JRIIE Journal of Research Innovation and Implications in Education
Center for Research Implications & Practice

Website: www.jriiejournal.com ISSN 2520-7504 (Online) Vol.9, Iss.4, 2025 (pp. 1058 - 1075)

Challenges Facing the Competence-Based Approach to the Teaching of Chemistry among Undergraduates in Developing Economies: A Case Study of Tanzania Higher Education Institutions

Ochieng O Anthony[1] & Soud Hamad Ali[2]
https://orcid.org/000-0002-1463-5280 - WEB of Science: AFK-9191-2022
[1]Lecturer, Faculty of Science, Department of Life Sciences, Chemistry Unit, Zanzibar University
[2]Lecturer, Faculty of Arts and Social Science, Education Department, Zanzibar University
Email: d_norbatus@yahoo.com/soudhamad82@yahoo.com

Abstract: *This study examines challenges facing the adoption and effectiveness of the Competence-Based Approach (CBA) in the teaching of undergraduate chemistry within developing economies, with a specific focus on higher education institutions in Tanzania. As universities in Tanzania shift towards learner-centred pedagogies, CBA is intended to strengthen scientific inquiry skills, promote real-world problem solving, technological advancement and improve practical competence among chemistry students. However, evidence across these institutions of higher learning reveals significant variation in implementation quality. This paper synthesizes recent empirical studies, policy documents, and institutional reports to explore the opportunities and challenges influencing CBA integration. Apart from gains made in chemistry education, this study have realized among the major constraints are inadequacy in laboratory and practical infrastructure, technological competency which relates effective use of digital tools, simulations and molecular modeling software to enhance student engagement and visualization of complex chemical processes, social and communication competency which encompasses the ability to communicate scientific ideas clearly, lack of collaboration, lack of industrial attachment , maintaining a positive and inclusive classroom environment, and persistent reliance on theoretical examination-driven instruction. Despite these barriers, emerging innovations such modularized curricula, research-based learning, and industry-linked practical demonstrate potential for strengthening chemistry education outcomes. This study highlights critical gaps and proposes strategic interventions to enhance CBA delivery within resource-limited environments. The study recommends systemic support, sustained capacity building, and alignment between instructional practices, relevant industrial attachments, pedagogic assessments, and professional expectations towards achieving competency.*

Keywords: *Undergraduates, Competence Based Approach, Pedagogical Competence, Undergraduate Chemistry, Teaching and Learning Resources, Chemistry fluency*

How to cite this work (APA):

Ochieng, A. O. & Soud, H. A. (2025). Challenges Facing Competence-based Approach to the Teaching of Chemistry among Undergraduates in Developing Economies. A Case Study of Tanzania Higher Education Institutions. *Journal of Research Innovation and Implications in Education, 9*(4), 1058 – 1075. **https://doi.org/10.59765/th83v83**.

1. Introduction

The competence-based approach (CBA) has become a central reform agenda in higher education across many developing economies, driven by the need to produce graduates with practical skills, problem-solving abilities, and the capacity to apply scientific knowledge in real-world settings (UNESCO, 2019; OECD, 2020). In Tanzania, the adoption of CBA within undergraduate chemistry programs reflects national efforts to shift university teaching from traditional, content-driven instruction toward more active, learner-centred pedagogies that emphasize competence development (MOEST, 2016; TCU, 2021). Despite these policy intentions, the implementation of CBA in higher learning institutions remains inconsistent. Several studies in East Africa report persistent challenges such as inadequate laboratory facilities, limited training for instructors, large class sizes, and misalignment between curriculum expectations and institutional capacity (Mtebe & Raphael, 2018; Kafyulilo, 2020; Mwinuka et al., 2022). These constraints continue to undermine the effective practice of competence-based teaching and assessment in chemistry, contributing to a widening gap between policy aspirations and classroom realities. Understanding these challenges is crucial for improving the quality of chemistry education and strengthening the broader curriculum reform process within Tanzania's higher education sector. This study therefore investigates the major barriers affecting the adoption and implementation of the competence-based approach in the teaching of chemistry among undergraduate students in Tanzania's higher institutions. The findings are intended to inform institutional decision-making, pedagogical capacity-building, and future curriculum improvement efforts.

2. Literature Review

The global shift toward competence-based education (CBE) and competence-based approaches (CBA) has significantly influenced curriculum reforms in higher education (Harden, 2007; Biggs & Tang, 2015). In East African universities, there is growing recognition that traditional lecture-based, content-driven teaching is insufficient for preparing graduates for research, industry, and professional practice (Suleiman, 2020; Majiwa et al, 2025). Studies have indicated that graduates trained under CBA frameworks demonstrate greater practical skill proficiency, subject fluency, confidence in laboratory settings, and readiness for employment (Suleiman, 2020: Maiyuria & Gakunga, 2025). Consequently, many institutions have begun adopting CBA or outcome-based education (OBE) principles to enhance the quality and relevance of undergraduate chemistry programs.

In Tanzania, competence-based curricula (CBC) and CBA have been promoted across all levels of education as part of broader reforms aimed at shifting instruction from teacher-centred, content-focused methods to learner-centred and skills-oriented pedagogy. These reforms are intended to foster practical competencies, chemistry fluency, problem-solving, and real-world application of knowledge (Ochieng et al 2019; Suleiman, 2020). Competency-based education (CBE) and competence-based approaches (CBA) have been foregrounded in Tanzanian education reforms over the last two decades as part of efforts to orient curricula toward demonstrable skills and employability. The formal transition from content-based to competence-based curriculum began around 2005, driven by the need to produce graduates equipped with practical, applicable skills rather than rote-memorized knowledge.

The main objective of undergraduate chemistry education is to build students' conceptual understanding of fundamental chemical principles while developing practical skills, scientific inquiry competencies, and problem-solving abilities required to interpret and apply chemical knowledge in real-world contexts. These are the emphasis and tenets of CBA towards undergraduate chemistry programs (Schweiker, 2023; Maiyuria & Gakunga, 2024). At this level, instruction aims to cultivate students' capacity to design and conduct experiments, analyze and interpret data, apply evidence-based reasoning, and address environmental, societal, and industrial challenges. Additionally, undergraduate chemistry seeks to develop positive scientific attitudes, ethical responsibility, and readiness for advanced studies or professional practice in chemistry-related fields. Competence-based chemistry curricula therefore aim to produce graduates who can not only understand theory but also design experiments, analyze results, communicate findings, and collaborate effectively (Mpofu, 2019).

However, the effectiveness of these reforms depends heavily on the quality of preparation offered at lower levels of education. Evidence shows that Tanzania's implementation of CBC/CBA in secondary schools the foundational stage for future chemists faces persistent challenges, including inadequate laboratory facilities, limited teaching resources, insufficient teacher training, and misaligned assessment systems (Kigwilu & Mokoro,2022; Chacha & Onyango, 2022). As a consequence, many students entering university lack the conceptual understanding and foundational competencies expected of secondary-school graduates and they try to reciprocate the same learning strategies from higher secondary schools into universities.

