Qualitative Content Analysis for Critical Thinking and Skill Development: A Case of Chemistry Curriculum

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Abstract

In the era of globalization and knowledge, critical thinking development is a necessary skill. The research focuses on analyzing the Chemistry curriculum for grades IX-X to explore its emphasis on fostering critical thinking skills among students being an essential skill for the twenty-first century. It aims to develop problem-solvers, independent thinkers, and decision-makers capable of applying their knowledge to real-life challenges. The curriculum advocates for interactive, learner-centered, participative, inquiry-based, practical, problem-solving, and analytical skills. It prioritizes the measurement of students' capacity for critical judgment, focusing on analysis and synthesis. NVivo 12 software was used with a qualitative content analysis approach to analyze the document. The findings of the study revealed a significant focus on the development of critical thinking to make them problem solvers, independent thinkers, and decision-makers to apply to the challenges of real life. As regards the standards and benchmarks, the curriculum is designed accordingly for the promotion of in-depth knowledge and higher-order thinking skills. Furthermore, the curriculum advocates for interactive, learner-centered, participative, inquiry-based, practical, problem-solving, and analytical skills. The assessment guidelines prioritize the measurement of student's capacity for critical judgment, focusing on analysis and synthesis. The study concludes by providing recommendations for teacher training, resource allocation, collaboration among stakeholders, regular curriculum updates, further research, and fostering a culture of critical thinking within educational institutions.

Keywords: Critical Thinking, Chemistry Education, Curriculum Analysis, Qualitative Content Analysis, Secondary Education.

Introduction

In the current era of globalization, the primary objective of education has shifted towards fostering critical thinking skills in students to enable them to navigate various aspects of life effectively (Higgins, 2015). Moreover, it is argued that education should aim to cultivate critical thinkers for the betterment and competency of the students (Siddiq et al., 2016). The twenty-first century is frequently emphasized as the age of 'knowledge explosion,' and effectively dealing with this phenomenon necessitates critical discernment of information (Zhang, 2018).

Critical thinking has been defined in various ways in academic literature. It has been described as the skills of analysis, inference, evaluation, and decision-making. Cottrell (2017) considers it a cognitive activity involving judgment, attention, and selection. Paul and Elder (2019) have referred to it as a vehicle for the education of the human mind. According to Facione and Facione (2007), critical thinking encompasses interpretation, inference, explanation,

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evaluation, and self-regulation. However, the most commonly used definition in the literature is the art of analyzing and evaluating thinking (Paul & Elder, 2019) and reasonable, reflective thinking focused on deciding what to believe or do.

Chemistry is a foundational science centered on constructing mechanism-based causal explanations of observed phenomena, which relies on and strengthens critical thinking (Ivanitskaya et al., 2002). Grasping chemical concepts involves disciplined evaluation of quantitative experimental data, logical analysis of intricate processes, coherent lines of argumentation, and reasoned judgments regarding limitations of claims (Etkina et al., 2006; Ivanitskaya et al., 2002). Therefore, Chemistry has proven more effective at enhancing generic critical skills like interpreting information, identifying assumptions, and making evidence-based decisions than most other subjects. Practicing Chemistry develops transferable competencies in precise questioning, causal analysis, and evaluating multifaceted information that underpins critical thinking (Ivanitskaya et al., 2002). Indeed, research shows secondary Chemistry instruction using active learning strategies that facilitate metacognition and abstract reasoning also directly improves performance on standardized critical thinking tests (Shaw et al., 2023). Therefore, Chemistry education provides an optimal platform to realize 21st-century skills.

The latest National Curriculum for Pakistan also positions Chemistry as enabling "systematic and logical thinking, central to the scientific method that cultivates analytical mindsets" from the secondary level onwards. Pakistan's policy documents assert the Chemistry curriculum can empower creative, evidence-based reasoning through inquiry tasks, concept mapping, and open-ended assessments evaluating students' conceptual application, coherent scientific explanations, and decision-making. Hence, curriculum analysis is warranted regarding national aims to enhance critical thinking via Chemistry education and corresponding gaps inhibiting implementation (Shaheen, 2016). Evaluating Chemistry curriculum design and classroom practices against constructivist, cognitivist principles can help overcome barriers to strengthening critical faculties (Ten Dam & Volman, 2004). This study, therefore, investigates Pakistan's secondary Chemistry curriculum using qualitative content analysis to appraise emphasis and opportunities for advancing critical skills, framing recommendations aligned to translated outcomes.

