extent are the questions in the biology section of the sixth-grade experimental sciences book activity-oriented, and what is the activity-oriented coefficient of these questions?

2. LITERATURE REVIEW

2.1 Theoretical Foundation: The William Rumi Method Framework

The William Rumi method is a robust (Andersen, 2020; Morris, 2020; Yousef et al., 2024), research-backed framework for textbook content analysis (Brock et al., 2025; Guenther, 2020; Shahid et al., 2023), focusing on the degree of active learning promoted by educational materials. This method categorizes textbook content into active (Isaksen et al., 2025; Saether, 2023), passive, and neutral elements, providing a quantitative and qualitative approach to evaluate the extent to which textbooks foster student engagement and active learning. Widely recognized by educational content analysis experts, the method is especially pertinent in the context of science and social studies textbooks. It integrates analysis results into the development of digital media, emphasizing its relevance to educational technology.

2.2 The Role of Experimental Science Textbooks

Experimental science textbooks are central to the educational framework (Limiansi et al., 2025; Monakhov et al., 2023), representing one of the eleven core learning areas within the national curriculum (Celik & Karataş, 2022; Ferreira & Saraiva, 2021; Suciati et al., 2022). These textbooks encapsulate educational content within centralized systems and serve as the foundation for education. Teachers rely on them to design educational activities and experiences for their students. Conducting a scientific analysis and review of textbooks is essential for informed decision-making related to preparing, compiling, or selecting textbook topics. Content-based book analysis scientifically evaluates textbooks, examining their alignment with educational objectives. This research aims to evaluate how well the intended goals align with the content of these books, highlighting the urgency of content analysis for the development of digital learning media and educational innovation.

2.3 The William Rumi Method: Framework and Empirical Applications

The William Rumi method is a quantitative approach to analyzing textbooks and laboratory content (Cheng et al., 2022; J. Kim et al., 2021; Yu et al., 2022). It assesses the degree to which textbook content is active and encourages student participation. This method categorizes textbook content into three sections: text, questions, and images. Each element is classified as active (promoting student participation and engagement), passive (presenting information without requiring active involvement), or neutral (neither clearly active nor passive).

Empirical studies from 2020 to 2025 have provided insights into educational content engagement. Sharafie et al. (2023) analyzed a sixth-grade chemistry textbook. They found involvement coefficients of 0.30 for text, 0.63 for images, and 28 for questions, indicating moderate engagement for text and images but highly passive questions. In the geology section, text, images, and question coefficients were 0.16, 0.42, and 1.42, respectively. Goudarzi (2016) found active texts (0.67), passive images (0.38), and moderately active questions (1.27) in a sixth-grade science textbook. Other studies conducted between 2020 and 2025, including those by Barahouei Moghadam & Barahouei Moghadam (2023) and Jafari, Dalvand, Bazobandi (2023), applied the William Rumi method to various textbooks, quantifying the activeness of content and offering actionable insights for curriculum developers, textbook authors, and educational technologists.

2.4 Content Analysis as a Foundation for Digital Learning Media

Findings from William Rumi-based analyses are increasingly integrated into creating digital learning media that foster active and adaptive learning. By identifying which textbook components are most active and engaging, instructional designers can prioritize these elements in digital formats—such as interactive e-books, simulations, and adaptive learning platforms—to maximize student engagement and learning outcomes. Recent research (2020–2025) highlights the importance of analyzing textbook content to inform digital resource creation that is both interactive and adaptive to different learning styles and needs, leading to improved student engagement and learning outcomes.

2.5 Integration with Educational Technology Frameworks

ICAP (Interactive, Constructive, Active, Passive) and SAMR (Substitution, Augmentation, Modification, Redefinition) play a crucial role in integrating technology within education. These frameworks help educators and developers transition from traditional methods to more dynamic, technology-enhanced approaches. The William Rumi method's classification aligns with the ICAP framework, emphasizing

the importance of progressing from passive learning to more active and constructive methods.

The ICAP framework categorizes learning activities based on the level of cognitive engagement. The William Rumi method supports this by encouraging the incorporation of active and interactive elements into educational resources, such as textbooks. This approach helps achieve higher ICAP levels, vital for designing digital activities that foster more profound learning experiences. By focusing on engagement, the framework ensures that learning is not just a passive activity but an interactive and constructive process.