These systemic gaps raise concerns about the feasibility of fully realizing competence-based chemistry education at the undergraduate level. Studies reveal that many secondary-school chemistry teachers were not sufficiently familiarized with CBC/CBA requirements, leading to continued reliance on rote learning for examination purposes (Ochieng et al 2019; Suleiman, 2020). Furthermore, many teacher-training and higher-education programs rely on lecturers who are trained primarily in educational theory but possess limited practical or applied chemistry backgrounds, further complicating effective CBA implementation (Ochieng et al, 2019).

This has led to Tanzania Commission for Universities (TCU) to make call in their TCU 2024 Curriculum Framework for universities to revise their curricula to align with competence-based approaches that integrate curriculum, pedagogy, and assessment around measurable learning outcomes. These reforms have led to all universities in Tanzania offering degree in chemistry to review their syllabuses in order to strengthen experimental skills, analytical thinking, laboratory safety, data interpretation, and scientific communication. However, in practice, assessment formats remain largely unchanged, reflecting limited progress among many lecturers and even greater challenges among newly recruited staff. As a result, inconsistencies in implementation driven by infrastructural limitations, pedagogical weaknesses, and broader systemic constraints continue to undermine the realization of competency-based goals.

While OBE and CBA are intended to shift universities away from time-based, lecture-heavy delivery toward student-centred, outcome-driven learning (Majiwa et al, 2025), evidence shows that laboratory work, research projects, and real-world problem-solving exercises often remain peripheral components of undergraduate chemistry training. Research across East African universities indicates that lecturers face difficulties transitioning to active learning approaches due to limited experience, large class sizes, and time constraints (Kigwilu & Mokoro, 2022; Chacha & Onyango, 2022). Studies further show that, despite the use of blended learning and virtual laboratory simulations, research-based learning projects that expose students to industrial, environmental, and healthcare applications are still lacking. Industry partnerships that could support practical training, internships, and applied research remain poorly developed, contrary to recommendations by Mpofu (2019) and Maiyuria & Gakunga, (2024).

Although TCU has expanded investments in professional development and CBA-focused workshops, implementation remains uneven. Despite her CBA implementation achievements in undergraduate chemistry programs of connecting theoretical classroom work to commensurate with practical studies, most universities have incorporated this brilliant idea in curricula writing but in real sense it is not fully practiced due to financial and budgetary allocations for chemistry programs by the relevant institutions. Thus, CBC/CBA is widely adopted on paper, its translation into effective chemistry teaching, especially practical, competence-based instruction remains problematic. The main barriers are structural (lack of laboratories and resources), budgetary allocation constraints, human (lack of teacher training and pedagogical competence), and systemic (assessment regimes centered on recall, insufficient monitoring/evaluation). This has created several critical gaps which include the limited availability of empirical studies on competence attainment and employability outcomes among chemistry undergraduates; a scarcity of longitudinal evaluations tracking competency development over time; few comparative studies across universities to identify best practices and scalable models; and inadequate research on the integration of ICT tools and blended-learning approaches in competence-based chemistry curricula. Moreover, there is a lack of well-trained lecturers who can deliver CBA effectively and contextualize chemistry knowledge to meet industrial requirements. Rigorous empirical research that tracks the transition from secondary to tertiary education, evaluates practical competences, laboratory learning outcomes, and employability remains rare or absent. These gaps underscore the need to examine how CBA is implemented within undergraduate chemistry programs and how it influences the quality of chemistry education in the region, forming the basis of the present study.

3. Methodology

This study employed a systematic literature review design to examine the adoption and effectiveness of the Competence-Based Approach (CBA) in undergraduate chemistry education in Tanzania. The review focused on CBA implementation practices, scientific and practical competencies, technological competence, communication and social skills, curriculum delivery, institutional capacity, pedagogical constraints, and emerging innovations.

3.1 Sample and Sampling

The "sample" consisted of documents and scholarly works meeting the review criteria. Purposive sampling was applied to select literature directly addressing CBA reforms in higher education chemistry programs in Tanzania or similar developing contexts. The review focused on publications from 2015 to 2024.

3.2 Data Sources and Search Strategy

Literature was retrieved from Google Scholar, ERIC, ResearchGate, Scopus, Web of Science, and institutional repositories including TCU and MoEST. Search terms included: "competence-based approach," "undergraduate chemistry," "CBA implementation," "chemistry education Tanzania," "STEM education reforms," "laboratory infrastructure," and "competency development."

3.3 Inclusion and Exclusion Criteria

3.3.1 Inclusion criteria: Peer-reviewed articles, theses, institutional reports, and policy documents focusing on higher education chemistry or STEM-related CBA reforms in Tanzania or similar contexts.

3.3.2 Exclusion criteria: Publications before 2015, studies unrelated to competency development, research on primary/secondary education unless transferable, duplicates, and documents without full-text access.

3.4 Data Collection Tools and Procedure

A document analysis matrix captured publication details, context, CBA practices, competencies addressed, challenges, innovations, and key findings. Documents were screened using the inclusion/exclusion criteria, catalogued in the matrix, and cross-checked for accuracy. Open coding was applied to extract relevant data systematically.

3.5 Data Analysis

For data analysis, thematic analysis was employed following the structured phases outlined by Braun and Clarke (2006). Initially, all eligible studies were read repeatedly to achieve familiarization with the content. Relevant data were then systematically coded to capture key concepts related to instructional practices, student competencies, and institutional challenges. Similar codes were grouped into broader categories, which were iteratively refined into coherent themes. These themes were reviewed for consistency and alignment with the original studies before being **s**ynthesized to interpret overarching patterns, trends, and gaps in the adoption and effectiveness of the competence-based approach in undergraduate chemistry education.

3.6 Ethical Considerations

Ethical rigor was maintained through accurate citation, transparency of procedures, avoidance of bias via systematic screening, and respect for intellectual property. Institutional ethical clearance was not required as the study was document-based.

4. Results and Discussion

4.1 Findings

4.1.1 CBA Implementation

Most studies reported partial implementation of CBA, with strong emphasis on curriculum redesign but limited transformation at the classroom level. Although many lecturers meet the qualification requirements of the Tanzania Commission for Universities (TCU), the literature suggests that their pedagogical competence to implement a chemistry-specific CBA remains limited. Some studies indicate that lecturers tend to interpret CBA superficially, equating it with providing more learning tasks rather than designing competence-oriented activities. Consequently, conceptual and practical components of the chemistry curriculum are often inadequately addressed. Assessment practices also show weak alignment with CBA principles, as many lecturers rely heavily on traditional, content-focused examinations rather than competency-based assessments. As a result, instructional practices remain predominantly lecture-centred, with minimal shift toward interactive, inquiry-based, or problem-based approaches. Overall, while CBA adoption is well-established at the policy and curriculum levels, actual implementation within undergraduate chemistry classrooms remains inconsistent and underdeveloped, indicating a persistent implementation–practice gap.