The exponential rise in access to information has increased the need for rapidly analyzing its credibility and utility to navigate personal, professional, and civic decisions (Kivunja, 2015b). However, research shows students often need more skills in evaluating multifaceted arguments, identifying assumptions, avoiding bias, and making logically coherent evidence-based judgments regarding complex issues (Niu et al., 2013). Yet, higher education and workplaces now expect such critical competencies. Hence, policy reports worldwide position critical thinking as one of the most crucial skills for global citizenship alongside creativity, collaboration, and communication (Saavedra & Opfer, 2012). School systems are thus reforming curricula across disciplines to systematically cultivate disciplined habits of inquiry, analysis, and decision-making underpinning rational thought (Abrami et al., 2015). Science education, grounded in the sophisticated metacognitive appraisal of empirical phenomena, provides an optimal avenue for enhancing critical skills (Underwood, 2018). The experimental investigation centered on logical analysis of evidence to test explanatory models intrinsically builds transferable critical faculties in synthesizing findings to reach reasonable, context-specific conclusions (Quitadamo et al., 2008). Chemistry mainly strengthens these cognitive abilities by elucidating intricate mechanisms behind observable data (Ivanitskaya et al., 2002). Therefore, aligning constructivist, inquiry-based science curricula to scaffold critical thinking development better explicitly equips students to evaluate real-world interdisciplinary problems (Kivunja, 2015a).

Recent studies evaluating critical thinking instruction across subjects confirm science and Chemistry classrooms effectively enhance rational analysis, evaluation, and evidence-based reasoning when lessons prioritize open investigation, collaborative analysis, metacognitive tasks, and explicit critical thinking frameworks (Abrami et al., 2015; Ten & Volman, 2004). Science practices nurture similar higher-order faculties, so integrating critical thinking vocabulary when teaching experimentation and causal explanatory models builds precisely these skills (Underwood, 2018). Indeed, Engineering education research shows adapting Chemistry instruction using case-based labs, debates, and creative problem-solving around socio-scientific issues directly improves performance on critical thinking tests like the Chemistry-adapted Watson Glaser (Shaw et al., 2023). Chemistry master students also demonstrate significant pre-post gains in generic critical measures after taking an adapted critical thinking course bridging concepts to decision contexts. Such interventions help students recognize and strengthen intellectual transfer. Hence, intentionally scaffolding the Chemistry curriculum advances rational competencies needed for personal, professional, and public domains.

In Pakistani context different studies have been conducted regarding development of critical thinking skills concerning document analysis (Jamil et al., 2020; Jamil et al., 2021a), teachers' perspective (Jamil et al., 2023), classroom observations (Jamil et al., 2021b) critical thinking development for social studies (Naseer et al., 2022) and other aspects of critical thinking skills development (Jamil, 2021; Jamil & Muhammad, 2019).

Objectives of the Study

The following was the objective of the study:

- To analyze the curriculum of Chemistry (IX-X_2006) for the development of critical thinking skills among secondary school students.

Literature Review

Education policies all over the world strengthen critical thinking and relevant competencies regarding global citizenship as well as the workforce and knowledge economy (Saavedra & Opfer, 2012). Critical thinking is used to analyze, argumentation, decision-making, and evaluation in different viewpoints (Cottrell, 2017). Through it, the possibility is to logically evaluate the credibility, assumptions of a context, logical reasoning, or claims to take rational decisions directing complication (Dwyer et al., 2014). The students of the 21st century require the intellectual tools for the authenticity of the information to be practical problem solvers in the real world. That is why, educational institutions have the aim to cultivate disciplined habits regarding higher order thinking and logical reasoning skills (Abrami et al., 2015).