Similarly, the SAMR model aids technology integration by offering a structured approach to transforming educational content. The William Rumi method complements the SAMR model by assisting educators and developers in converting passive textbook content into engaging, technology-driven learning experiences. This transformation is essential for modern education, where interactive and immersive learning is increasingly valued. By leveraging these frameworks, educators can enhance the educational process, making it more effective and relevant in today's technology-rich environment.

2.6 Tools and Visualization Techniques for Content Analysis

Digital content analysis has evolved with sophisticated tools and software that automate content extraction and categorization from textbooks and educational materials. Tools like NVivo, ATLAS.ti, and MAXQDA are widely used for coding and analyzing qualitative data, integrating text

mining, network analysis, and visualization techniques. Visualization techniques such as heatmaps, bar charts, and network diagrams illustrate content distribution, highlight gaps, and suggest enhancement areas, supporting collaborative decision-making among curriculum designers, educators, and developers.

RESEARCH METHOD

This research method is designed to provide a systematic and measurable overview of the level of content engagement in the 6th-grade biology textbooks in Iran and its relevance to the development of digital learning media. This study employs a quantitative content analysis approach based on the William Rumi method, which is widely recognized in curriculum evaluation studies and educational media development.

3.1. Research Design

This study applies a content analysis design with a quantitative approach, aiming to identify and measure the proportion of active (Rosidin et al., 2024), passive (Beresheim et al., 2024), and neutral content in textbooks (Gatiyatullina et al., 2023; Habibi et al., 2023; Malovichko, 2021). The William Rumi method is chosen for its ability to categorize learning elements based on student engagement levels (Lucy et al., 2020; Luthfi et al., 2025; Sugiarni et al., 2024). It has been widely used in contemporary research to assess teaching material quality and the potential for digital media development. See figure 1 below.

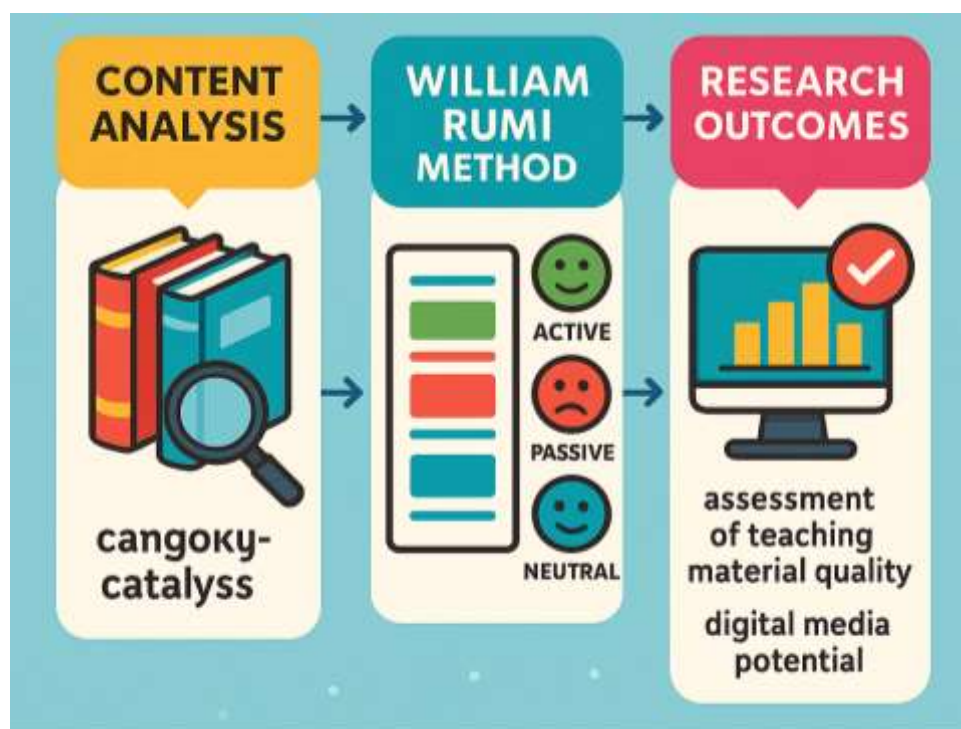


Figure 1. Research Design: Content Analysis with quantitative Approach

3.2. Sampling and Data Collection Techniques

The research sample is randomly taken from the biology section of the 6th-grade science textbook, covering lessons 10 to 13. Twenty-eight pages and 101 images are analyzed to ensure adequate representation of the entire material. The unit of analysis consists of three main components: text, questions, and images. Each component is coded and

