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EVALUATING CHEMISTRY TEXTBOOKS IN GHANAIAN SENIOR HIGH SCHOOLS: A FOCUS ON THE PRESENTATION OF QUALITATIVE ANALYSIS AND PERSPECTIVES OF TEACHERS AND LEARNERS

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Abstract

This study investigated learner and teacher perspectives of chemistry textbooks, alongside a comparative analysis of textbook variations and the presentation of qualitative analysis concepts. A mixed-methods approach was employed, surveying 466 learners and 33 teachers, and evaluating three widely used chemistry textbooks in Ghana senior high schools. The findings revealed learners' positive perspectives of textbooks, but highlighted the need for enhanced visual and digital support. Teachers prioritized curriculum alignment and guidance, yet recognized gaps in concept representation. Textbook analysis exposed varying levels of comprehensiveness, presentation styles, and omissions. The study highlights the importance of considering learner and teacher perspectives, alongside textbook variations, to inform chemistry education. Recommendations include developing learner-centered textbooks, providing teacher professional development, and ensuring curriculum alignment and comprehensive concept representation. This research contributes to the ongoing effort to improve chemistry education, informing teachers, policymakers, and textbook developers. By addressing identified gaps, teachers can foster a deeper understanding of qualitative analysis concepts and promote effective learning outcomes.

Key words: *chemistry education, qualitative analysis, chemsitry textbooks, textbook evaluation, learner perspectives , teacher perspectives.*

INTRODUCTION

The significance of textbooks in the teaching-learning paradigm cannot be underrated. Literature emphasized textbooks' pivotal role as primary educational resources and shaping the instructional landscape (Smart & Jagannathan, 2018; Dockx et al., 2020). Effective textbook utilization has been linked to enhanced learner achievement, as it delineates curriculum boundaries and provides a structured framework for knowledge transmission (Musilekwa & Mulenga, 2019). Moreover, high-quality textbooks foster autonomous learning, cultivating critical thinking and analytical skills in learners (Chiu, 2017). In resource-constrained settings, textbooks assume added importance, compensating for potential instructional deficits and promoting educational equity for disadvantaged learners (Haulle & Kabelege, 2021). By providing standardized access to knowledge, textbooks democratize learning opportunities, thereby bridging the gap between socioeconomically diverse student populations.

Despite their centrality in education, textbooks are inherently flawed, often perpetuating alternative conceptions that hinder effective learning. Research reveals a striking correlation between learners' errors and textbook content, underscoring the potential for textbooks to misinform (Wijaya et al., 2015). Specifically, chemistry textbooks have been criticized for their presentation of complex concepts, such as chemical equilibrium, where ambiguous language and oversimplification can impede comprehension (Quílez, 2021). Similarly, the inadequate treatment of chemical kinetics and scant coverage of key topics limit learners' conceptual understanding (Gegios et al., 2016). Furthermore, prevailing

textbook approaches prioritize foundational skill acquisition over higher-order cognitive development, neglecting learner-centered pedagogies (Gurung et al., 2022). This teacher-centered orientation hampers learners' ability to engage with textbooks independently. Consequently, authors' expertise in chemical concepts assumes paramount importance, as their influence on learner achievement surpasses that of publishers (Abd-El-Khalick et al., 2017). This emphasizes the need for textbook authors to ensure the accuracy and pedagogical effectiveness of their materials.

Notwithstanding the profound limitations of textbooks on teaching and learning, a concerning oversight persists: subject teachers, including those in chemistry, rarely scrutinize textbook content (Vojíř & Rusek, 2022a). To ensure the accuracy and effectiveness of scientific information, rigorous evaluation of textbooks is imperative. As primary conduits of scientific knowledge, textbooks warrant meticulous examination to identify potential shortcomings (Wain, 2022). Teachers bear a professional responsibility to critically assess textbooks, examine their impact on learner outcomes and inform textbook selection for instructional purposes (Laabidi & Nfissi, 2016). Ahmadi and Derakhshan (2016) concur, advocating for textbook evaluation as an integral component of teacher practice. Regrettably, despite the abundance of textbooks globally, research on chemistry textbook evaluation remains inadequately understudied, with no investigations addressing this critical aspect of science education (Vojíř & Rusek, 2022a). This knowledge gap emphasizes the need for systematic textbook evaluation to inform evidence-based teaching practices.