4.1.2 Scientific and Practical Competencies

The shift toward competence-based curricula has been significantly hindered by inadequate laboratory facilities, outdated equipment, and persistent resource constraints, resulting in limited development of practical competencies such as laboratory skills and inquiry-based learning. In many institutions, laboratory settings have remained largely unchanged for decades, with students performing the same traditional experiments that do not align with modern competency requirements. The shortage of consumables, limited access to contemporary instruments, and insufficient laboratory maintenance further restrict students' opportunities to acquire hands-on skills. As a result, undergraduate expectations such as designing experiments, conducting procedures safely, interpreting data, and troubleshooting errors are rarely met in practice. Although systematic reviews highlight that the use of improvised chemicals and low-cost experimental materials can enhance student engagement, motivation, and performance in resource-limited contexts, such approaches are not widely implemented. Many chemistry instructors have been trained exclusively with conventional reagents and standardized laboratory setups, which contributes to reliance on costly imported materials and reduces willingness to adopt innovative, low-cost alternatives. Consequently, while evidence suggests that alternative laboratory strategies can strengthen practical competence, these methods remain insufficiently documented and underutilized in undergraduate chemistry programs (Turan-Oluk, 2022).

4.1.3 Pedagogical Practices and Classroom Implementation

The second major finding relates to persistent challenges in implementing learner-centred pedagogies. Although CBA advocates for inquiry-based learning, problem-based laboratory work, collaborative group tasks, and real-world chemical applications, most undergraduate chemistry classes continue to rely on traditional didactic instruction. Lecturers often report insufficient training in competency-based instruction, resulting in inconsistent teaching quality.

Evidence shows that while some faculty members successfully incorporate active learning activities such as guided inquiry experiments and case-based discussions others lack the pedagogical confidence or resources to shift from teacher-centred methods. Large class sizes, inadequate laboratory equipment, and limited time allocation further reinforce teacher-led instruction. Consequently, learner engagement remains constrained, especially in foundational chemistry courses.

4.1.4 Assessment Systems and Competency Evaluation

Findings reveal a structural tension between competency-based assessment and conventional examination-driven evaluation practices. Most universities continue to rely heavily on high stakes written exams as the primary determinant of academic performance. These assessment formats typically evaluate memorization and promote rote learning techniques rather than applied skills, contradicting the principles of CBA. Chemistry, authentic assessments such as laboratory portfolios, project-based tasks, and reflective research reports implementation are inconsistent among universities. Majority still lack clear rubrics for assessing competencies such as experimental competence, safety awareness, chemical data interpretation, and scientific communication. As a result, assessment practices do not reliably measure the competencies outlined in curriculum documents, weakening the effectiveness of CBA reform efforts.

4.1.5 Institutional Capacity and Learning Environment

Institutional factors significantly shape the success of CBA implementation. The analysis shows that Tanzania universities face limitations in laboratory infrastructure, availability of chemicals and equipment, and digital resources required for modern chemistry instruction. Weak institutional support reduces the feasibility of frequent laboratory-based learning, which is essential for competency acquisition. Lecturers frequently cite insufficient training opportunities, limited funding for instructional innovation, and inadequate ICT integration. Modern teaching tools such as virtual laboratories, simulation software, and digital learning platforms are available in some institutions but remain underutilized or over utilized. These structural constraints directly impede practical competence development, particularly in analytical and organic chemistry courses where hands-on experience is crucial. Table 1 below shows key challenges and innovations in competence based undergraduate chemistry education and table 2 shows how these challenges are linked to targeted competences

4.1.6 Key Challenges and Innovations in Competence-Based Undergraduate Chemistry Education

Findings indicate a persistent gap between the intentions of competence-based education and its practical execution. Key challenges include limited laboratory infrastructure, large class sizes, lecturer reliance on teacher-centred delivery, and assessment practices that remain dominated by high-stakes, content-focused examinations. These constraints hinder the development of practical, inquiry-based, and transferable competencies among chemistry undergraduates. However, several innovations are emerging, including increased use of blended learning, virtual laboratory simulations, modularized curricula, and growing institutional investment in pedagogical training for lecturers. While promising, these innovations remain unevenly implemented and require sustained institutional commitment to achieve full competency alignment**.** These key findings are tabulated in table 1 and 2 show how they are linked to targeted competences.

Category	Key Challenges	Emerging Innovations / Strategies
Pedagogical	- Lecturer reliance on traditional lecture-based methods - Limited pedagogical content knowledge for CBA - Large class sizes restricting active learning	- Professional development and workshops on CBA - Problem-based learning (PBL) and inquiry-based laboratory exercises - Modularized teaching units aligned to competencies
Laboratory & Resources	- Inadequate laboratory infrastructure - Shortage of chemicals, equipment, and consumables - Overcrowded labs limiting hands-on practice	- Virtual laboratories and molecular modeling software - Simulation-based experiments to complement wet-labs - Collaboration with industry for access to laboratory facilities
Assessment	- Predominance of theory-focused, summative exams - Misalignment of assessment with competency objectives - Limited use of performance-based or formative assessments	- Integration of continuous assessment and practical evaluations - Research projects, portfolios, and lab reports as assessment tools - Competency-aligned rubrics for evaluating practical and analytical skills
Technology & ICT	- Limited access to computers, software, and high-speed internet - Low digital literacy among lecturers and students	- Blended learning approaches combining virtual and physical labs - Training programs to enhance digital competency - Use of interactive simulations and molecular visualization tools
Social & Communication Competencies	- Uneven student participation in collaborative tasks - Limited opportunities for teamwork and scientific communication	- Structured group research projects - Scientific presentations and oral defense exercises - Collaborative problem-solving sessions fostering professional communication
Systemic / Institutional	- Insufficient funding for CBA initiatives - Weak policy enforcement or monitoring - Slow curriculum reform implementation	- Strategic policy alignment and institutional support - Monitoring and evaluation frameworks for competency attainment - Industry partnerships for experiential learning and internships
Category	**Key Challenges**	**Emerging Innovations / Strategies**
Pedagogical	- Lecturer reliance on traditional lecture-based methods - Limited pedagogical content knowledge for CBA - Large class sizes restricting active learning	- Professional development and workshops on CBA - Problem-based learning (PBL) and inquiry-based laboratory exercises - Modularized teaching units aligned to competencies
Laboratory & Resources	- Inadequate laboratory infrastructure - Shortage of chemicals, equipment, and consumables - Overcrowded labs limiting hands-on practice	- Virtual laboratories and molecular modeling software - Simulation-based experiments to complement wet-labs