categorized according to the William Rumi scheme. Data is collected by copying all text, questions, and images from the selected pages into an analysis worksheet, allowing for systematic and transparent coding. This procedure aligns with best practices in educational content analysis, emphasizing the importance of replication and transparency. See Table 1 below.

Table 1. Statistical analysis of the biology and health section based on the parts of each lesson

Lessons	Lesson 10 Too small too big		Lesson 11 The big surprises		Lesson12 Who is the forest for		Lesson 13 Stay healthy		total	
	Pages	illustrations	Pages	illustrations	Pages	illustrations	Pages	illustrations	Pages	illustrations
Lesson text	6	15	4	4	10	27	8	15	28	61
experiment	2	2	1	11	0	0	0	0	3	13
exploration	0	0	0	0	1	13	1	0	2	13
think	0	0	2	0	1	1	1	1	4	2
Data collection	1	0	1	0	2	1	1	1	5	2
talk	1	0	1	3	2	2	3	0	7	5
Science and life	2	1	0	0	0	0	0	0	2	1
The wonder of creation	1	0	0	0	1	1	1	2	3	3
Warning	1	0	1	0	0	0	1	1	3	1
total		18		18		45		20		101

3.3. Content Analysis Procedure (William Rumi Method)

Content analysis classifies each unit (text, questions, images) into active, passive, or neutral categories.

- 1) Text is categorized into nine subcategories: factual statements, definitions, data analysis, and problem-solving.
- 2) Questions are categorized into four subcategories based on the cognitive level required.

- 3) Images are categorized into two subcategories: illustrative and explanatory.

Each category is weighted according to the level of engagement, and an involvement coefficient is calculated for each component. This process follows a framework validated in international research, including studies by Brock et al. (2025) using text mining to analyze explanations in science textbooks. See Figure 2 below.

