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Evaluation of Critical Thinking Elements: A Qualitative Content Analysis of Physics Textbook Grade IX

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Abstract: *Critical thinking skills are essential in the 21st century in all academic and overall life. This skill is among the 4Cs of the twenty-first century that enable learners to analyze information, argumentation evaluation, decision making, and problem-solving. The purpose of the current study is to analyze the 9th-grade physics textbook about the development of critical thinking skills among students. A purpose sampling technique was utilized to select the physics textbook. Nvivo 12 software was used as a facilitator to get the analysis of the document after importing it in PDF format through the qualitative content analysis method. Passages and activities regarding critical thinking skills development were identified. As per the analysis of the document, five aspects were extracted regarding the development of critical thinking skills, encouragement of inquiry-based tasks, promotion of application and problem-solving, development of analysis and evaluation, creative thinking, and connection of concepts towards real-life situations. There are different examples from the textbook that promote open-ended questions, practical problems, analysis, and creative exercises to challenge students to think critically with the application of their knowledge. Through engagement in inquiry-based activities, data analysis, problem-solving, evaluation, and creativity, the learners of the twenty-first century can develop the capability of critical thinking with innovation and logic.*

Key Words: Critical Thinking Skills, Physics Textbook, Inquiry-Based Learning, Problem-Solving, Qualitative Content Analysis

Introduction

Critical thinking is a buzzword of today that has emerged as an important competency for success in academic and professional life. It involves the capability of analysis of the information, evaluation of arguments, problem-solving, and informed decision-making (Dwyer et al., 2014). In science education, these skills are of much importance, and the learners have expectations of engagement in complex concepts, data interpretation, and application of knowledge in the real-life world (Vieira et al., 2011). Therefore, the development of critical thinking (CT hereafter) skills has become a major goal for science education in the twenty-first century.

Physics, being a basic branch of science, plays a significant role in the development of CT among learners of the twenty-first century. Thus, analysis of Physics is engaged in logical reasoning application, analytical thinking, and problem-solving for the understanding of the natural world (Holmes et al., 2020). CT showed an advantage in promoting mathematics achievement in elementary school students over secondary school students (Li & Ma, 2010). That is why it is important to analyze how the physics textbook fosters CT among students. Current studies have highlighted the importance of the incorporation of CT elements into science textbooks. A study found problem-solving activities useful for the improvement of the student's metacognition and problem-solving skills in science education programs (Akben, 2020). In the same way, a study by Sabri (2019) uncovered the impact of inquiry-based learning on the development of critical thinking skills in biology in the context of the UAE.

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The focus of the current study is to analyze the document regarding fostering CT among students in 9th grade. 9th grade is a critical phase of science education where students transition from basic concepts to advanced ideas. This stage for developing CT is paramount for the students to engage effectively through complex concepts and apply them in the real-life world. The current study aims to analyze the Physics textbook for grade 9 to identify the key aspects that contribute to CT skills development. Through the analysis of the textbook using qualitative content analysis, the current study aimed to identify specific aspects and instructional strategies used in the textbook for CT skills enhancement. The study findings may inform the development and design of the curriculum about instructional material and pedagogical practices in content through a qualitative content analysis. This study aims to shed light on the specific elements and strategies employed in the textbook to foster critical thinking abilities. The findings of this study can inform the design of the curriculum, including instructional material and pedagogical practices focusing on CT skills development in physics students.

Objective of the Study

- To analyze the critical thinking skills development incorporated in the Physics textbook for Grade 9.

Literature Review

In the field of education, critical thinking has gained vital attention and importance, especially in the field of science education. There are several studies conducted in the previous literature regarding the importance of CT skills and strategies used for the development of science education students. In the view of Vieira et al. (2011), critical thinking is necessary for scientific knowledge and dynamic citizenship in the twenty-first century. Moreover, they argued about the focus of science education towards CT skills and abilities to engage students during scientific issues and make them better decision-makers. Similarly, Dwyer et al. (2014) developed a framework for critical thinking with a focus on cognitive processes that are involved in CT aspects like analysis, synthesis, inference, and evaluation. Moreover, the focus is also on explicit instruction and to practice these skills in an educational context.