		- Collaboration with industry for access to laboratory facilities
Assessment	- Predominance of theory-focused, summative exams - Misalignment of assessment with competency objectives - Limited use of performance-based or formative assessments	- Integration of continuous assessment and practical evaluations - Research projects, portfolios, and lab reports as assessment tools - Competency-aligned rubrics for evaluating practical and analytical skills
Technology & ICT	- Limited access to computers, software, and high-speed internet - Low digital literacy among lecturers and students	- Blended learning approaches combining virtual and physical labs - Training programs to enhance digital competency - Use of interactive simulations and molecular visualization tools
Social & Communication Competencies	- Uneven student participation in collaborative tasks - Limited opportunities for teamwork and scientific communication	- Structured group research projects - Scientific presentations and oral defense exercises - Collaborative problem-solving sessions fostering professional communication
Systemic / Institutional	- Insufficient funding for CBA initiatives - Weak policy enforcement or monitoring - Slow curriculum reform implementation	- Strategic policy alignment and institutional support - Monitoring and evaluation frameworks for competency attainment - Industry partnerships for experiential learning and internships

Table 2 below how these challenges are linked to target competencies in undergraduate chemistry CBA

Challenge Category	Specific Challenge	Target Competency Affected	Suggested Innovation / Intervention
Pedagogical	Reliance on lecture-based teaching	Critical thinking, problem-solving, independent learning	Professional development, PBL, modularized CBA-aligned teaching
	Limited lecturer knowledge of CBA	Competency in applying theory to practice, scientific reasoning	Workshops, mentoring, peer observation programs
Laboratory & Resources	Inadequate lab infrastructure and materials	Practical laboratory skills, experimental design, safety competence	Virtual labs, simulation software, industry partnerships
	Overcrowded labs limiting hands-on practice	Teamwork, collaboration, procedural proficiency	Rotational lab schedules, blended learning, group-based experiments
Assessment	Theory-focused exams misaligned with competencies	Practical competence, analytical reasoning, scientific communication	Formative and performance-based assessments, lab reports, portfolios
	Lack of practical evaluation tools	Problem-solving, inquiry skills	Competency-based rubrics, research projects, oral defenses
Technology & ICT	Low access to digital tools and internet	Digital literacy, data analysis, visualization of chemical processes	Blended learning, virtual simulations, ICT training
	Low digital literacy among lecturers and students	Competency in computational chemistry, molecular modeling	Targeted ICT skill workshops, guided simulation exercises
Social & Communication	Unequal participation in group work	Teamwork, collaboration, leadership, communication	Structured group projects, peer assessment, scientific presentations
	Limited platforms for scientific communication	Written and oral scientific communication	Oral defenses, poster sessions, collaborative writing assignments
Systemic / Institutional	Insufficient funding and support	All competencies due to restricted implementation	Institutional investment, resource allocation, monitoring and evaluation
	Slow curriculum reform and weak enforcement	Alignment of learning outcomes with graduate expectations	Policy alignment, regular curriculum review, partnerships with industry

4.1.7 Thematic Analysis

The data collected from journal articles, policy documents, and institutional reports were analyzed using a thematic analysis approach following Braun and Clarke's (2006) framework to allow systematic identification of recurring patterns related to CBA implementation and its influence on undergraduate chemistry education as shown in table 3 and table 4 below. These themes collectively reveal a performance practice gap between CBA policy intentions and the actual learning environment.

Table 3 below shows themes and supporting evidence from the literature review

Theme	Description	Supporting Evidence (Derived from Reviewed Literature & Abstract)
1. Variability in CBA Implementation	Differences in how institutions apply CBA principles, leading to inconsistent learning outcomes.	• Universities demonstrate uneven adoption of learner-centred pedagogy. • Some institutions still rely on content-driven, lecture-based methods.
2. Scientific and Practical Competence Gaps	Students lack adequate laboratory skills, scientific inquiry abilities, and hands-on practical experience expected under CBA.	• Insufficient laboratory time and practical exposure. • Students struggle with designing experiments, analyzing data, and applying chemistry principles.
3. Technological Competence and Digital Readiness	Ability of students and instructors to use digital tools, simulations, modeling software, and virtual labs in chemistry teaching.	• Limited digital infrastructure and technological skills. • Low use of molecular modeling tools and simulations for visualization.
4. Social and Communication Competencies	Capacity to communicate chemical ideas, collaborate effectively, and function within an interactive classroom environment.	• Students and lecturers show weak communication practices. • Limited collaborative learning due to tradition of passive instruction.
5. Institutional and Infrastructural Challenges	Systemic resource shortages affecting CBA delivery in chemistry programs.	• Inadequate laboratories, chemicals, glassware, and equipment. • Insufficient ICT infrastructure to support e-learning and simulations.
6. Pedagogical and Assessment Misalignment	Continued reliance on theoretical and examination-driven teaching, inconsistent with CBA outcomes.	• Assessments emphasize recall rather than competence. • Lecturers lack training in competency-based instructional strategies.
7. Weak University–Industry Linkages	Limited opportunities for students to gain real-world, industry-based experience.	• Lack of structured industrial attachments for chemistry undergraduates. • Employers report competency gaps in graduates.
8. Emerging Innovations Supporting CBA	New strategies that promote competency development within resource-constrained settings.	• Use of modularized curricula to improve progression. • Adoption of research-based learning and small-scale practical.
9. Systemic and Policy-Level Support Needs	Institutional and national policies required to sustain effective CBA adoption.	• Need for capacity building for lecturers. • Necessity for alignment between TCU standards, curriculum design, and assessment.

Table 4 below shows themes, indicators, and measurement approaches

Theme	Indicators	Measurement / Data Source
1. Variability in CBA Implementation	- Extent of learner-centred pedagogy adoption - Alignment of curriculum with CBA principles	- Document analysis of curricula and syllabi - Review of institutional reports - Survey/interviews with lecturers
2. Scientific and Practical Competence Gaps	- Students' ability to design and conduct experiments - Accuracy in data analysis and interpretation - Application of chemistry principles in practical tasks	- Laboratory assessment records - Student performance in practical exams - Observations of laboratory sessions
3. Technological Competence and Digital Readiness	- Use of simulations, molecular modeling, virtual labs - Lecturer and student ICT proficiency - Integration of digital tools in teaching	- Survey of lecturers and students - Analysis of course materials for digital content - Observation of classroom/virtual sessions
4. Social and Communication Competencies	- Clarity in presenting chemical concepts - Participation in group work and discussions - Collaboration in lab exercises	- Peer and lecturer evaluations - Observation checklists - Student self-assessment questionnaires
5. Institutional and Infrastructural Challenges	- Availability and adequacy of labs, chemicals, and equipment - ICT infrastructure - Access to learning resources	- Institutional facility audits - Policy and budget document analysis - Interviews with administrative staff
6. Pedagogical and Assessment Misalignment	- Use of theoretical vs. competency-based assessment - Lecturer familiarity with CBA methods - Frequency of active learning strategies	- Review of assessment tools and examination questions - Lecturer surveys/interviews - Classroom observation
7. Weak University–Industry Linkages	- Availability of industrial attachment programs - Student exposure to real-world applications - Partnerships with chemical industries	- Review of internship programs and MoUs - Interviews with students and industry supervisors - Surveys on industry engagement
8. Emerging Innovations Supporting CBA	- Adoption of modularized curricula - Implementation of research-based learning - Use of small-scale or simulated practical	- Document analysis of curricula - Lecturer interviews on teaching strategies - Observation of innovative teaching sessions
9. Systemic and Policy-Level Support Needs	- Lecturer training and capacity building programs - Alignment with TCU policies - Availability of funding for CBA implementation	- Review of policy documents and guidelines - Interviews with policy makers and university management - Institutional reports on professional development

4.1.8 Summary of Findings

Based on the thematic analysis of recent empirical studies, policy documents, and institutional reports, several key findings emerged:

4.1.8.1 Variability in CBA Implementation

The review revealed significant differences in how CBA principles are applied across universities. While some institutions have actively integrated learner-centred and competency-based pedagogies, others remain largely content-driven and lecture-based. This inconsistency contributes to variations in student learning outcomes.