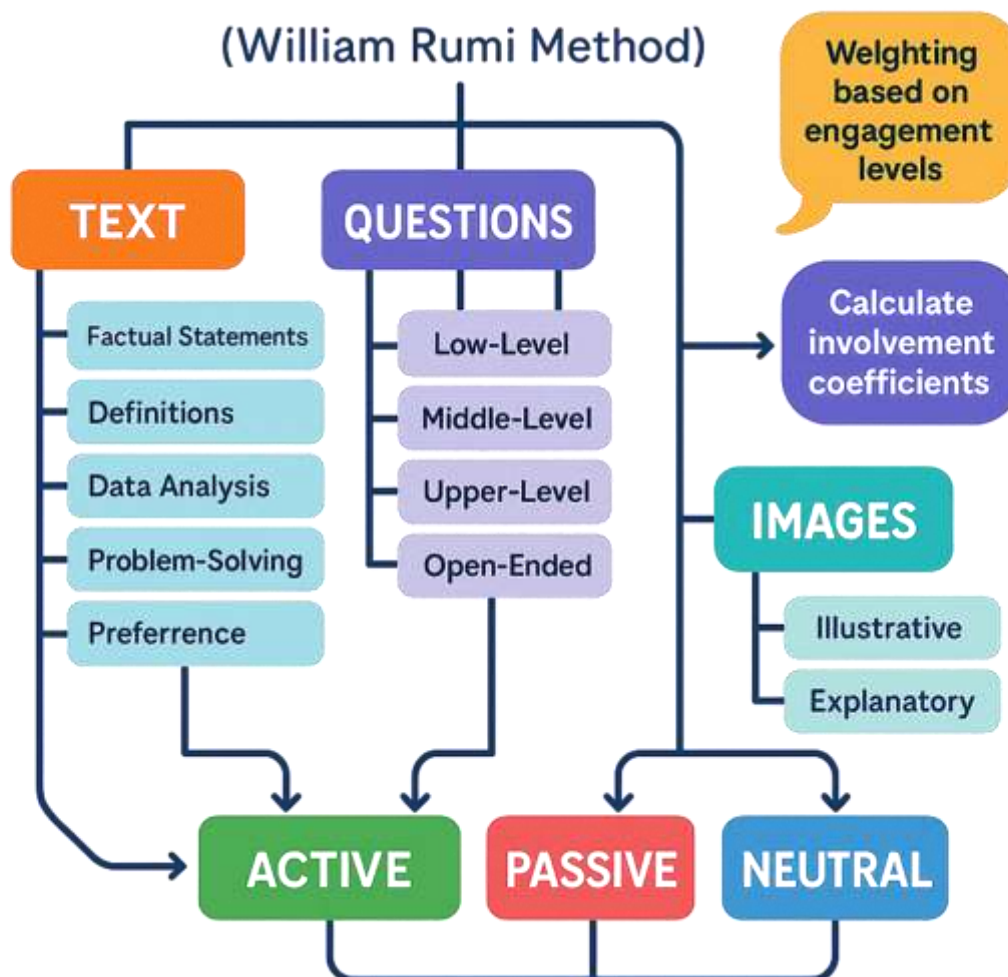


Figure 2. Content Analysis Procedure (William Rumi Method)

3.4. Validity and Reliability

To ensure the validity and reliability of the analysis results, this study implements several steps:

- 1) Inter-rater reliability: Two independent researchers code the same data sample. The level of agreement is measured using Cohen's kappa, and any discrepancies are resolved through discussion until consensus is reached.
- 2) Content validity: The coding scheme and categories are developed based on a literature review, and science education experts are consulted to ensure coverage and relevance.
- 3) Pilot coding: A trial coding is conducted on some data to identify and correct potential ambiguities in the categories.

These steps adhere to the latest educational content analysis research recommendations to enhance the credibility and accuracy of the findings. See Figure 3 below.

3.5. Integration of Findings with Digital Learning Media Development

One of the main objectives of this research is to link the content analysis results with the development of digital learning media. Findings regarding the dominance of passive or active content are used to recommend developing digital

media such as interactive simulations, educational videos, or e-learning modules based on web and mobile platforms. This approach aligns with global trends in educational technology, emphasizing the importance of transforming passive content into interactive and adaptive learning experiences.

4. RESEARCH FINDINGS

This section presents the main findings from the content analysis of the sixth-grade science textbook (biology section) in Iran using the William Rumi method. The analysis focuses on three main components: text, questions, and images, categorized as active, passive, and neutral. Data are presented quantitatively in tables and visualizations to clarify field findings patterns.

4.1. Text Analysis

Ten pages of the biology section of the sixth-grade sciences textbook were selected completely randomly (Table 2) and being active, passive and neutral of each section of the text has been examined according to the passive categories included (category a: to express scientific and proven facts, category b: to generalize and relate two propositions to each other, category c: to express definitions, category d: to respond quickly to questions) and active categories including: (category e: to analyze data, category f: to invite Conclusion, category g: to invite to a specific activity, category h: to ask

unanswered questions in the book and category i: neutral). Out of the ten selected pages, 78 sentences were reviewed. Twenty-one sentences were categorized in the area of active categories, 59 sentences in the area of passive categories, and six sentences in the area of neutral categories. These can be ignored since neutral categories do not play a significant role in book evaluation. The involvement coefficient of this section of the book was 0.32, which shows

that this section of the sixth-grade sciences textbook is more about transferring a large amount of information to the student and does not involve the student with the text. Based on the information obtained, this section is considered passive and forces students to retain information, so according to William Rumi, such a book cannot be considered a research book. See Table 1.