Regarding Physics, there are different studies conducted to investigate the strategies and instructional approaches for the facilitation of CT skills development. Holmes et al. (2020) conducted a study to compare cognitive activities that were engaged in a Physics undergraduate research program. More opportunities for CT skills development were explored through the provided research experience, and different aspects of CT skills, such as analysis, synthesis, evidence evaluation, decision-making, and problem-solving, were explored.

Textbooks have a pivotal role in shaping excellent learning experiences for students and developing CT skills among them as twenty-first-century learners. Textbooks have a significant role in the promotion of CT skills development, especially in science education (van den Berg et al., 2022). Moreover, different instructional strategies have been described in the textbooks, such as real-world applications, open-ended questions, and inquiry-based learning activities for the promotion of CT abilities. Furthermore, the emphasis of textbooks is also on the provision of explicit instructions and guidance for effective implementation of teaching in the respective classroom.

In the local context of Pakistan, different studies have been conducted to investigate critical thinking through different aspects regarding their development, focusing on the teaching-learning process as well as education policy documents. In the national context of Pakistan, different studies focus on CT skills development at different levels and in diverse aspects. A recent qualitative study has been conducted to explore creative thinking in public schools in Pakistan as per teachers' perceptions and practices (Fazal et al., 2023). Creative thinking is an important aspect of the twenty-first century, but it is not being promoted effectively. In another experimental study, it was found that the integration of ICT enhanced students' reasoning skills. Moreover, ICT integration had a positive effect on student achievement in Physics (Ali et al., 2023). CT has been explored in the national context regarding science studies, including Physics, Chemistry, and Biology curricula and teaching practices (Jamil, 2021; Jamil et al., 2024; Jamil & Rafiq, 2024; Jamil et al., 2023; Jamil & Muhammad, 2019; Jamil et al., 2021a, 2021b). Secondary school science teachers' perceptions and practices have been explored in different studies for the promotion of critical thinking (Jamil et al., 2023; Jamil et al., 2021b); analysis has been done for the policy documents regarding CT (Jamil



& Muhammad, 2019); and assessing critical thinking skill development opportunities in textbooks. In another study, the effect of flipped science classrooms was explored on students' achievement in grade 7 (Saeed & Munir, 2023). It was found that students with flipped classroom experiences showed meaningful improvements in their CT capabilities. In another study, the effect of problem-based learning was explored for the development of CT skills in Physics at Sargodha, Pakistan (Iqbal & Omeodu, 2023). In the experimental study, students taught through problem-based learning were found to be more effective than control group students.

Research Methodology

The current study employed a qualitative content analysis approach to analyze the Physics textbook regarding the development of CT skills among secondary school science students. The current method is the most suitable one since it systematically interprets the large textual data to identify its themes, patterns, and meanings (Kyngäs, 2020). For textbook analysis, this approach is considered the most suitable in educational material, such as textbooks, to get insights from the content and its learning outcomes (Mayring, 2004). The Physics textbook (downloaded from <https://pctb.punjab.gov.pk/E-Books>) for grade IX (2020) was selected through a purposive sampling technique. This technique was used based on specific criteria and characteristics (Etkina et al., 2006). NVivo software was used as a facilitator for qualitative content analysis (Jackson et al., 2019). Moreover, NVivo is used to organize and analyze data and efficiently extract textual data (Silver & Woolf, 2018).

Findings of the Study

Encouraging inquiry and questioning:

The document encourages students to ask questions, inquire, and investigate various concepts and phenomena. This aspect helps students develop a curious mindset and fosters their critical thinking abilities by prompting them to explore and delve deeper into the subject matter. Open-ended questions and thought-provoking prompts stimulate students' inquisitiveness and encourage them to look beyond the surface level of information presented. The following text illustrates this.

"Think of objects around us getting heat or giving out heat." (Page 195)

"Can you conclude that the atmospheric pressure acts on a bubble equally in all directions?" (Page 149)

Promoting problem-solving and application

The document provides numerous examples and problems that require students to apply the learned concepts in practical situations. This aspect helps students develop critical thinking skills by challenging them to transfer their knowledge to new contexts and real-world scenarios. By solving problems and applying concepts, students practice analyzing information, identifying relevant principles, and formulating strategies to arrive at solutions. This process encourages them to think critically and logically while also enhancing their ability to apply theoretical knowledge to practical situations. Following are the examples from the textbook.