4.1.8.2 Scientific and Practical Competence Gaps

Despite the intentions of CBA, many students lack essential laboratory skills, scientific inquiry abilities, and practical experience. Limited laboratory sessions, inadequate reagents and equipment, and insufficient hands-on training were cited as major barriers to developing practical competence.

4.1.8.3 Technological Competence and Digital Readiness

Technological adoption in chemistry education remains low. Both students and lecturers often demonstrate limited ability to use digital tools, simulations, molecular modeling software, and virtual laboratories. This gap restricts the effective visualization of complex chemical processes and reduces engagement.

4.1.8.4 Social and Communication Competencies

The capacity for clear communication, teamwork, and collaborative learning is underdeveloped among students. Traditional lecture-based instruction and minimal group interaction limit opportunities for building these essential competencies.

4.1.8.5 Institutional and Infrastructural Challenges

A major constraint across universities is inadequate laboratory and ICT infrastructure, insufficient chemicals and teaching materials, and limited funding. These deficiencies hinder effective delivery of competency-based curricula.

4.1.8.6 Pedagogical and Assessment Misalignment

Although CBA emphasizes practical and problem-based learning, assessment practices in many institutions remain theoretical and examination-driven. Many lecturers also lack sufficient training in competency-based instructional strategies, further undermining implementation.

4.1.8.7 Weak University–Industry Linkages

Opportunities for industrial attachment and exposure to real-world chemical applications are limited. Weak collaboration with industry reduces students' ability to apply classroom learning to practical, professional contexts.

4.1.8.8 Emerging Innovations Supporting CBA

Some universities have adopted innovative practices such as modularized curricula, research-based learning, and small-scale or simulated practical exercises. These strategies show promise for enhancing competence development, even in resource-constrained settings.

4.1.8.9 Systemic and Policy-Level Support Needs

Sustained implementation of CBA requires systemic support, including lecturer training, alignment of curriculum with Tanzania Commission for Universities (TCU) standards, and adequate funding. Policy-level interventions are necessary to ensure that competency objectives are consistently achieved across institutions.

The findings reveal a significant mismatch between the intended goals of CBA and the actual teaching learning conditions in undergraduate chemistry programs. While institutions express commitment to competency development, practical, technological, and institutional, limitations restrict effective adoption. As a result, students' mastery of scientific, laboratory, and digital competencies remains weaker than expected under a fully implemented CBA framework.

4.2 Discussion

The discussion integrates empirical evidence with theoretical perspectives to interpret the extent to which CBA has been adopted, the degree of competence development among undergraduates, and the barriers that shape implementation outcomes.

4.2.1 CBA Implementation Practices and the Performance Practice Gap

The study revealed that although universities have formally embraced CBA within curriculum documentation, full implementation remains limited. This aligns with multiple studies in African higher education which note that policy-level adoption of CBA often fails to translate into everyday teaching practice (Makunja, 2015; Kasuga & Kalolo, 2025). Chemistry lecturers reported using problem-based tasks and learner-centred activities, but these were inconsistently applied across modules. This suggests a performance practice gap, where the intention to shift pedagogy has not been matched by adequate structural and pedagogical support. The persistence of lecture-dominant teaching indicates that traditional pedagogical cultures remain intact. Studies in East Africa similarly observe that lecturers tend to default to content delivery due to large class sizes, limited training in competency pedagogy, and assessment pressures (Ndalichako, 2015; Babola & Genga, 2024). Our findings confirm that assessment practices also remain largely theoretical, with minimal use of performance-based evaluation despite its centrality in CBA (Mulenga & Kabombwe, 2019). Thus, while CBA has been adopted at the policy level, its operationalization within undergraduate chemistry courses is still emerging rather than consolidated.

4.2.2 Lecturer competencies, pedagogical knowledge and staff development

Effective delivery of CBA requires instructors who are comfortable with learner-centred pedagogies, performance-based assessment, and the facilitation of practical inquiry (Ngonge, 2024). Empirical work in Tanzania signals variability in lecturers' preparedness: while some demonstrate openness to active learning, many report limited training in CBA methods, lack of experience designing competency-based assessments, and heavy workloads that constrain adoption of time-intensive active methods. A good chemistry lecturer in a CBA system must have strong pedagogical, laboratory, digital, assessment, and curriculum-alignment competences alongside deep subject knowledge to deliver practical, inquiry-driven, and industry-relevant learning experiences. Recruitment of chemistry lecturers should be guided by expertisms not on scores subject to approval by the relevant institution upon satisfaction of pedagogical and instructional competence which is very essential for CBA. In addition to TCU lecturer requirements, it is an advantage for chemistry lectures to have chemical- based- industrial experience to score the practicability of conceptualized chemistry in order to explore CBA tenets as teaching chemistry concerns. Student-teacher too needs to be prepared well for the job (Juma, 2024). Recent higher-education studies point to the need for sustained professional development, mentorship, and institutional incentives to shift teaching cultures from lecture-dominant to facilitation of competencies (Ngonge, 2024; Ochieng & Hemed, 2nd Ed, 2025) for the betterment of CBA.

4.2.3 Development of Practical and Scientific Competencies

Practical competence rooted in laboratory skills, experimentation, and scientific reasoning remains a critical yet underdeveloped component of undergraduate chemistry education. The study found that outdated equipment, inadequate laboratory infrastructure, limited practical sessions, and overcrowding severely restrict students' opportunities to develop essential hands-on skills and access scientific instrumentation. Similar constraints have been widely reported in developing-country universities, where laboratories often lack modern analytical tools such as spectroscopy, chromatography, and digital sensors (Mureithi et al., 2021; UNESCO, 2022). Consequently, many graduates exhibit solid theoretical understanding but lack sufficient practical mastery. Limited opportunities for inquiry-based laboratory work further restrict their capacity to engage in authentic scientific problem-solving**.** Literature shows that inquiry-driven experimentation is essential for developing higher-order competencies, including critical thinking, methodological rigour, analytical reasoning (Aydin-Günbatar, 2020; Alhashem, 2023) and even strengthens lecturers' pedagogical content knowledge (PCK) and competence-based instructional strategies. Our findings therefore reflect a broader regional challenge: chemistry students graduate with strong theoretical background but insufficient laboratory mastery, affecting their readiness for research and industry. Furthermore, the overcrowding of laboratories diminishes the effectiveness of practical instruction. Previous studies indicate that high student equipment ratios undermine safety, reduce hands-on time, and weaken skill acquisition (Hastie & Saunders, 2014). The presence of outdated laboratory setups sometimes unchanged for over 15 years further demonstrates the slow modernization of teaching infrastructure. Overall, the study confirms that material constraints remain one of the most significant barriers to achieving the scientific competencies envisioned in CBA.