In Ghanaian senior high schools, the plethora of chemistry textbooks available has failed to mitigate the persistent misconceptions and difficulties encountered by students in qualitative analysis experiments, as consistently highlighted in WAEC's chief examiners' reports (WAEC, 2017, 2018, 2020). Research in chemistry education corroborates these findings, revealing that high school learners (Adu-Gyamfi et al., 2024) and trainee chemistry teachers (Hanson, 2015) struggle to grasp qualitative analysis concepts. Specifically, learners' difficulties lie in comprehending experimental procedures, reactions, and inference-making, leading to incorrect tests, observations, and conclusions (WAEC, 2019, 2020). Notably, these challenges transcend national boundaries, with secondary school learners in Nigeria, Gambia, Sierra Leone, Singapore, and Malaysia facing similar hurdles (Lay & Osman, 2018; Shamsulbahri & Zulkiply, 2021; WAEC, 2018, 2019). This pervasive trend underscores the need for a thorough examination of textbook content and pedagogical approaches to improve learning outcomes in qualitative analysis.

As a cornerstone of chemistry curricula, qualitative analysis underpins various fields, including forensic chemistry, pharmaceutical chemistry, and medical laboratory technology. Its significance is reflected in its inclusion in prominent examinations, such as Cambridge IGCSE and WASSCE (CAIE, 2017a; WAEC, 2018-2023). Recent years have seen a surge in chemistry textbook evaluation studies (Hrast & Savec, 2024), primarily focusing on general chemistry or specific topics like organic/inorganic chemistry (Gurung et al., 2022), electrochemistry (Zupanc & Devetak, 2021), and chemical kinetics (Seethaler et al., 2018).

Research has consistently highlighted learners' conceptual difficulties with qualitative analysis in various countries, including Ghana (Adu-Gyamfi et al., 2024; Anim-Eduful & Adu-Gyamfi, 2022; Hanson, 2015), Malaysia (Shamsulbahri & Zulkiply, 2021; Lay & Osman, 2018), Singapore (Tan et al., 2009), Colombia (Guerrero et al., 2016), Turkey (Akkuzu & Uyulgan, 2017), and Morocco (Bouabdallah, 2021). This study addresses the absence of research on textbook presentations of qualitative analysis instruction, seeking to bridge this knowledge gap and inform evidence-based teaching practices. Grounded in constructivist theory, this study recognizes learners as active constructors of knowledge, building upon their existing cognitive frameworks (Clark, 2018). Constructivism, a

multidimensional paradigm, emphasizes learner-centered knowledge construction, contextualizing learning experiences. This theoretical framework aligns with the views of Jean Piaget, who posited that knowledge acquisition results from dynamic interactions between learners' environments and internal cognitive structures (Waite-Stupiansky, 2017). Piaget's concepts of accommodation and assimilation are pivotal to this study, as they illuminate how learners construct and reconstruct knowledge in qualitative analysis.

In chemistry education, constructivism is particularly relevant, as it acknowledges the intricate relationships between learners' prior knowledge, cognitive structures, and the learning process (DeKorver & Towns, 2016). Qualitative analysis, with its complex prerequisites, including acid-base reactions, solubility, and chemical bonding, necessitates learners' ability to assimilate and accommodate new concepts (Hanson, 2010; Tan et al., 2009). Constructivist principles facilitate this process, enabling learners to link concepts across symbolic, sub-microscopic, and macroscopic levels (Tan et al., 2009).

By embracing constructivism, this study acknowledges the significance of learners' internal frameworks and environmental interactions in shaping their understanding of qualitative analysis. The research questions guiding this investigation include:

How do learners perceive the presentation of qualitative analysis concepts in their chemistry textbooks?

What are chemistry teachers' perspectives regarding the presentation of qualitative analysis concepts in their textbooks?

How do different chemistry textbooks vary in their coverage, depth, and presentation styles of qualitative analysis concepts?

This study's constructivist foundation underscores the importance of contextualizing learning experiences, recognizing learners' agency, and addressing the complex interplay between prior knowledge, cognitive structures, and environmental factors.

RESEARCH METHODOLOGY

To comprehensively address the research problem and questions, this study employed a convergent mixed methods design, leveraging the strengths of both quantitative and qualitative approaches (McMillan & Schumacher, 2010). This design enabled the convergence of evidence, facilitating triangulation of findings and ensuring more reliable and robust conclusions (McMillan & Schumacher, 2010; Schoonenboom & Johnson, 2017). The two-stage methodology commenced with a survey, utilizing a proportional stratified random sampling technique to gather quantitative data from 466 senior high school chemistry learners and 33 teachers across nine public schools in Ghana's southern, northern, and middle-belt zones.

The survey method was chosen for its efficacy in gathering information on respondents' preferences, convictions, and knowledge (Cohen et al., 2007). This stage provided insights into textbook preferences and evaluations of chemistry textbook presentations on qualitative analysis. Subsequently, three popular chemistry textbooks were selected for in-depth case studies, offering a holistic understanding of how qualitative analysis concepts are presented (Yin, 2014).