Science education, stranded in the rational inquiry of observable phenomena through verifiable explanatory models, provides a natural avenue to advance multifaceted analytical faculties and evaluative dispositions ((Underwood, 2018). The iterative empirical process intrinsically relies on and thus builds transferable skills in assessing causal claims, identifying assumptions, avoiding bias, and synthesizing heterogeneous datasets toward reasonable context-specific conclusions (Etkina et al., 2006; Quitadamo et al., 2008). Therefore, science practices foster questioning direction, logical rationality, and evidence-based decision-making underpinning critical thought. Indeed, school science standards worldwide increasingly require analytical abilities applied through authentic tasks (Kivunja, 2015a). Similarly, studies confirm intentionally scaffolding metacognition and open-ended concept application when teaching the experimental method directly strengthens students' critical competencies (Abrami et al., 2015). Sophisticated reasoning skills constitute both instrumental means and ends for science education meeting global priorities.

The subject of Chemistry relied on critical evaluation regarding decision-making and evaluation for decision-making tasks. There is also the observable phenomenon through the integration of mathematical laws with data analysis for coherent explanations for continual questioning (Etkina et al., 2006). Knowledge of the subject of Chemistry requires disciplined evaluation, logical coherence, argument-making, dispositions with precisions, and critical thoughts (Ivanitskaya et al., 2002). Moreover, Chemistry has been seen to explain the material process with metacognition monitoring regarding reasoning that strengthens rational and logical competencies. Therefore, education in Chemistry equips students with questioning abilities so that they may be able to fulfil the demands of the context (Underwood, 2018). Fostering and developing CT is the main aim of the Chemistry curriculum with pedagogical shifts (Ivanitskaya et al., 2002; Kivunja, 2015a). Traditional transmissive education often anticipated students to remember secluded facts or processes rather than genuinely grasp unifying explanatory frameworks. However contemporary reforms frame Chemistry learning as actively investigating authentic questions through collaborative inquiry and debates analyzing socio-scientific scenarios (Kivunja, 2015a). Modern curricula embed analytical vocabulary when teaching core concepts and explicitly reference transferable critical skills learning outcomes, intentionally bridging metacognitive abilities with epistemic knowledge construction (Underwood, 2018). Corresponding immersive, dialogic pedagogies require applying sophisticated reasoning to local realities, advancing citizenship alongside cognition (Kivunja, 2015a). Hence research demonstrates actively engaging Chemistry concepts through case-based analysis, argumentation, and decision-making improves critical measures (Shaw et al., 2023). Contemporary principles position Chemistry as empowering rational, ethical citizenship.

National policy frameworks also increasingly promote critical thinking across the curriculum with science and Chemistry mainly expected to strengthen sophisticated cognitive skills for local and global contribution (Saiful et al., 2020). Pakistan's secondary national Chemistry curriculum asserts that "systematic and logical thinking, central to the scientific method," develops "analytical mindsets." To achieve this, student-centered active learning is recommended for grades 6-12, with inquiry tasks, debates, and concept mapping explicitly building evidence-based reasoning ability evaluated through open-ended assessments). At the undergraduate level, Chemistry degree policy outlines expectations to judge argument validity, make coherent decisions amidst complexity, and apply causal analysis addressing issues from industry to environmental sustainability. National documents envisage Chemistry as enabling empowered engagement with multifaceted modern realities.

The current study adopted a qualitative method of research by exploring the Curriculum of Chemistry for grades IX-X (2006) regarding critical thinking skills development among students of chemistry at the secondary level. There is a need for evaluation for alignment and gaps in contemporary skills advancement to help evidence-based recommendations for curriculum developers, teachers, and policymakers focusing on the realizing and analytical capabilities. Furthermore, the document analysis focuses on critical thinking skills development among students as described in the curricula as being an essential skill for the learners of the twenty-first century.

Research Methodology

The present study employed a qualitative content analysis approach (Kyngäs, 2020). Purposive sampling was utilized to select education policy documents, as the primary objective of the study was to examine the official education policy documents produced by the government of Pakistan for the development of critical thinking skills (Patton, 2014). The current sampling technique was chosen for a comprehensive understanding of the curriculum document (Zikmund et al., 2013). The chemistry curriculum has its central role in the textbook