4.2.4 Assessment systems and the examination driven culture

A recurrent theme in the literature is the misalignment between high-stakes, summative examinations and the formative, performance-based assessments central to CBA. Most lecturers continue to rely on traditional lecture-based delivery, and assessment remains content-focused and norm-referenced dominated by theoretical examinations rather than authentic competency development hence generates wash back effects which incentivize rote learning and prioritize factual recall over practical demonstrable skills (Ochieng et al, 2019; French et al, 2024, Teymoori & Mirza, 2024). This systemic tension undermines adoption of competency-aligned assessment practices in undergraduate chemistry courses unless assessment reform is pursued in parallel. And also where laboratory competence, analytical reasoning, and inquiry-based problem solving require iterative, formative assessment rather than one-off examinations (Mpofu, 2019; Bičak, 2021; Maiyuria & Gakunga, 2024).To add more ills, most lecturer to have not undergo competence examination skill analysis, therefore it is a subject worth training or fear of student failing examinations since most of them are from content driven system. Consequently, without parallel reforms in assessment policy, examiner capacity, and institutional culture, efforts to advance competence-based chemistry education risk remaining symbolic rather than transformative. Assessment systems must be redesigned to align with competency expectations, incorporating practical, performance-based, and formative assessment methods.

4.2.5 Technological and ICT Competence in undergraduate chemistry

The findings revealed limited integration of digital resources, simulation tools, and virtual laboratories in chemistry teaching. This is consistent with global and regional literature showing that ICT integration in science education across many developing economies remains superficial, often limited to Classroom management, PowerPoint or basic multimedia presentation (Nyakito et al, 2021; Hassan & Mohammed, 2023; Chalale et al, 2025). Chemistry education increasingly relies on digital tools such as molecular modelling software, data-analysis platforms, and virtual lab simulations which students need to be taught from the word go. Research demonstrates that such tools significantly enhance conceptual understanding, reduce laboratory risk, and support learning where consumables are limited (Turan-Oluk, 2022; Bazie et al., 2024). However, persistent digital challenges poor connectivity, insufficient computers, lack of training and lecturers prevent full realization of these benefits. The findings also suggest that limited ICT competence among lecturers contributes to the slow adoption of digital pedagogies. This is supported by studies indicating that lecturer digital skills strongly predict ICT utilization in chemistry teaching (Khalid et al, 2025). Consequently, students graduate with inadequate technological fluency, limiting their competitiveness in research environments and industrial chemical analysis where digital literacy is now standard. There is a need for introducing computational chemistry in undergraduate chemistry in order for our graduates to improve on critical, analytical thinking, problem solving and able to do simulations and docking in order to evaluate molecular structures and reactivity so as to be fully complaint. This digital gap restricts students to innovation, research, employability and industrial environs

4.2.6 Social and communication competencies, teamwork and inclusive practices

Competence frameworks commonly include social and communication competencies, that is the ability to work in teams, present findings, and communicate scientific ideas to diverse audiences. Studies of classroom practice in Tanzania indicate limited emphasis on such soft skills: large class sizes, teacher-centred modes, and limited group-work time impede regular practice of collaboration and science communication (Likuru & Mwila, 2022). Gender and inclusion issues also arise where classroom culture or practical task allocation inadvertently marginalizes certain student groups, social barriers, reducing equitable opportunities to build competencies. Addressing these requires deliberate instructional design and faculty support.

4.2.7 System-level constraints and funding models

Beyond classroom-level factors, system constraints hamper nationwide CBA roll-out: procurement cycles unsuited to regular replenishment of chemicals and consumables, limited capital investment for modernization, and budgetary rules that do not prioritize hands-on instruction. Many universities operate laboratories with obsolete equipment and limited reagents, making sustained CBA implementation challenging. Similar resource constraints have been documented in Kenyan, Tanzanian, and Ugandan universities (Nsubuga, 2021), where operational budgets cannot meet the demands of modern STEM training. Additionally, accreditation and licensing frameworks focused primarily on curricular content rather than demonstrable competency outcomes can reduce institutional incentives to fully embrace CBA. These structural and fiscal issues call for policy-level realignment and targeted financing mechanisms. To add, Institutional barriers emerged as the overarching factors shaping the effectiveness of CBA. These include insufficient funding, rigid curriculum structures, high enrolment, and limited professional development opportunities for lecturers. These findings align with a wide body of research indicating that CBA demands significant investment in infrastructure, continuous staff training, and pedagogical re-orientation (Kabombwe & Innocent, 2019; UNESCO, 2022).

4.2.8 Pedagogical Capacities

Limited lecturer training in CBA methodologies emerged as a significant hindrance. Literature consistently finds that without targeted professional development, lecturers struggle to translate CBA principles into classroom strategies (Okeyo, 2023). Pedagogical inertia reinforced by heavy workloads and assessment pressures further discourages experimentation with innovative methods.

4.2.9 Structural and Administrative Factors

Rigid curricula reduce flexibility in redesigning tasks, modules, and assessments to align with competencies. Additionally, bureaucratic approval processes slow innovation. These findings correspond with studies reporting systemic barriers that prevent curriculum decentralization and adaptation within African universities (Thivhavhudzi, 2025).

4.2.10 Documented innovations and promising practices

Despite the constraints, the literature reports several local innovations that align well with CBA objectives. Nevertheless, promising strategies include the adoption of modularized curricula that break complex competencies into manageable units (Schweiker, 2023). These include modularized curricula that break competencies into assessable units, research-based and project-based learning modules that tie chemistry to local problems, partnerships with industry for practical and internships, and blended approaches that combine limited wet-lab time with virtual simulations. Evaluations of pilot programs suggest that when modular design, workplace linkages, and targeted tutor training are combined, student engagement and the demonstration of practical competencies improve. However, evidence is often from single-institution pilots and lacks long-term follow-up to prove sustainability and scalability

5. Conclusion and Recommendations

5.1 Conclusion

The literature demonstrates that competence-based approaches hold substantial promise for strengthening undergraduate chemistry education when adopted across institutions. From our findings, its practical application remains inconsistent, that is, it is conceptually embraced and practically constrained. The study reveals a significant gap between policy intention and classroom practice. Addressing these challenges requires coordinated investment, capacity building, and curriculum reform to align chemistry education with contemporary scientific and industrial demands. For university chemistry programs to achieve the intended outcomes of CBA namely, producing graduates who can think scientifically, perform laboratory procedures competently, solve complex problems, and apply chemistry to real-world contexts a coordinated, system-wide transformation is required. Resource shortages, high student–lecturer ratios, rigid curricula, and limited pedagogical training for lecturers remain major obstacles to effective CBA implementation must be resolved in order to enhance learner-centred, inquiry-based, and competency-oriented chemistry education. Furthermore, the adoption and scaling of proven innovations such as PCK modules, competency-based education and training (CBET) practices, blended learning, and virtual laboratories should be prioritized. These efforts must be supported by strong institutional commitment to monitoring, evaluation, and continuous improvement of CBA implementation within higher education. Without such systemic interventions, the gap between curricular intent and enacted chemistry teaching will persist, undermining student competence development, limiting scientific capacity-building, and reducing the overall quality of chemistry graduates. Ultimately, the advancement of competence-based chemistry education in Tanzania will depend on coherent policy alignment, meaningful faculty development, equitable resource allocation, and robust evaluation frameworks to ensure that learning outcomes genuinely reflect graduate competencies.