Teacher participants were selected due to their critical role as curriculum implementers and stakeholders in the teaching-learning process (Syahabuddin et al., 2020; Bongco & David, 2020). Final-year elective science students were targeted, as they had completed the qualitative analysis curriculum and were preparing for their final exams, thereby providing a comprehensive understanding of the topic. The sample size was determined using Krejcie and Morgan's (1970) calculation, yielding a total of 466 students and 33 teachers.

Table 1. Presents The Distribution of Participating Schools, Teachers, and Learners

Table 1

Distribution of accessible population for the study

Variables	Sample size
Cape Coast Metropolis	
Selected public senior high schools offering elective chemistry	3
Elective chemistry teachers	11
Form three elective chemistry learners	172
Tamale Metropolis	
Public senior high schools offering elective chemistry	2
Elective chemistry teachers	8
Form three elective chemistry learners	101
Kumasi Metropolis	
Public senior high schools offering elective chemistry	4
Elective Chemistry Teachers	14
Form three elective chemistry learners	193

To inform the case studies, a tally of chemistry textbooks used by survey participants was conducted, yielding the top two most frequently used texts. The fourth most widely used textbook was selected over the third, considering its longevity and endorsement by the Ghana Association of Science Teachers, whose members authored the book.

To gather quantitative and qualitative data, three research instruments were designed: Teachers' Survey Questionnaire, Learners' Survey Questionnaire, and Textbook Evaluation Checklist on Qualitative Analysis. To investigate learners' and teachers' perspectives on the presentation of qualitative analysis concepts in chemistry textbooks, as well as the variations in textbook coverage, this study employed a multi-method approach. Specifically, the Learners' Survey Questionnaire was administered to gather data on learners' perspectives regarding the presentation of qualitative analysis concepts in their chemistry textbooks. Similarly, the Teachers' Survey Questionnaire was used to elicit chemistry teachers' perspectives on the same issue. To examine the variations in textbook coverage, depth, and presentation styles, a Textbook Evaluation Checklist on Qualitative Analysis was developed and applied to a selection of widely used chemistry textbooks. By triangulating data from these three instruments, this study provided a comprehensive understanding of the strengths and limitations of current chemistry textbooks in presenting qualitative analysis concepts.

Questionnaires, comprising closed and open-ended items, were chosen for their efficacy in collecting respondents' opinions, behaviors, and beliefs. Survey questionnaires ensured confidentiality, anonymity, and uniformity of responses (McMillan & Schumacher, 2010). All 33 chemistry teachers and 466 final-year elective chemistry learners from nine selected schools participated.

The Textbook Evaluation Checklist on Qualitative Analysis, featuring open-ended questions and Likert scale rating statements, assessed the qualitative analysis chapter in three government-approved chemistry textbooks. This instrument examined tasks, sequence, and scope of cation and anion analysis concepts, aligning with the chemistry curriculum objectives.

Following an exhaustive literature review, the research instruments were crafted to ensure content validity. Three experts in chemistry education at Accra College of Education reviewed the instruments for legibility, feasibility, and lucidity. To establish reliability, the survey instruments were piloted in three senior high schools, yielding Cronbach Alpha values of 0.74 (Teachers' Survey Questionnaire) and 0.78 (Learners' Survey Questionnaire), exceeding the 0.7 reliability threshold.

The Textbook Evaluation Checklist on Qualitative Analysis was pretested using two government-approved chemistry textbooks not included in the study, ensuring its suitability and effectiveness.

The learners' survey questionnaire data was analyzed utilizing SPSS version 28.0 software. A comprehensive codebook was developed, defining, labeling, and assigning unique codes to variables, while specifying scales of measurement. Open-ended responses were subjected to thematic analysis, where emergent themes were coded and integrated into the codebook. Each questionnaire was assigned a distinct identifier for efficient tracking.

Data entry was executed systematically, followed by rigorous data cleaning to ensure

accuracy. Initial exploratory data analysis employing diagrams and tables verified data integrity. Descriptive statistics subsequently illuminated the elemental features of the data.

Complementary to the survey analysis, a meticulous evaluation of qualitative analysis concept presentations in three popular chemistry textbooks was conducted using the Textbook Evaluation Checklist on Qualitative Analysis. Inter-rater reliability was ensured through independent assessments by the researcher and an experienced chemistry teacher. Discrepancies were resolved through collaborative discussions.

Thematic analysis revealed the strengths and weaknesses of each textbook, with emergent themes elaborated upon in-depth. This dual-pronged analytical approach provided a comprehensive understanding of learners' perspectives and textbook presentations, yielding a rich dataset for informed conclusions.

RESULTS AND DISCUSSION

The study's results are presented in alignment with the research questions. The first research question explored learners' perspectives of their chemistry textbooks. To contextualize these findings, Table 1 provides demographic information on the 466 participating senior high school learners.

