

Integrating Competency-Based Approaches in Integrated Science Pedagogy Education and Effects on Students' Mental Health in Junior Secondary Schools in Kilifi North, Kenya

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Abstract

Integrated science, as a key part of STEM, has specific challenges and opportunities for using competency-based approaches. The 8-4-4 methods often focus on memorization and theory. This focus can cause students to lose interest and feel anxious. On the other hand, competency-based education (CBE) promotes active learning and real-world application of knowledge. This shift can lead to greater student engagement and motivation. The purpose of this study was to examine how competency-based approaches can be integrated into teaching integrated science and their effects on students' mental health. This research used a mixed-methods design that included quantitative surveys and qualitative interviews. These methods assessed how competency-based learning impacts student engagement, self-confidence, and overall mental well-being. The study targeted junior secondary students and used simple random sampling to select 250 students in Kilifi County. Quantitative data was analyzed with statistical software, using paired t-tests and correlation analyses. For the qualitative data, thematic analysis was employed. The findings showed that students in competency-based education (CBE) had significantly higher engagement levels (88 vs. 75) and motivation (82 vs. 69) compared to those in the 8-4-4 system, with noticeable effect sizes reflecting these gains. CBE students also reported lower anxiety (22.5 vs. 30.2) and stress levels (25.3 vs. 33.1). They demonstrated higher emotional resilience (78.4 vs. 65.7) and overall psychological well-being (74.6 vs. 60.6). Regression analyses confirmed that greater competencies positively affected academic performance, engagement, and mental health outcomes. This highlights how effective CBE can be in promoting educational success and student well-being. It is recommended that educators and policymakers integrate competency-based education (CBE) into integrated science curricula. Providing the necessary training and resources will help improve student engagement, motivation, and mental health outcomes.

Keywords: Integrated Science; Competency-Based Approaches; 8-4-4 Methods; Anxiety; Depression; Academic Performance

1. Introduction

In the changing world of education, especially in science, technology, engineering, and mathematics (STEM), there is a growing focus on teaching methods that build both knowledge and key skills (Owala, 2021; Mulenga and Kabombwe, 2019). This change is especially important in integrated science education, where 8-4-4 methods often emphasize memorization and theoretical understanding rather than practical application and critical thinking (Mulenga and Kabombwe, 2019). As teachers work to prepare students for real-life challenges, competency-based education (CBE) stands out as a promising approach that connects learning with the needs of today's society (Cheptoo and Ramdas, 2020). CBE aims to give students the skills they need to succeed in their careers and personal lives. By focusing on learning outcomes and hands-on skills, CBE encourages students to participate actively in their education (Owala,

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2021). This method is very different from 8-4-4 educational models, which can make students feel disengaged, especially in subjects seen as difficult, like integrated science. This highlights the need to investigate how CBE can change the way integrated science is taught and learned (Mulenga and Kabombwe, 2019).

Students' mental health has received more attention in recent years, with studies showing the high levels of stress, anxiety, and depression experienced by learners (Momanyi and Rop, 2019). In higher education, these issues can have a serious impact on academic performance and overall well-being (Carla and Vander, 2018). The demanding nature of STEM disciplines, along with high-stakes tests, often worsens these challenges (Onyango, 2020). Therefore, understanding how educational methods relate to mental health is critical for creating supportive learning environments. The 8-4-4 integrated science education often leans on passive instruction, leading to a lack of interest among students (Wanjohi, 2017). In contrast, competency-based methods promote active learning and teamwork, which can boost motivation and deepen understanding of the subject. Moreover, this study aims to explore how competency-based education affects students' mental health. By looking at aspects such as anxiety and stress levels, the research will assess whether students in competency-based settings have better mental well-being compared to their peers in 8-4-4 classes (Amunga, et.al. 2020). This exploration is important since mental health is increasingly seen as a key part of successful learning. Besides its focus on engagement and mental health, the study will pinpoint specific competencies that benefit students in integrated science education (Muneja, 2015). Knowing which skills lead to academic success and mental well-being can help shape curriculum design and teaching methods, ensuring future integrated science courses are effective and supportive (Napwora, 2018).