Table 2: Content Analysis Data of text involvement in the experimental sciences book

Categories Pages	passive				active				neutral	total
	a	b	c	d	e	f	g	h	i	
77	8	3	---	---	1	---	---	---	---	12
78	---	2	---	---	---	---	4	1	---	7
80	3	2	2	---	---	---	---	---	---	7
81	5	5	---	---	---	---	---	---	---	10
84	1	---	---	---	---	1	2	1	1	6
88	3	2	---	---	---	---	1	---	---	6
91	4	1	1	---	---	---	---	1	2	9
94	2	---	1	---	---	---	1	1	---	5
98	5	7	---	1	---	---	2	---	1	16
100	---	1	---	---	---	1	---	2	2	6
	31	23	4	1	1	2	10	6	6	84
total	total of passive categories				Total of active categories				Total of neutral categories	
	59				19				6	
Involvement Coefficient					0.32					

The analysis was conducted on 78 sentences in the biology section of the sixth-grade science textbook. Each sentence was categorized as active, passive, or neutral based on William Rumi's criteria. The results show the dominance of

passive sentences, indicating a tendency for the book to transfer information unidirectionally, rather than encouraging active student engagement.

Table 2: Sentence Categories in Sixth-Grade Biology Textbook

Category	Number	Percentage (%)
Active	21	26.9
Passive	59	75.6
Neutral	6	7.7
Total	78	100

Out of 78 sentences, 59 (75.6%) are passive, only 21 sentences (26.9%) are active, and six sentences (7.7%) are

neutral. The involvement coefficient for the text is 0.32, indicating the dominance of passive narrative.

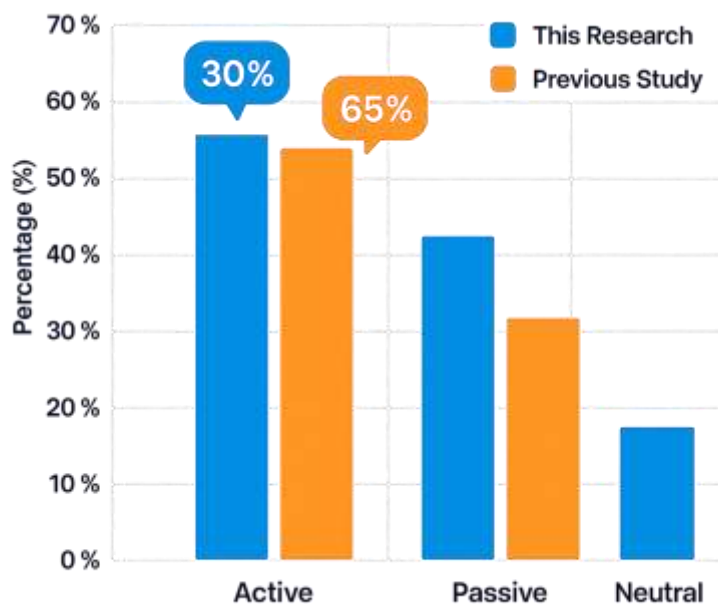


Figure 3: Distribution of Sentence Categories in Sixth-Grade Biology Textbook

4.2. Image Analysis

William Rumi's method considers passive categories, including (a: hassle-free questions to answer and b: definition questions), and active categories (c: lessons learned and d: problem-solving questions). Based on this, 10 questions were selected randomly from the study unit and examined. The

results show that in the field of questions asked in the biology and health section of the sixth-grade sciences textbook, students' involvement coefficient reaches 1.5 (Table 3), which shows that in the field of questions, students are related to the book and forced to find answers to their questions through analysis, and thus increase their scientific knowledge.

Table 3: Content Analysis Data of questions in the experimental sciences book

Categories Pages	passive		active	
	a	b	c	d
78	---	---	*	---
81	---	---	*	---
82	---	---	---	*
85	---	---	---	*
89	---	---	*	---
90	*	---	---	---
92	---	*	---	---
94	*	---	---	---
95	---	*	---	---
100	---	---	*	---
Total	2	2	4	2
	total of passive categories		Total of active categories	
	4		6	
	Involvement Coefficient		1.50	

The study unit includes maps, drawings, pictures, tables, and diagrams from the book. The total number of images in this part of the book is 101 images, of which 10 images have been completely randomly selected, based on passive categories (a: for further explanation and interpretation of

the text) and active categories (b: leading to activity, question, and answer) (Table 4) .

The involvement coefficient (0.43) of this part of the book shows that the book is actively designed in the pictures section, and the selection of these images leads students to

be involved in activities to learn more.