Table 2

Demographics of Learners who participated in the survey

Characteristic	Number (n)	Percentage (%)
Gender		
Male	293	62.9
Female	173	37.1
Age		
Less than 12 years	1	0.2
12 to 14 years	5	1.1
15 to 17 years	311	66.7
18 years and above	149	32.0
Programme		
Science	456	97.9
Technical	1	0.2
Agricultural science	9	1.9
School type		
Boys only	161	34.5
Girls only	60	12.9
Coeducational	245	52.6
Elective subjects' combination		
Chemistry, physics, elective mathematics, and biology	384	82.4
Chemistry, physics, elective mathematics, and ICT	56	12.0
Chemistry, physics, elective mathematics, and geography	15	3.2
Chemistry, physics, technical drawing, and metal works	2	4
Chemistry, physics, engineering drawing and electricals	0	0
Chemistry, physics, general agriculture, and animal husbandry	9	1.9

The demographic data reveal a notable gender disparity, with males (n = 293) outnumbering females (n = 173). The age distribution shows that 311 learners (66.7%) fell within the 15-17 age range, although one outlier was less than 12 years old. The sample comprised learners from diverse school settings: coeducational (52.4%, n = 245), boys' single-sex (34.5%, n = 161), and girls' single-sex (12.9%, n = 60) schools.

Furthermore, the elective subject combinations revealed that the majority (82.4%) of learners studied physics, elective mathematics, and biology in conjunction with chemistry. The remaining learners pursued alternative elective subject combinations. These demographic characteristics provide a foundation for understanding learners' views on their chemistry textbooks.

Learners Perspectives of Chemistry Textbooks

The study revealed diverse learner perspectives on their chemistry textbooks, as presented in Table 3. Notably, a significant majority of respondents (72.3%) reported that their chemistry textbooks were teacher-recommended, and 75.7% confirmed that these texts adequately covered qualitative analysis content.

Table 3

Learners' evaluation of chemistry textbooks

	Percentages				
Statement	SD	D	NS	A	SA
The chemistry textbook(s) I am currently using was recommended by my chemistry teacher(s)	8.4	12.7	6.7	34.1	38.2
The chemistry textbook I use has adequate content on qualitative analysis and its related concepts	3.2	8.2	12.9	48.9	26.8
The chemistry textbooks I use enhances higher thinking skills on qualitative analysis	5.2	9.4	20.4	45.5	19.5
Concepts in chemistry textbooks on qualitative analysis are teacher-centered and not student-centered	10.5	33.9	26.6	20.4	8.6
Concepts on qualitative analysis in my chemistry textbook(s) are easy to understand	7.3	16.5	17.2	44.4	14.6
The chemistry textbooks I use has pictures and links to videos on qualitative analysis	36.1	29.0	12.9	15.7	6.4
The chemistry textbook I use has many exercises/tasks on qualitative analysis	6.4	12.4	11.8	45.5	23.8
Text complexity of chemistry textbooks I use is appropriate for my level of understanding	9.2	12.9	31.1	36.9	9.9

*SD: Strongly disagree; D: Disagree; NS: Not sure; A: Agree; SA: Strongly Agree

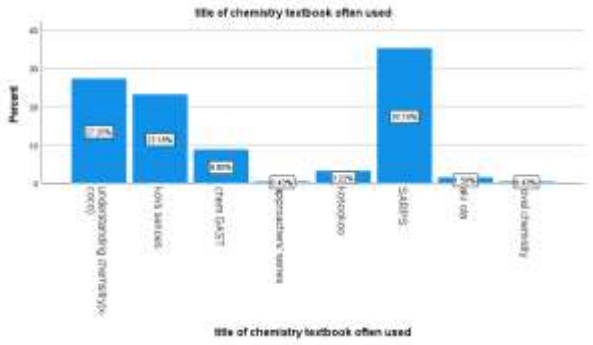
The data suggests that learners generally held positive views about their chemistry textbooks, perceiving them as conducive to higher-order thinking and understanding. Specifically, 59.0% of respondents found qualitative analysis concepts easy to comprehend. Additionally, many learners appreciated the textbooks' task-oriented approach, with appropriate text difficulty.

However, a notable discrepancy emerged regarding multimedia enhancements. Only 22.1% of learners reported that their textbooks incorporated symbols, pictures, and video links to facilitate qualitative analysis understanding. This shortfall highlights a potential area for improvement in textbook design.

These findings underscore the importance of teacher recommendations and content adequacy in shaping learners' perspectives of chemistry textbooks. Nevertheless, the results also emphasize the need for enhanced visual and digital supports to augment qualitative analysis instruction.