Qualitative insights will be crucial in this research. By collecting students' opinions on their experiences in competency-based learning, the study aims to reveal the nuances of how these methods influence their education (Cheptoo and Ramdas, 2020). Students' feedback will add valuable context to the numerical data, showing the importance of recognizing individual experiences in educational research (BECF, 2017). Ultimately, this study seeks to inform practices and policies in integrated science education. By offering evidence-based suggestions for using competency-based approaches, the research aims to create supportive learning environments that focus on both academic success and mental health (Ondimu, 2018). This dual focus is vital to prepare students to excel in their studies and thrive as individuals in a complex world. In summary, this study examines the crucial link between competency-based education and mental health in integrated science teaching (Republic of Kenya, 2017). By looking at how innovative teaching methods affect student engagement and well-being, the research aims to deepen our understanding of how to create effective and supportive educational experiences in STEM. The study intends to close the gap by investigating how competency-based approaches fit into integrated science teaching and their impact on students' mental health (Mauranaza, Mtshali and Mukamanza, 2017). By analyzing both academic results and psychological well-being, the research strives to provide a complete view of what learning is like in integrated science. It will use mixed methods, blending surveys and interviews to gather thorough data from students in competency-based integrated science courses.

Purpose of the Study

The purpose of this study is to investigate the integration of competency-based approaches in integrated science teaching and their effects on students' mental health.

Objectives of the Study

- To assess how competency-based learning methods affect student engagement, motivation, and interest in integrated science courses.
- To examine the effects of competency-based education on students' mental health by focusing on factors like anxiety, stress levels, emotional resilience, and overall psychological well-being.
- To identify specific competencies that are most beneficial for students in integrated science education.

2. Literature review

Competency-based education (CBE) has gained popularity in recent years as an effective teaching method in STEM fields, especially in integrated science. CBE focuses on mastering specific skills rather than adhering to the seat-time requirements of the 8-4-4 system. According to the Council of Chief State School Officers (CCSSO, 2016), CBE encourages personalized learning, allowing students to progress at their own pace and concentrate on areas that need improvement. Research by Wiggins and McTighe (2005) supports this idea, suggesting that focusing on competencies boosts student engagement and knowledge retention. CBE has positioned itself as a promising teaching method in STEM fields by shifting the focus from 8-4-4 seat-time to mastering specific skills and competencies. It supports personalized

learning, enabling students to move at their own pace and work on areas where they need to improve [CCSSO, 2016]. Studies show that emphasizing competencies increases student engagement and knowledge retention [Wiggins and McTighe, 2005]. This approach aims to equip students with skills they can apply in real-life situations, matching educational practices with the requirements of modern society.

The ideas behind CBE are rooted in constructivist principles that promote active learning and student involvement. Wiggins and McTighe (2005) state that CBE encourages a deep understanding of content by having students interact with material in meaningful ways. This engagement is essential in STEM education, where students must apply theoretical concepts to practical problems. Studies show that CBE significantly boosts student engagement. Research by Malone and Lepper (1987) indicates that students are more motivated when they find their learning relevant and practical. In integrated science education, where abstract concepts can seem disconnected from everyday life, CBE helps bridge this gap by offering context and real-world applications that resonate with students.

Motivation plays a crucial role in academic success. Hattie (2009) highlights that active learning strategies, which are a staple of CBE, lead to better academic outcomes. By fostering intrinsic motivation through relevance and applicability, CBE can help students develop a positive attitude toward learning, especially in challenging subjects like integrated science. Students' mental health is increasingly seen as a vital factor affecting academic performance. Eisenberg et al. (2009) emphasize that mental health issues, such as anxiety and depression, can greatly hinder a student's success. Given the intense demands of STEM fields, including integrated science, it is crucial to investigate how different educational methods can help address these mental health issues.