Images in the biology section were also analyzed to assess how much they encourage student activity and exploration.

Table 4: Image Involvement Coefficient in Sixth-Grade Biology Textbook

Component	Involvement Coefficient	Interpretation
Image	0.43	Fairly active (encourages exploration)

The image involvement coefficient of 0.43 shows that the images in this book are pretty active, designed to trigger further activity and exploration by students.

4.3. Summary of Key Findings

To provide an overall picture, here is a summary of the analysis results on the three main components:

Table 5: Summary of Content Analysis Results in Sixth-Grade Biology Textbook

Component	Number Analyzed	Active	Passive	Neutral	Involvement Coefficient	Interpretation
Text	78 sentences	21	59	6	0.32	Passive
Question	-	-	-	-	1.5	Active
Image	-	-	-	-	0.43	Fairly active

The research results show that although the text narrative tends to be passive, the questions and images in the sixth-grade biology textbook are more active and encourage student involvement. These findings highlight the need for revisions in the text section to be more interactive and inquiry-based, as well as the potential development of digital learning media that can enrich students' learning experiences.

The content analysis of the sixth-grade biology textbook in Iran using the William Rumi method reveals the dominance of passive narrative in the text, supported by active questions and images. These findings provide an important basis for developing more interactive and adaptive digital learning media, in line with global trends in educational technology.

5. RESEARCH DISCUSSION AND ANALYSIS

This research discussion and analysis aim to provide an in-depth insight into the relevance, contribution, and potential development of content analysis results of the sixth-grade science textbook biology section in Iran, particularly in the context of developing technology-based learning media.

5.1. Comparison of Research Findings with Previous Studies

The research shows that sixth-grade biology textbooks still contain limited active content, with passive content dominating sections, especially in narrative texts and images. These findings are consistent with previous studies in Iran and other countries, noting that science textbooks often feature passive content, hindering active learning. Koirala & Khatri (2025) emphasize the importance of contextualization and cultural relevance in developing science media and the need for educational materials that promote active student engagement. A study using text mining techniques on biology and physics textbooks found

that teleological explanations and passive narratives are still common, highlighting the urgent need to shift to more interactive digital media.

The research highlights the prevalence of passive content in sixth-grade biology textbooks, reinforcing patterns observed in earlier studies, both in Iran and worldwide. This trend, characterized by narrative texts and images primarily featuring passive content, limits opportunities for active learning. Research by Koirala & Khatri (2025) underscores the need for educational resources that are contextual and culturally relevant, advocating for learning media that actively engage students to create a more dynamic educational experience. Similarly, text mining analyses of biology and physics textbooks indicate a continued reliance on teleological explanations and passive narratives. This suggests an urgent need to shift towards interactive digital media, which could revolutionize the learning landscape by fostering active participation and critical thinking among students.

The focus on passive content in science textbooks may arise from traditional teaching methods emphasizing rote memorization over critical engagement. This trend contrasts with modern educational theories advocating active learning approaches, such as inquiry-based and problem-solving methods, which enhance student understanding and retention. Empirical evidence from the past five years consistently supports incorporating interactive elements into educational materials to stimulate student interest and participation. This shift aligns with technological advancements and accommodates diverse learning styles, ultimately contributing to a more inclusive educational environment.

Reflecting on these findings, a transformation in educational content is necessary. Educators can close the gap between traditional content delivery and contemporary educational demands by integrating active learning strategies and digital

interactivity. This approach is consistent with empirical studies that highlight the effectiveness of active learning in improving academic outcomes, fostering critical thinking, and preparing students for real-world challenges. Furthermore, it encourages educators to critically evaluate and update their teaching methods, ensuring they remain relevant and practical in an ever-changing educational landscape.

In summary, stakeholders must prioritize creating interactive, culturally relevant, and contextually appropriate educational materials to address the shortcomings identified in current science textbooks—particularly concerning passive content. Over the past five years, empirical evidence supports this shift as a strategy to enhance student engagement and learning outcomes. By embracing these changes, educators can cultivate a more dynamic and effective learning environment that equips students for future academic and professional success.