Textbook Utilization Patterns

Figure 1 below provides a visual representation of the most frequently employed chemistry textbooks among respondents. A notable disparity emerges in textbook usage, with SARPS' series dominating as the most widely used textbook (35.2%). This prevalence suggests a strong reliance on this resource among senior high school learners.
Figure 1



In contrast, Approachers' Series and Noval Chemistry were found to be the least utilized textbooks. Kov's series secured the third position in terms of frequency of use. Interestingly, Chemistry GAST, the flagship textbook of the Ghana Association of Science Teachers, ranked fourth in usage among respondents.

These findings highlight the varied textbook preferences among senior high school learners and teachers, potentially influencing instruction and learning outcomes. The dominance of the SARPS'series warrants further investigation into its features and effectiveness.

Demographic Profile of Chemistry Teachers

Table 3 presents the demographic characteristics of the 33 senior high school chemistry teachers participating in the survey. A significant gender disparity is evident, with males (n = 29) outnumbering females (n = 4), indicating a predominantly male-dominated teaching workforce in chemistry.

Table 4

Demographics of teachers who participated in the survey

Characteristic	Number (n)	Percentage
Gender		
Male	29	87.9
Female	4	12.1
Age Range		
21 to 30 years	4	12.1
31 to 40 years	17	51.5
41 to 50 years	11	33.3
51 to 60 years	1	3.0
Highest Educational Qualification		
Bachelor's degree	20	60.6
Master's Degree	12	36.4
PhD	1	3.0
Area of Specialization		
Chemistry	31	93.9
Agricultural Science	2	6.1
Years teaching chemistry		
1 to 5 years	8	24.2
6 to 10 years	8	24.2
11 to 15 years	8	24.2
16 to 20 years	5	15.2
21 to 25 years	3	9.1
26 years and above	1	3.0
Teach other subject(s) in addition to chemistry		
Yes	23	69.7
No	10	30.3
Category of School		
Category of A	12	36.4
Category B	9	27.3
Category C	11	33.3
Category D	1	3.0
School type		
Boys only	6	18.2
Girls only	6	18.2
Co-educational	21	63.6

The age distribution reveals a concentration of teachers (51.5%, n = 17) within the 31-40 age range. Notably, the vast majority (93.9%) of teachers specialized in chemistry, although 6.1% taught outside their area of specialization. Additionally, 69.7% of teachers taught multiple subjects beyond chemistry.

The teaching context and experience levels of respondents are also noteworthy. Most teachers (63.6%) were employed in coeducational schools, and 75.8% had six or more years of teaching experience in chemistry, indicating a seasoned teaching workforce.

These demographic findings provide valuable insights into the composition and

characteristics of senior high school chemistry teachers, highlighting potential implications for teacher training, specialization, and instructional effectiveness.

Teacher Perspectives on Textbook Evaluation and Quality

Table 5 presents the chemistry teachers' views on textbook evaluation and availability, shedding light on instructional support for qualitative analysis. Notably, an overwhelming majority (87.9%) of teachers reported evaluating textbooks to ensure alignment with the Senior High School (SHS) chemistry curriculum.

Table 5 *Teachers' responses on textbooks evaluation*

	Percentages				
Statement	SD	D	NS	A	SA
I usually evaluate chemistry textbooks I use to ensure they are in line with the SHS chemistry curriculum objectives	3.0	0.0	9.1	36.4	51.5
I assist my learners to choose appropriate chemistry textbook	3.0	0.0	0.0	45.5	51.5
All my learners have the required/recommended chemistry textbooks	6.1	33.3	18.2	27.3	15.2
The chemistry textbook I use has adequate content on qualitative analysis and its related concepts	3.0	9.1	24.2	30.3	33.3
The chemistry textbooks I use enhances higher thinking skills on qualitative analysis	3.0	9.1	24.2	36.4	27.3
The chemistry textbook I use is appropriate for the level of my learners	0.0	9.1	9.1	51.5	30.3
Concepts in chemistry textbooks on qualitative analysis are teacher-centered and not learner-centered	24.2	30.3	21.2	18.2	6.1
Common errors made by learners in qualitative analysis can be attributed to how concepts are presented in chemistry textbooks	12.1	42.4	21.2	15.2	9.1
The chemistry textbooks I use depicts qualitative analysis concepts at symbolic, submicroscopic, and macroscopic levels	24.2	36.4	0.0	21.2	18.2
Text complexity in the chemistry textbooks is appropriate for the level of understanding of my learners	6.1	12.1	27.3	36.4	18.2

*SD: Strongly disagree; D: Disagree; NS: Not sure; A: Agree; SA: Strongly Agree

Teachers demonstrated a strong commitment to guiding learners in selecting suitable chemistry textbooks, with 97.0% reporting this practice. However, variability emerged regarding textbook quality. While 63.6% of teachers deemed their textbooks adequate for covering qualitative analysis and related concepts, only 39.4% believed these texts effectively represented concepts at symbolic, submicroscopic, and macroscopic levels.