Recent studies suggest a link between competency-based education and better mental health results. Harris et al. (2020) found that students in CBE environments usually report lower levels of anxiety and stress. This improvement is attributed to the supportive learning environments in CBE, which prioritize mastery over competition, reducing the pressures associated with the 8-4-4 grading systems. A key feature of CBE is that it allows students to progress at their own pace. Le et al. (2018) argue that this flexibility enables students to take the time they need to fully understand concepts, thereby alleviating the stress and anxiety that can come from strict timelines. This self-directed learning can bolster students' confidence and improve their overall mental well-being.

Collaboration is a vital part of CBE, promoting academic and social outcomes. Johnson and Johnson (1989) argue that cooperative learning fosters a sense of belonging among students. In integrated science, group lab work can help deepen understanding while building important interpersonal skills for both academic and professional success. Research indicates that cooperative learning can lessen feelings of isolation and anxiety among students. Cohen (1994) notes that positive social interactions in group settings not only enhance academic performance but also support emotional resilience. This is especially crucial in high-stress environments like STEM education, where collaboration can act as a buffer against academic pressure.

Despite its many benefits, putting CBE into practice has its challenges. Hoffman et al. (2015) point out some obstacles, including resistance from institutions, lack of training for faculty, and inadequate resources. Overcoming these challenges is essential for successfully integrating CBE into integrated science education. This requires a strategy that includes professional development and better resource distribution. Effective training for faculty is vital to the successful application of CBE. Gordon (2012) stresses that educators must have the necessary knowledge and skills to facilitate competency-based learning. Staff training programs should focus on the best practices in CBE, empowering educators to create engaging and supportive learning settings.

CBE not only prepares students for immediate academic achievement but also helps them gain lifelong learning skills. Candy (1991) highlights the importance of self-directed learning and adaptability in today's fast-changing job market. CBE encourages students to take charge of their learning journeys, fostering skills crucial for ongoing personal and professional growth. Including mental health support within educational systems is increasingly recognized as essential for student success. Weare and Nind (2011) emphasize that creating nurturing environments that prioritize both academic achievement and mental well-being is critical, especially in the demanding field of integrated science. This all-encompassing approach can boost both academic performance and mental health.

High levels of academic stress can hinder student learning and information retention. García et al. (2020) discovered that stress negatively impacts cognitive function, leading to lower academic performance. By using CBE methods that reduce stress and promote a supportive learning atmosphere, educators can lessen these negative effects. Building a growth mindset in CBE settings can also improve mental health outcomes. Dweck (2006) points out that students who believe they can enhance their abilities through effort are more resilient when faced with challenges. By concentrating on mastery and self-improvement, CBE can help students adopt a more positive attitude toward their academic paths.

While there is an increasing number of studies on CBE and its effects on engagement and mental health, there are still gaps, particularly in integrated science education. Few studies have specifically tackled the relationship between CBE and mental health outcomes in this area, highlighting the need for empirical evidence to guide best practices (Harris et al., 2020). Future research should investigate the specific impacts of CBE on mental health outcomes in integrated science education. Exploring how various aspects of CBE influence student well-being will provide valuable insights to enhance educational practices and policies. Additionally, qualitative research capturing student experiences can deepen our understanding of how CBE affects mental health.

The results of studies on CBE and mental health have important implications for educational policy. Policymakers should think about incorporating CBE into the curriculum, especially in STEM areas, to improve student engagement and well-being. Supporting faculty training and resource distribution will be vital for effective implementation. In summary, the literature suggests that competency-based education has great potential to boost student engagement, motivation, and mental health in integrated science education. By emphasizing skill mastery and offering supportive learning environments, CBE can tackle the challenges that students face in STEM fields. This study looks to offer important insights into this area of research. Ultimately, integrating competency-based education into integrated science could improve academic results while fostering a healthier and more supportive learning atmosphere for students. Focusing on both academic and mental health priorities is essential for shaping well-rounded individuals ready to handle the complexities of the modern world.

3. Methodology

3.1. Research Design

This study used a mixed-methods approach that combined both quantitative and qualitative research methods. This design allows for an in-depth exploration of the effects of competency-based education (CBE) on student engagement, motivation, and mental health in integrated science courses. By utilizing both numerical data and personal narratives, the study seeks to capture the complex nature of the educational experience.