development that is used for the students of secondary level. Through the facilitation of NVivo 12 software, a qualitative content analysis was conducted on the data. This software was chosen for its ability to effectively handle the massive volume of text data covered within the education policy documents (Bazeley & Jackson, 2019).
Moreover, NVivo software was believed to be the most suitable software as it presents different tools to address the research aim from various data sources. The qualitative content analysis followed a four-step procedure in NVivo: importing data, coding data, creating framework matrices, and reporting the findings (Bazeley & Jackson, 2019). The Chemistry curriculum was imported as PDF sources into NVivo 12, and relevant text was coded as nodes. Relevant passages were coded into appropriate nodes and child nodes (Miles, 2020). Additionally, the coding units were condensed after summarizing to obtain in-depth meanings of the text (Bazeley & Jackson, 2019). Four themes were generated, keeping the main aim of the study in view:
Aim of Education/Curriculum and SLOs
Importance of Critical Thinking
Pedagogy for CT Skills Development
Assessment for CT Skills Development

Study Findings

The findings of the study are described in the following aspects:

Aim of Education/Curriculum and SLOs

The Chemistry curriculum document outlines its primary objective as the cultivation of independent thinkers, problem solvers, and decision-makers capable of applying their understanding to real-life challenges in personal, social, and professional contexts. The curriculum emphasizes the importance of students' ability to address daily problems related to Chemistry logically. The standards within the Chemistry curriculum document have been meticulously designed to foster in-depth knowledge and higher-order thinking skills, enabling students to establish connections with the world around them. Consequently, the benchmarks are derived from these standards. The curriculum encourages students to exhibit curiosity about the natural world. It stresses the significance of employing science and technology to identify and resolve issues in their personal, social, and professional lives. The Chemistry curriculum document's description underscores its aim to develop independent thinkers who possess the ability to formulate questions and arrive at their conclusions. The document recommends the use of observation as a tool for investigation and problem-solving. Furthermore, the Student Learning Outcomes (SLOs) section of the Chemistry curriculum advocates for the application and analysis of concepts to nurture critical thinking (CT) skills. As in the curriculum, it has been described under points after completion of the Chemistry curriculum, students will be:

- *Able to think scientifically and use the Chemistry content knowledge to make decisions about real-life problems (p.1).*
- *Able to make wise judgments on statements and debates that claim to have a science base (p.1).*

In the aims and objectives section, the heading of aims is narrated in the following way:

- *An ability to apply the understanding of Chemistry to relevant problems (including those from everyday real life) and to approach those problems in a rational way (p.2).*
- *The capacities to express themselves coherently and logically, both orally and in writing, and to use appropriate modes of communication characteristics of scientific work (p.2).*

Importance of Critical Thinking

The Chemistry curriculum document also emphasizes various facets of critical thinking (CT) skills development. It is anticipated that students will exhibit curiosity regarding the natural world and technology. The document advocates for the utilization of reasoning, observation, and investigation as a means to solve problems. Through this approach, students can harness scientific and technological knowledge to become creative and influential decision-makers. The document articulates that one of its primary objectives is to cultivate problem-solving abilities among students, enabling them to tackle daily challenges by applying rational thinking and conceptual understanding. Moreover, the standards outlined in the document prioritize higher-order thinking skills, encompassing analysis, application, and evaluation. Standards in the curriculum have been based on higher-order thinking, deep knowledge, and connection with the world.

Under objectives section has been described in the following manner:

- Analyze data and conclude.
- Evaluate investigative procedures and the conclusions drawn from such investigations.

Pedagogy for CT Skills Development

The Chemistry curriculum also places a strong emphasis on the development of interactive, learner-centered, participative, inquiry-based, practical, problem-solving, and analytical skills. This focus is aligned with the curriculum's overarching aim to cultivate higher-order thinking and foster independent learners and problem-solvers who actively engage in questioning. The curriculum recommends the implementation of pedagogical practices that are activity-based and learner-centered, such as active participation, demonstrations, laboratory work, workshops, inquiry-based teaching, and the utilization of diagrams, graphs, flow charts, and fieldwork. These approaches are designed to promote student engagement, hands-on learning experiences, and the development of critical thinking skills.