Moreover, a minority (24.3%) of teachers attributed common learner errors in qualitative analysis to inadequate concept presentation in textbooks. This finding suggests that teachers may recognize additional factors contributing to learner difficulties.

These results highlight the importance of teacher agency in textbook evaluation and selection, underscoring the need for ongoing professional development and high-quality instructional materials to support effective teaching and learning of qualitative analysis.

Textbook Analysis: Presentation of Qualitative Analysis Concepts

This study analyzed three National Council for Curriculum and Assessment (NACCA)-approved chemistry textbooks for senior high schools in Ghana: CSSS (Ameyibor & Wiredu, 2006), CNMC (Sarpong, 2021), and UC (Ansong, 2021). The analysis focused on how these textbooks present qualitative analysis concepts.

The findings reveal varying levels of comprehensiveness in covering qualitative analysis. CSSS dedicated 9 pages (261-269) to qualitative analysis, while CNMC allocated 29 pages (355-384) and UC spread the concept across two chapters (13 and 20). Notably, all three textbooks covered the nine cations and eight anions specified in the Ghanaian chemistry curriculum.

However, differences emerged in presentation styles and depth. CSSS emphasized solubility rules and precipitate formation, whereas CNMC and UC explored qualitative analysis beyond aqueous solutions, incorporating solid-state substances and flame tests. UC provided explanations for flame test procedures and included a picture illustrating the process.

The textbooks shared similarities in presenting cation analysis content, but lacked connections to related topics like acid-base reactions, redox reactions, periodicity, and complex salt formation. None of the textbooks utilized chemical equations to explain cation analysis reactions or provided links to simulations/videos for enhanced visualization.

Table 6 summarizes the similarities and differences in cation analysis content presentation across the three textbooks. The findings underscore the need for textbooks to integrate qualitative analysis with broader chemical concepts and incorporate multimedia resources to facilitate deeper understanding.

Table 6

Evaluation of cation analysis content in the chemistry approved textbooks

Textbook gave reason(s) for the following statements:	CSSS	CNMC	UC
Explained why $NH_{3(aq)}$ or $NaOH_{(aq)}$ are used for preliminary test of cation.	No	No	Yes
Gave reason(s) why $NH_{3(aq)}$ or $NaOH_{(aq)}$ are added in drops and in excess	Yes	No	No
Explained why moist red litmus paper is brought close to the open end of the boiling tube when testing for $NH_{4(aq)}^{+}$ using $NaOH_{(aq)}$	No	No	No
Explained precaution to take when using moist litmus paper	No	No	Yes
Used equations to denote reactions which occurred during cation analysis	No	Yes#	No
Provided links to simulations/videos on cation analysis	No	No	No
Explained precipitation reactions which occur during cation analysis	Yes	No	No
Explained complex salt formation during cation analysis	No	Yes#	No
Explained why a solution of $Fe^{2+}_{(aq)}$ turns brown on the surface of the mixture and walls of test tube on standing	No	No	No
Explained why no visible reaction is seen when $NH_{3(aq)}$ is added in drops or excess to a solution containing $Na^{+}_{(aq)}$	No	No	No
Differentiated between precipitate and complex ion formation	No	No	No
Related concepts on cation analysis to what had been discussed in previous chapters on:			
acid-base reactions	No	No	No
redox reactions	No	No	No
Periodicity	No	No	No
Complex salt formation	No	No	No
Double decomposition/precipitation reactions	No	No	No
Solubility rules	Yes	No	No

Note: # means concept only appeared in the sample questions.

Textbook Analysis: Anion Analysis Concept Presentation

Table 7 below reveals a striking similarity in the presentation of anion analysis concepts across the three chemistry textbooks (CSSS, CNMC, and UC). Notably, the authors employed a uniform approach, but with significant omissions.

Table 7

Evaluation of anion analysis content in three chemistry approved textbooks

Textbook gave reason(s) for each of the following:	CSSS	CNMC	UC
Explained why specific test reagents such as $AgNO_{3(aq)}$, $BaCl_{2(aq)}$ and $Pb(NO_3)_{2(aq)}$ are used for anion analysis.	No	No	No
Explained why test reagents such as $AgNO_{3(aq)}$, $BaCl_{2(aq)}$ $Ba(NO_3)_{2(aq)}$ and $Pb(NO_3)_{2(aq)}$ are followed by acids such as $HNO_{3(aq)}$ or $HCl_{(aq)}$ during anion analysis	Yes	No	No
Used equations to denote reactions which occurred during anion analysis	No	Yes#	No
Explained why excess $NH_{3(aq)}$ is added to a precipitate of $AgCl_{(s)}$ during anion analysis of $Cl^{-}_{(aq)}$	No	No	No
Explained why there is evolution of gases during anion analysis of $CO_3^{2-}{}_{(aq)}$ and $SO_3^{2-}{}_{(aq)}$ after addition of an acid.	No	No	No
Explained why $FeSO_{4(aq)}$ used during anion analysis of $NO_3^{-}{}_{(aq)}$ should be freshly prepared	No	No	No
Explained why acidified (H_2SO_4) $KMnO_{4(aq)}$ is used to confirm the presence of $SO_3^{2-}{}_{(aq)}$ or $S^{2-}{}_{(aq)}$	No	No	No
Linked microscopic, submicroscopic, and macroscopic concepts on anion analysis	No	No	No
Related concepts on anion analysis to what had been discussed on:			
acid-base reactions	No	No	No
redox reactions	No	No	No
Solubility rules	No	No	No