Overall, the study concludes that the competence-based approach offers a strong pedagogical pathway to make undergraduate chemistry education more relevant and practice-oriented in Tanzania. The effective adoption of CBA in undergraduate chemistry requires systemic change spanning funding, curriculum restructuring, technological investment, restructuring of classes to appropriate numbers, lecturer development, and supportive policy frameworks. Without these reforms, CBA will remain conceptually accepted but practically unrealized. And the realization of competency outcomes translate into employability and scientific capacity building is a dream.

5.2 Recommendations

Based on the thematic findings and discussion, actionable recommendations for policymakers, university administrators, chemistry departments, and future researchers are proposed and these include:

1. **Recommendations for Policy Makers:** Increase funding for STEM infrastructure to ensure modern, well-equipped chemistry laboratories, consumables, maintenance of scientific instruments and annual academic industrial trips; Develop national minimum standards for laboratory facilities and ICT integration in chemistry programs across universities; Support continuous curriculum review to align course outcomes, competencies, and assessment practices with CBA principles and Establish national programs for lecturer development focusing on competency-based pedagogy, assessment, and digital literacy.
2. **Recommendations for University Administrators:** Invest in laboratory modernization**,** including upgrading instruments, procuring reagents, and reducing student equipment ratios; Enhance ICT infrastructure, including stable internet connectivity, access to digital laboratories, simulation tools, and modelling software; Reduce class sizes or provide additional laboratory streams to ensure that all students receive adequate practical exposure; Create incentives for pedagogical innovation**,** such as grants for teaching improvement, recognition awards, or training support; Strengthen collaboration with industry and research institutions to provide access to modern analytical facilities and internship opportunities.
3. **Recommendations for Chemistry Departments and Lecturers:**Increase the use of inquiry-based and problem-based laboratory activities to enhance scientific reasoning and practical

competence; Adopt performance-based assessment (e.g., lab portfolios, practical demonstrations, research mini-projects) to better measure competencies; Integrate digital tools such as molecular modelling programs, data analysis software, virtual labs, and online simulations into coursework; Engage in continuous professional development to improve CBA instructional skills, ICT competence, and assessment literacy; Allow industrial visits or attachments, Strengthen mentorship and academic support systems to ensure students receive feedback and guidance in developing scientific skills.

4. **Recommendations for Students:** Actively participate in laboratory activities, seek additional practice opportunities, and engage in independent experimentation where possible; Utilize digital resources**,** including open-source modelling tools, online tutorials, and virtual lab platforms, to supplement limited physical lab time; Engage in peer-learning groups to strengthen conceptual and practical understanding through collaborative inquiry; Pursue internships, research attachments, and student-led projects to enhance hands-on exposure beyond the institutional laboratory setting.
5. **Recommendations for Future Research:** Conduct longitudinal studies assessing how CBA influences graduate competence and workplace readiness over time; Examine the effectiveness of virtual laboratory tools as a supplement to physical labs in low-resource environments; Compare CBA implementation across different STEM disciplines to identify transferable strategies and discipline-specific barriers; Investigate student perceptions of CBA to understand motivational, cultural, and behavioral factors influencing engagement; Explore industry perspectives on the competency gaps among chemistry graduates to inform curriculum redesign**.**

Acknowledgments

Many thanks go to Zanzibar University for the moral support they gave us during this grueling hard work and Faculty of Science, Zanzibar University for relevant material without which this work would not have gone to completion. It is wrong without mentioning Department of Education, Zanzibar University for professional guidance in particular Lecturer Sudi Hamad Ali the Education Lecturer for innuendo roles he played to make sure the manuscript is done.

References

Alhashem, F., & Alfailakawi, A. (2023). Technology-enhanced learning through virtual laboratories in chemistry education. Contemporary Educational Technology, 15(4), ep474. https://doi.org/10.30935/cedtech/13739

Aydin-Günbatar, S. (2020). Inquiry-based laboratory instruction and scientific competency development. Chemistry Education Research and Practice, 21(2), 417–430.

Babalola, S. S., & Genga, C. A. (2024). Managing digital transformation in African higher education institutions: Challenges and opportunities. International Journal of E-Learning & Distance Education, 39(1). https://doi.org/10.55667/10.55667/ijede.2024.v39.i1.1333

Bazie, H., Lemma, B., Workneh, A., & Estifanos, A. (2024). The effect of virtual laboratories on the academic achievement of undergraduate chemistry students: Quasi-experimental study. JMIR Formative Research, 8, e64476. https://doi.org/10.2196/64476

Bičak, B. E. (2021). Measuring and fostering preservice chemistry teachers' self-regulatory competency by implementing problem-solving experiments and explanatory videos. Education Sciences, 11(9), 496. https://doi.org/10.3390/educsci11090496

Biggs, J., & Tang, C. (2015). Teaching for quality learning at university: What the student does (4th ed.). McGraw-Hill Education.

Chacha, J., & Onyango, D. (2022). Challenges faced by teachers in implementing competence-based chemistry curriculum in public secondary schools in Nyamagana District, Mwanza, Tanzania. Journal of Research Innovation and Implications in Education, 6(1), 346–358.

Chalale, G., Maro, W., & Tarmo, A. (2025). Relevance of curriculum content for ICT-mediated teaching: Perspectives from Tanzanian computer science student teachers and tutors. Papers in Education and Development, 42(2). https://www.ajol.info/index.php/ped/article/view/291524

Charles Nyakito, Amimo, C., & Allida, V. B. (2021). Challenges of integrating information and communication technology in teaching among National Teachers' Colleges in Uganda. East African Journal of Education and Social Sciences, 2(3), 157–171. https://doi.org/10.46606/eajess2021v02i03.0114

French, S., Dickerson, A., & Mulder, R. A. (2024). A review of the benefits and drawbacks of high-stakes final examinations in higher education. Higher Education, 88, 893–918. https://doi.org/10.1007/s10734-023-01148-z

Harden, R. (2007). Outcome-based education: The future is today. Medical Teacher, 29(7), 625–629. https://doi.org/10.1080/01421590701729930

Hassan, I., & Usman, M. A. (2023). Utilization of ICT for teaching and learning of science and technical subjects in senior science and technical colleges for sustainable economic development in North-Eastern Nigeria. International Journal of Innovative Information Systems & Technology Research, 11(1), 41–53.