"EXAMPLE 8.5: A container has 2.5 liters of water at 20°C. How much heat is required to boil the water?" (Page 175)

"EXAMPLE 7.4: The weight of a metal spoon in the air is 0.48 N. Its weight in water is 0.42 N. Find its density." (Page 157)

Fostering Analysis and Evaluation

The document encourages students to analyze and evaluate situations, data, and concepts. This aspect promotes critical thinking by requiring students to break down complex information, examine it from multiple perspectives, and make sound judgments or assessments. Students are prompted to scrutinize information, identify patterns, draw connections, and evaluate the validity or significance of ideas or observations. This exercise develops their analytical and evaluative skills, enabling them to think critically and make informed decisions based on evidence and reasoning. The text below explains further in the following way.

"Explain the impact of the greenhouse effect on global warming." (Page 174)

"Explain how the birds are able to fly for hours without flapping their wings and glider is able to rise by riding on thermal currents which are streams of hot air rising in the sky." (Page 174)

Promoting Creative and Critical Thinking

The document includes open-ended questions and activities that encourage students to think critically and creatively. This aspect fosters critical thinking by challenging students to think beyond the given information, explore alternative perspectives, and generate innovative solutions or ideas. Open-ended prompts stimulate students' imaginative and divergent thinking, encouraging them to consider unconventional approaches and think "outside the box." This aspect helps students develop their ability to think critically, creatively, and flexibly while also enhancing their problem-solving and decision-making skills. The below text is about this.

"Write a dream during which you are driving a car and suddenly the friction disappears. What happened next...?" (Page 76)

"Think of a body which is at rest but not in equilibrium." (Page 105)

Connecting to Real-life Situations

The document relates the concepts to real-life situations and applications, helping students understand the practical relevance of the subject matter. This aspect promotes critical thinking by providing students with authentic contexts and real-world examples to which they can relate. When students see the applicability of concepts in their daily lives or practical scenarios, they are more likely to engage critically with the material and develop a deeper understanding. This connection to real-life situations also encourages students to think critically about the implications, consequences, and potential solutions related to various situations or phenomena, thereby enhancing their critical thinking abilities. The following examples illustrate this.

"Describe the use of cooling caused by evaporation in the refrigeration process without using harmful CFC." (Page 168)

"Explain the use of a Hydrometer to measure the density of a car battery acid." (Page 144)

Through the incorporation of these aspects, the textbook aims to develop CT skills among students by promoting problem-solving, developing inquiry, encouragement of analysis, evaluation, creative thinking, and conceptual understanding of real-life situations. These aspects also challenge the students to engage actively through deeper thinking and the application of knowledge in a meaningful way to enhance CT abilities.

Discussion

The current study aimed to analyze the Physics textbook of grade 9 about critical thinking skills development among students at the secondary level. The qualitative content analysis revealed 5 main aspects contributing to the CT skills development abilities. These aspects are inquiry-based learning, problem-solving, analysis and evaluation, creative thinking, and real-world connection. The findings of this study are aligned with the previous studies on the promotion of CT in Physics. The focus of the textbook is on inquiry and questioning, which are the principles of inquiry-based learning that are used as an effective approach for CT skills development in science education (Riga et al., 2017). Moreover, conceptual understanding, questioning, and investigation are used for the development of curiosity, which is needed for higher-order thinking skills development (Mulyati et al., 2021). Open-ended questions also provide a mindset thought-provoking that is illustrated in the textbook and also supported by the findings of Monrat et al. (2022) who are of the view that open-ended questions can be used in developing mathematical critical thinking skills.

Another aspect contributing to the development of CT skills in the textbook is problem-solving and application. Previous research studies support this finding that focuses on the role of problem-solving in the development of CT abilities (Dwyer et al., 2014; Holmes et al., 2020; Juandi & Tamur, 2021). The textbook provides an opportunity for the students to apply their knowledge regarding practical situations and real-world scenarios, encouraging the analysis of information, identification of the relevant



principles, and formulation of strategies for solutions. This process also develops critical thinking skills and capabilities through logical reasoning among science students.