Note: # - only appeared in the sample questions.

A critical gap emerged in the lack of explanatory rationales for the selection of test reagents, such as AgNO3(aq), BaCl2(aq), and Pb(NO3)2(aq), used to identify anions. Only CSSS provided a cursory explanation for the sequential use of these reagents followed by acids (HNO3(aq) or HCl(aq)) in anion analysis experiments, while CNMC and UC omitted this crucial detail.

Furthermore, the textbooks demonstrated limited use of chemical equations to illustrate anion analysis reactions. CNMC sporadically employed equations in sample questions, whereas CSSS and UC entirely neglected this explanatory tool. The absence of visual aids, such as pictures or links to videos, further hindered readers' ability to visualize complex reactions.

These findings suggest that the textbooks may not adequately support learners' comprehension of anion analysis concepts. The omission of explanatory rationales and visual aids may undermine students' ability to critically evaluate and apply anion analysis principles.

The complexities of choosing effective chemistry textbooks are well-documented (Saadipour & Shakouri, 2016). However, this study reveals a notable exception. Learners and teachers participating in the survey consistently reported that teachers played a pivotal role in selecting suitable chemistry textbooks, alleviating the difficulty of choice.

This collaborative approach complements existing research emphasizing teacher involvement in textbook evaluation (Ahmadi & Derakhshan, 2016). As primary users of textbooks, teachers' and learners' perspectives are crucial in ensuring curriculum alignment and instructional effectiveness.

Notably, teachers reported evaluating textbooks to ensure congruence with the senior high school chemistry curriculum, underscoring their agency in textbook selection. This finding challenges the assertion that textbook evaluation is solely the domain of scholars (Marpaung &

Pongkendek, 2020), instead highlighting the importance of teacher expertise in this process.

The study's results suggest that teacher-learner collaboration in textbook selection can facilitate engaging and simplified learning experiences, mitigating the challenges associated with textbook choice.

This study reveals a positive consensus among chemistry teachers and learners regarding the quality of their textbooks. Both groups reported favorable perspectives , indicating that their textbooks effectively foster higher-order thinking skills and maintain an appropriate level of difficulty.

These findings align with Akef and Moosavi's (2014) research, which similarly found that teachers and learners generally hold positive views of their textbooks. However, our results diverge from Rusek and Vojíř's (2019) study, which identified inconsistencies between text complexity and learners' grade levels in secondary school chemistry textbooks.

Notably, the discrepancy in text complexity found by Rusek and Vojíř (2019) can have deleterious effects on learners' understanding of chemistry concepts. In contrast, our study suggests that the chemistry textbooks used by participants strike an optimal balance between challenge and accessibility.

The convergence of teacher and learner perspectives in this study underscores the importance of considering stakeholder perspectives in textbook evaluation. These findings contribute to ongoing discussions on textbook quality and its implications on chemistry education.

This study reveals a divergence between teacher/learner perspectives and existing research regarding the quality of chemistry textbooks. Notably, participants expressed satisfaction with the content of qualitative analysis, contradicting Aldahmash and Omar's (2021) finding that chemistry textbooks prioritize teacher-centered approaches. Instead, teachers in this study reported that their textbooks employed learner-centered presentations.

However, a disconnect emerged between teacher perspectives and the potential relationship between the textbook content and learner errors. While teachers generally absolved their textbooks of responsibility for common errors in qualitative analysis, Wijaya et al.'s (2015) research suggests that textbook content plays a significant role in learner misconceptions.

Despite overall positive evaluations, learners and teachers identified significant limitations in their textbooks. Specifically, they noted the absence of visual aids (pictures and video links) to support qualitative analysis concepts. Furthermore, teachers acknowledged that their textbooks failed to provide opportunities for integrating concepts across symbolic, submicroscopic, and macroscopic levels.

These findings highlight the complexities of textbook evaluation and the need for nuanced assessments of chemistry education resources. While teachers and learners reported general satisfaction, specific limitations underscore the importance of ongoing textbook development and refinement.