Hastie, Peter & Saunders, John. (2014). Effects of Class Size and Equipment Availability on Student Involvement in Physical Education. The Journal of Experimental Education. 59. 212-224. 10.1080/00220973.1991.10806561.

Juma, H., & Patel, G. S. (2024). Competence-based assessment in Tanzanian teacher education in the Fourth Industrial Revolution. Journal of Issues and Practice in Education, 16(1), 200–224. https://www.ajol.info/index.php/jipe/article/view/275266

Kabombwe, Yvonne & Mutale Mulenga, Innocent. (2019). Implementation of the competency-based curriculum by teachers of History in selected Secondary Schools in Lusaka district, Zambia. Yesterday and Today. 22. 19-41. 10.17159/2223-0386/2019/n22a2.

Kafyulilo, A. C. (2020). Teacher preparedness for competence-based curriculum implementation in Tanzanian secondary schools. Journal of Education and Practice, 11(4), 45–56.

Kasuga, W., & Kalolo, J. F. (2025). Competency-based curriculum in Tanzania: Charting dilemmas for successful implementation. Cogent Education, 12(1). https://doi.org/10.1080/2331186X.2025.2563711

Khalid, I. L., Nor, M., Abdullah, M. N. S., & Fadzil, H. (2025). A systematic review: Digital learning in STEM education. Journal of Advanced Research in Applied Sciences and Engineering Technology, 53, 48–62. https://doi.org/10.37934/araset.51.1.98115

Kigwilu, P., & Mokoro, D. (2022). Teachers’ assessment practices in implementing competence-based curriculum in secondary schools in Arumeru District of Tanzania. East African Journal of Education Studies, 5, 324–333. https://doi.org/10.37284/eajes.5.2.792

Likuru, L. C., & Mwila, P. M. (2022). Overcrowded classrooms: Effect on teaching and learning in public secondary schools in Ilemela Municipality, Tanzania. Asian Journal of Education and Social Studies, 30(2), 75–87. https://doi.org/10.9734/ajess/2022/v30i230744

Majiwa, S. H., Ogondiek, M. W., & Lukindo, J. (2025). Challenges experienced in the implementation of the competency-based curriculum in Tanzania public secondary schools. International Journal of Humanities and Education Development, 7(4), 93–103.

Maiyuria, M., Mackatiani, C., & Gakunga, D. (2024). Competency-based curriculum in Kenya: Impact of resources on implementation. International Journal of Research and Innovation in Social Science, 8, 3659–3668. https://doi.org/10.47772/IJRISS.2024.8080271

Makunja, G. (2015). Adopting competence-based curriculum to improve secondary education in Tanzania: Dream or reality? International Journal of Education and Research, 3(11).

Manarisip, A. J. (2023). Competencies of chemistry teachers and prospective teachers: A review of literature. Jurnal Penelitian Pendidikan IPA, 9(1). https://doi.org/10.29303/jppipa.v9i1.6031

Mbwillo, J. S. (2023). Competency-based education and training on students' engagement in learning at Tanzania Public Service College–Mbeya Campus. Journal of Public Sector Management, 7(1).

Ministry of Education, Science and Technology (MOEST). (2016). Education sector development plan: 2016–2021. Government of Tanzania

Mirza, M., Teymoori, H., & Mirza, R. (2024). Washback effects of high-stakes examinations on competency-based instruction in higher education. International Journal of Learning, Teaching and Educational Research, 23(4), 112–130.

Mpofu, V. (2019). A theoretical framework for implementing STEM education. In IntechOpen. https://doi.org/10.5772/intechopen.88304

Mtebe, J. S., & Raphael, C. (2018). Challenges in implementing competence-based education in higher learning institutions in East Africa. International Journal of Education and Development Using ICT, 14(2), 67–84.

Mureithi, E., Wanjiku, M., & Kimani, J. (2021). Laboratory infrastructure and STEM skills development in Kenyan universities. African Journal of Science, Technology and Education, 5(1), 45–58.

Mutale Mulenga, I., & Kabombwe, Y. (2019). Understanding a competency-based curriculum and education: The Zambian perspective. Journal of Lexicography and Terminology, Volume 3, No.1, Published 10

Mwinuka, A. B., Mtana, N., & Malete, L. (2022). Lecturers' experiences with competence-based pedagogy in Tanzanian universities. African Journal of Teacher Education, 11(1), 112–130.

Ndalichako, J. (2015). Secondary school teachers' perceptions of assessment. International Journal of Information and Education Technology, 5, 326–330. https://doi.org/10.7763/IJIET.2015.V5.524

Ngonge, R. G. (2024). Adopting pedagogical content knowledge in secondary school chemistry teaching in Tanzania. Asian Research Journal of Arts & Social Sciences, 22(8), 76–91. https://doi.org/10.9734/arjass/2024/v22i8562

Nsubuga, H. (2021). STEM infrastructure challenges in Ugandan universities. Makerere Journal of Higher Education, 13(2), 45–60.

Ochieng, O. A., Shabaan, H. M., & Nassor, S. M. (2019). Performance in chemistry among lower secondary schools in Zanzibar. African Journal of Chemical Education, 9(2).

Ochieng, O. A., & Nassor, S. M. (2025). Guidelines towards competence in teaching chemistry (2nd ed.). KeLb Publishers.

Okeyo, S., & Mokua, Z. (2023). Preparedness of teachers for implementing competency-based curriculum in public secondary schools in Nyamira South Sub-county. East African Journal of Education Studies, 6, 406–418. https://doi.org/10.37284/eajes.6.2.1387

Organisation for Economic Co-operation and Development. (2020). Skills for 21st-century graduates: A global perspective. OECD Publishing

Schweiker, S., & Levonis, S. (2023). Enhancing chemistry education through technology-enhanced learning. ASCILITE 2023 Conference Companion Materials. https://doi.org/10.14742/apubs.2023.463

Suleiman, M. M. (2020). Curriculum reform and implementation: Secondary science teachers' responses to a competency-based curriculum in Tanzania (Doctoral dissertation, University of Leeds).

Tanzania Commission for Universities (TCU). (2021). University qualifications framework and guidelines for curriculum development. TCU.

Thivhavhudzi, M. B. (2025). Barriers and facilitators impacting curriculum reforms for sustainability in higher education. E-Journal of Humanities, Arts and Social Sciences, 6(9), 2143–2154. https://doi.org/10.38159/ehass.20256929

Turan-Oluk, N. (2022). Chemistry teachers' self-efficacy perception scale for laboratory teaching: Development and validation. Journal of Chemical Education, 99(4), 1489–1499. https://doi.org/10.1021/acs.jchemed.2c00240

UNESCO. (2022). STEM education in Sub-Saharan Africa: Status, challenges and opportunities. UNESCO.

UNESCO. (2019). Competency-based education and learning assessment: Global trends and practices. UNESCO Publishing