Moreover, the textbook's focus is on analysis and evaluation, which is parallel to the main components of critical thinking (Facione et al., 2020). Encourage analysis and evaluation for the students in a specific situation, as well as analyzing the data and evaluating the relevant concepts. The textbook focuses on promoting analysis and evaluation skills that are vital for critical thinking. This finding is also supported by Neswary and Prahani (2022), who analyzed the students' CT skills and application for problem-based learning models based on a digital book for the physics textbook in secondary school.

Another noteworthy aspect of the Physics textbook is creative thinking, which is used for CT skills development after the inclusion of open-ended questions and different activities that support and encourage CT and explore the alternative perspective for the promotion of creativity and divergent thinking (Suherman & Vidákovich, 2022).

The textbook of Physics also focuses on the connection of the concepts with real-life situations, which is a significant strategy for the promotion of critical thinking. This finding is aligned with and supported by the findings of Elder and Paul (2020). Through the provision of real-world examples, the textbook helps the learners correlate physics concepts with daily life, which also encourages them to think critically about the application aspect. These findings are also consistent with Martawijaya et al. (2023), who emphasize the importance of critical thinking through the application of project-based learning in the subject of Physics.

The current study findings have significant applications in designing and developing physics textbooks that focus on fostering critical thinking skills among secondary school students. The authors and publishers of these textbooks should incorporate the elements of inquiry-based learning and activities, analytical exercises, problem-solving tasks, creative prompts, and real-life connections for the promotion of critical thinking skills abilities. Furthermore, teachers may play a great role in promoting the use of these textbooks effectively after employing recommended student-centered pedagogies that are aligned with critical thinking elements presented in the textbooks (Abrami et al., 2015).

Conclusion

The current study investigated the Physics textbook grade 9 (2020) to explore the development of critical thinking skills among students in 9th grade. Through qualitative content analysis, five core aspects provide the CT skills development capabilities. These aspects were encouragement of inquiry-based questions, promotion of problem-solving with application, development of analysis and evaluation, fostering creative thinking, and connection to real-world situations. The textbook focuses on questioning and inquiry-based learning in Physics for the development of CT skills. Moreover, it also focuses on problem-solving and the application of knowledge in practical and real-life situations. Activities related to analysis and evaluation are also incorporated to develop critical thinking. Open-ended questions and activities are also explored in the textbook to promote creativity and divergent thinking among 9th-grade students. Furthermore, the association of concepts to real-world situations is a valuable strategy that fosters CT skills. The study has an important implication regarding the design and development of Physics textbooks for authors and publishers. Overall, fostering CT skills is crucial to prepare the students of the 21st century to face the challenges that have been focused on in the Physics textbook. It has been concluded that a well-designed textbook can promote critical thinking skills effectively through the incorporation of different aspects of critical thinking to make the learner's problem solvers and responsible citizens who can make decisions in the increasingly complex world.

Recommendations

The following recommendations are made based on the findings of the current study:

1. Textbook authors and publishers should prioritize the incorporation of critical thinking elements, such as inquiry-based activities, problem-solving tasks, analytical exercises, creative prompts, and real-life connections when developing physics textbooks for grade 9 students.
2. Teachers should be provided with professional development opportunities to learn effective

strategies for implementing student-centered pedagogical approaches that align with the critical thinking elements present in the textbooks.

3. Curriculum developers should consider integrating critical thinking skills as a central component of the physics curriculum, ensuring that textbooks and other learning resources are designed to support the development of these skills.
4. Educational institutions should invest in the procurement and utilization of physics textbooks that have been evaluated and found to effectively promote critical thinking skills among students.
5. Future research should explore a broader range of physics textbooks used in different contexts to gain a more comprehensive understanding of their potential to foster critical thinking skills and to identify best practices in textbook design.
6. Empirical studies should be conducted to assess the actual impact of physics textbooks that incorporate critical thinking elements on students' critical thinking abilities in classroom settings, using both quantitative and qualitative research methods to gather evidence of their effectiveness.

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