A critical examination of chemistry textbooks used by survey participants revealed a disconnect between their high ratings and the textbooks' actual effectiveness. Despite favorable evaluations, these textbooks exhibited significant limitations in qualitative analysis concepts, potentially hindering learners' comprehension (Dockx et al., 2020).

The three evaluated textbooks included some tasks on qualitative analysis, but fell short of ideal standards. Specifically, they lacked thought-provoking questions essential for deep conceptual understanding (Allen et al., 2015). Notably, CSSS had the fewest tasks, while UC and CNMC relied heavily on recycled WASSCE chemistry practical questions.

A concerning limitation emerged: the textbooks' tasks failed to provide learners with opportunities for experiment design and implementation. Instead, learners were confined to following predetermined instructions, potentially stifling creativity and experimental skills development (Marpaung & Pongkendek, 2020).

This finding resonates with Bakken and Andersson-Bakken's (2021) observation that Norwegian science textbooks similarly neglected to cultivate essential skills.

This deficiency is particularly troubling given the Ghanaian Senior High School chemistry curriculum's emphasis on developing learners' capabilities to design experiments addressing practical chemistry problems (Ministry of Education, Science and Sports, 2010). The textbooks' shortcomings may undermine this curricular aim, highlighting the need for revised content that prioritizes learner-centered, inquiry-based learning experiences.

Research emphasizes the importance of connecting chemical concepts across microscopic, symbolic, and macroscopic levels to enhance learner understanding (Sujak & Daniel, 2018; Talanquer, 2018). However, a critical evaluation of the evaluated textbooks revealed a significant omission: none provided opportunities for learners to establish these crucial linkages.

Furthermore, the textbooks lacked supplementary resources, such as video links or simulations, to facilitate qualitative analysis experimentation. Equations supporting reactions during these experiments were also scarce. This finding contradicts Tan et al.'s (2009) evidence that presenting concepts at multiple representative levels fosters mastery of chemical qualitative analysis.

The absence of multi-level concept linkage in these textbooks has profound implications. Research warns that neglecting this approach can severely impair learners' conceptual understanding in chemistry (Dumon & Mzoughi-Khadhraoui, 2014). Conversely, facilitating multiple representations of chemistry concepts can enhance learners' ability to articulate written arguments and deepen their understanding (Hand & Choi, 2010).

This study highlights the need for revised textbook content that integrates multi-level concept linkage, supplementary resources, and equation-based explanations to promote comprehensive understanding and critical thinking skills in chemistry.

CONCLUSION

This study explored three critical research questions to gain a comprehensive understanding of the presentation of qualitative analysis concepts in Senior High School chemistry textbooks.

Firstly, the investigation into learners' perspectives revealed that students generally hold positive views about their chemistry textbooks, finding them conducive to higher-order thinking and understanding. The findings reveal a complex landscape of learner perspectives, highlighting both strengths and weaknesses in textbook design and utilization. The lack of multimedia enhancements, such as symbols, pictures, and video links, hinders qualitative analysis understanding. The study recommends that textbook authors and publishers should prioritize multimedia enhancements and interactive features.

Secondly, the study's findings on teacher perspectives indicated that educators prioritize curriculum alignment and actively guide learners in selecting suitable textbooks. While most teachers deem textbooks adequate for covering qualitative analysis, significant gaps exist in representing concepts at multiple levels (symbolic, submicroscopic, and macroscopic. Teachers recognize textbook limitations but attribute learner errors to multifaceted factors beyond inadequate concept presentation. These implies that educational authorities should provide teachers with regular training and resources for textbook evaluation. In addition, textbook developers should prioritize comprehensive concept representation and clarity.

Lastly, the comparative analysis of different chemistry textbooks revealed varying levels of comprehensiveness, differences in presentation styles, and significant omissions. The study highlighted the dominance of certain textbooks, such as SARPS' series, and the need for enhanced multimedia resources and connections to broader chemical concepts. While the textbooks covered the required cations and anions, they lacked connections to broader chemical concepts, explanatory rationales for test reagent selection, and visual aids to facilitate deeper understanding. Textbook authors should integrate qualitative analysis with related chemical concepts to promote a holistic understanding. The study is calling for a revised textbook guidelines emphasizing comprehensive coverage and innovative presentation.

Integrating these findings, this study highlights the importance of considering learner

and teacher perspectives, alongside textbook variations, to enhance the presentation of qualitative analysis concepts. To improve chemistry education, educators and policymakers should prioritize developing learner-centered textbooks with multimedia enhancements. Provide teachers with ongoing professional development on textbook evaluation and ensure curriculum alignment and comprehensive concept representation.

These findings underscore the need for rigorous textbook evaluation and revision to ensure accuracy, completeness, and alignment with learning objectives. By addressing these deficiencies, educators can foster a more comprehensive understanding of qualitative analysis and mitigate conceptual difficulties.

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