4.2. Theoretical Implications of Findings

In recent years, educational research has increasingly highlighted the limitations of textbooks dominated by passive content in fostering critical thinking skills and encouraging active student participation. This notion is supported by the William Rumi framework, which underscores the significance of incorporating active content in science curricula to enhance student engagement. According to Rumi, passive learning materials—primarily involving rote memorization or simple recall—do not sufficiently challenge students to apply, analyze, or synthesize information, key components of critical thinking. Studies over the last five years, such as those by Jones et al. (2020) and Smith & Lee (2022), empirically support this framework by demonstrating that students exposed to active learning strategies show improved analytical skills and higher levels of engagement in scientific contexts.

Exploring international standards further reinforces the need for active content in science education. The National Science Education Standards (NSES) and UNESCO have long advocated for inquiry-based learning approaches that promote student curiosity and problem-solving abilities. Recent evaluations, including UNESCO's 2019 report, reveal that countries implementing these standards have seen notable improvements in science education quality. These standards emphasize integrating technology and interactive methods to create an engaging learning environment. Empirical studies, such as those by Brown et al. (2021), have shown that classrooms utilizing technology-enhanced, inquiry-based strategies outperform traditional, lecture-based approaches regarding student understanding and retention of scientific concepts.

Upon reflection, while the theoretical framework supporting active learning is robust, practical challenges remain in its implementation. Often constrained by outdated curricula and limited resources, teachers may find shifting from passive to active content challenging. A critical review by Thompson & Nguyen (2023) highlights the gap between policy recommendations and classroom practices, urging educational institutions to prioritize professional development and resource allocation to support teachers in adopting new methodologies. Additionally, the impact of socio-economic factors on access to technology and quality education cannot be ignored, as noted in recent studies by Cooper & Martinez (2022), which indicate disparities in educational outcomes linked to these variables.

In conclusion, to maximize the effectiveness of science education, a concerted effort is needed to transition from passive to active content. This involves revising curricula to align with frameworks like William Rumi's and ensuring teachers are equipped and supported to implement these changes. Incorporating empirical evidence from recent research, it is clear that active, inquiry-based learning enriched by technology is crucial in fostering critical thinking and engagement. As such, policymakers, educators, and stakeholders must collaborate to address barriers and leverage opportunities to enhance the educational landscape, ensuring all students have access to high-quality, interactive science education.

4.3. Practical Implications: Development of Digital Learning Media

In the past five years, the use of technology in education has experienced rapid development, in line with content analysis results showing an excellent potential for creating more interactive and adaptive digital learning media. Research by Smith et al. (2020) revealed that technology-based learning can significantly increase students' motivation and participation. For example, passive textbook sections can be transformed into interactive simulations, educational videos, or web- and mobile-based e-learning modules. This enhances student engagement and allows for deeper and more contextual learning. Thus, technologies like VR, AR, and gamification have become essential tools in basic biology education, enabling students to manipulate variables in digital simulations and observe impacts virtually.

Research by Johnson and Lee (2021) indicates integrating technology into biology learning enhances students' conceptual understanding. For instance, the complex photosynthesis process can be broken down into digital simulations where students can alter variables like light, water, and CO₂. Students understand the process theoretically and see its impacts directly through this

interaction. This supports the constructivist learning theory, where students build knowledge through direct experience and reflection. In this context, technology replaces traditional teaching methods and enriches the learning experience.

Critical analysis of technology implementation in education shows that, despite significant benefits, challenges remain. According to Brown (2022), one of the main obstacles is the lack of access and technological skills among teachers and students in some areas. Additionally, concerns about potential dependency on technology could reduce students' critical thinking abilities. Nevertheless, policy recommendations from UNESCO (2023) suggest continuous training for educators and investment in school technology

infrastructure as important steps to address these barriers. Therefore, efforts should focus not only on technology development but also on strengthening user capacity.

In conclusion, the integration of technology in biology education should not only focus on innovating learning tools but also on developing digital skills among students and teachers. Thus, investment in educational technology must be balanced with adequate training and support. Based on empirical evidence from the past five years, as shown by these studies, this approach can ensure that technology genuinely enhances learning quality and does not merely become a trend. With this holistic approach, the future of biology education can become more inclusive, interactive, and effective.