Assessment for CT Skills Development

The Chemistry curriculum document focuses on analysis and synthesis as "assessment should measure the capacity of students for critical judgment" (NCC, 2006, p. 55). In summary, the curriculum emphasizes developing critical/ higher-order thinking skills in students, highlights its importance, recommends pedagogical strategies to promote it, and advises assessing those skills. Relevant concepts are integrated throughout the document. In addition, the final evaluation is recommended to be comprised of 85% weightage of Bloom's taxonomy levels. Moreover, in theory, 40% of the questions should be formed to measure higher-order abilities based on problem-solving and application of the information (NCC, 2006).

Discussions

The findings of the current study emphasize how vital it is for students in grades IX through X to learn critical thinking capabilities in the Chemistry curriculum. Based on the analysis, the strong emphasis of the curriculum is to develop students who are independent thinkers, skilled problem solvers, and efficient decision-makers who can apply their learning of chemistry to natural settings. This focus is online with the improving understanding that critical thinking capabilities are essential for science students (Rossi et al., 2021). The Chemistry curriculum aims to make the students of Chemistry essential thinkers and to develop the capabilities to solve the problems of real life and surroundings. The current methodology is aligned with the different earlier scholars who focus on the importance of fostering critical thinking abilities in science education (Facione et al., 2020). As per the current studies about effective pedagogy to develop critical thinking skills, the curriculum has a strong emphasis on learner-centered, participative, practice, problem-solving, inquiry-based, and analytical skills (Ghanizadeh, 2017).

Moreover, the studies demonstrate incorporating activities like laboratory work, participation, inquiry-based instruction, demonstration, and workshops to enhance students' engagement to develop the growth of their critical thinking abilities (Holmes et al., 2015). Furthermore, the assessment criteria have top priority for the students' evaluation, critical judgment, focusing on analysis and synthesis. Earlier scholars have suggested the same, concentrating on the significance of critical thinking abilities for science subjects (Santos, 2017). The aim and objectives have focused on critical thinking and logical reasoning for teachers to use the pedagogy in an effective way (Huber & Kuncel, 2016). So, the findings of this study revealed a strong emphasis on developing critical thinking skills within the Chemistry curriculum. The document emphasizes fostering independent thinkers capable of logical problem-solving and decision-making, as these soft skills have been in demand in the 21st century. It highlights the importance of students' ability to address daily challenges related to Chemistry and establish connections with the world around them. The standards and benchmarks within the curriculum aim to nurture in-depth knowledge and higher-order thinking skills among students. The study identified four main themes: the objective of education/curriculum and Student Learning Outcomes (SLOs), the importance of critical thinking, pedagogy and assessment, and critical thinking development. So, keeping in view the findings of the study, there is a need for implementation of the curriculum documents, suggestions, and recommendations that can be acquired after the incorporation of these suggestions by the teachers teaching at the secondary level. Future studies should analyze the problems and opportunities involved in employing critical thinking.

Conclusion

The Chemistry curriculum for grades IX-X emphasizes the development of critical thinking skills, aiming to cultivate independent thinkers, problem solvers, and decision-makers who can apply their understanding of Chemistry to real-life challenges. In the standards and benchmarks of the curriculum, there is a focus on deep knowledge and critical thinking skills development with the encouragement of the students to connect with the natural world around them. Furthermore, it also focuses on learner-centered, interactive, participating, practical, inquiry-based, problem-solving, and rational skills. Moreover, the assessment section for the curriculum provides guidelines regarding measuring students' capacity building about critical judgment, focusing on synthesis and analysis. For the final evaluation, the recommendation is described as including Bloom's taxonomy level and a minimum of 40% questions to be included for measuring higher-order thinking skills focusing on problem-solving and application based on analytical reasoning.

Recommendations

- They should be provided with complete professional development programs to warrant that teachers are well-equipped to implement the curriculum's aims linked to critical thinking skills efficiently.
- Assign adequate resources, involving well-equipped laboratories, present teaching aids, and access to digital resources, to aid the completion of interactive, problem-solving, and inquiry-based learning activities.
- Foster collaboration among teachers, educational institutions, and scholars to share best methods, practices, and novel teaching approaches that foster critical thinking skills in Chemistry.
- Consistently review and update the Chemistry curriculum to integrate the latest research findings and improvements in pedagogical procedures related to critical thinking skills.

- Further research may be conducted for the investigation of the challenges and opportunities related to the implementation of critical thinking skills development in the context of the Chemistry curriculum for grades IX-X.

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