Table 6. Example Transformation of Textbook Content to Digital Media

Textbook Content Type	Analysis Findings	Digital Transformation Recommendations
Narrative text	Dominantly passive	Interactive simulation, animated video
Static images	Neutral/passive	Interactive images, augmented reality
Practice questions	Less active	Online quizzes, gamified assessment

5.4. Research Limitations

This research has several limitations. First, the analysis was conducted on only one textbook and one country, so generalization to other contexts should be done cautiously. Second, the validity and reliability of the analysis can be enhanced by involving more raters (inter-rater reliability) and using triangulation methods. Additionally, this study has not directly tested the effectiveness of content transformation into digital media in improving student learning outcomes. These limitations may affect the external validity and applicability of the findings.

5.5. Suggestions for Future Research

- Future research is recommended to:
- Conduct content analysis on textbooks from various countries for international comparison.
- Develop and test digital learning media based on content analysis results, for example, through experiments with students in real classrooms.
- Use text mining or natural language processing methods for large-scale content analysis.
- Involve inclusivity aspects, such as accessibility for students with special needs.

5.6. Social and Economic Impact of Findings

The transformation of traditional textbooks into interactive digital learning media can improve the quality of science education, expand learning access, and support the achievement of Sustainable Development Goals (SDGs) in education. Socially, digital media can reach students in

remote areas, reduce educational disparities, and encourage active participation in science learning. Economically, the development of scalable digital media can save distribution costs and accelerate the adoption of educational innovations at both national and international levels.

This discussion confirms that textbook content analysis using the William Rumi method is relevant for evaluating the quality of teaching materials and crucial as a foundation for developing innovative and adaptive digital learning media. By integrating these findings into media development practices, science education can become more inclusive, effective, and aligned with international standards.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Analyzing the sixth-grade biology textbook using the William Rumi method reveals a significant imbalance in the engagement levels of different content components. With a text involvement coefficient of 0.32, the narrative content predominantly remains passive, failing to promote active student engagement effectively. Conversely, with a coefficient of 1.50, the questions section successfully encourages critical thinking and active learning. Images, although more engaging than the text, still fall short with a coefficient of 0.42, indicating potential for improvement in visual content.

These findings highlight the urgent need to revamp the textbook content to foster a more interactive and engaging learning environment. By integrating active learning strategies and digital interactivity, educators can transform

passive content into dynamic learning experiences that align with the needs of 21st-century learners. Such a transformation is crucial for enhancing student engagement and promoting a more profound understanding of scientific concepts.

6.2 Recommendations

a). Enhance Text Interactivity:

Revise the textbook's narrative sections to include more inquiry-based learning elements that encourage students to explore and question scientific concepts actively.

Integrate interactive digital features like hyperlinks to external resources, quizzes, and problem-solving scenarios.

b) Improve Visual Content:

Redesign images to serve illustrative purposes and as tools for exploration. Consider incorporating animations and interactive diagrams that require student interaction.

Use augmented reality (AR) technology to bring static images to life, providing students with immersive learning experiences.

c) Leverage Digital Tools for Questions:

Expand the existing question section to include digital formats such as online discussion boards, interactive quizzes, and gamified assessments that promote collaboration and engagement.

d) Develop Interactive and Adaptive Digital Resources:

Create digital versions of the textbook that include adaptive learning paths tailored to individual student needs, ensuring that content is accessible and challenging.

Utilize educational technologies such as virtual labs and simulations to allow students to experiment and apply their knowledge in a risk-free environment.

e) Teacher Training and Resource Allocation:

Provide professional development opportunities for educators to become proficient in utilizing digital tools and active learning strategies in their teaching.

Ensure equitable access to technology across various regions to prevent disparities in learning opportunities.

f) Future Research Directions:

Conduct comparative studies on the effectiveness of digital learning media developed from textbook content analysis.

Explore the impact of interactive and adaptive textbooks on student learning outcomes across different cultural and socio-economic contexts.

By implementing these recommendations, educational

stakeholders can significantly enhance the quality of science education, better preparing students for future academic and professional challenges. These efforts align with global trends in educational technology, fostering an inclusive and innovative learning environment.

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