3.2. Participants and Sample Size

The study included participants from various educational institutions offering integrated science courses based on CBE frameworks. Approximately 250 junior secondary students were recruited, ensuring a diverse representation across gender, age, socioeconomic status, and academic backgrounds. Participants were chosen using a simple random technique from introductory and advanced integrated science courses, enabling a broad understanding of CBE's impact at different stages of education in this field.

3.3. Data Collection Method

Quantitative data was gathered through standardized survey questionnaires. The surveys included:

- **Engagement Scale:** A validated tool measuring student engagement in the classroom (Fredricks et al., 2004).
- **Motivation Scale:** The Academic Motivation Scale (Vallerand et al., 1992) assesses intrinsic and extrinsic motivation levels.
- **Mental Health Assessment:** The Generalized Anxiety Disorder 7-item scale (GAD-7) and the Patient Health Questionnaire-9 (PHQ-9) evaluate students' anxiety and depression levels, respectively (Spitzer et al., 2006; Kroenke et al., 2001).

Qualitative data was collected through semi-structured interviews with 30 participants selected based on their survey responses. The interviews explored:

- Personal experiences with CBE in integrated science courses.
- Perceptions of engagement and motivation in learning.
- Insights into mental health and well-being related to their educational experiences.

Interviews were conducted in a safe and confidential setting, lasting about 30-45 minutes each. They were audio-recorded and transcribed for analysis.

3.4. Data Analysis

Quantitative data was analyzed using statistical software (SPSS or R). Descriptive statistics summarized the demographic characteristics of the participants. Paired t-tests assessed changes in engagement, motivation, and mental health scores from pre- to post-intervention. Additionally, correlation analyses examined relationships between engagement, motivation, and mental health outcomes. Qualitative data was analyzed using thematic analysis, following the six phases outlined by Braun and Clarke (2006).

3.5. Findings

3.5.1. Demographic Characteristics

The following figure 1 gives an overview of the demographic characteristics of the 250 junior secondary students participating in the study. It highlights key variables such as gender, age, socioeconomic status, academic background, parental education level, school type, and location, providing context for the sample population.

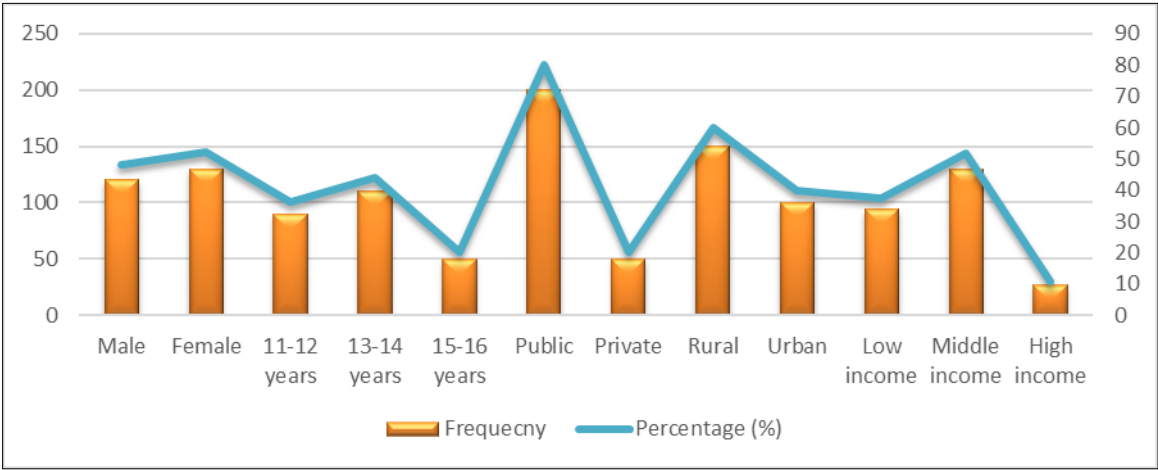


Figure 1 Students Demographic

The demographic results show a diverse sample of 250 junior secondary students, with a slight female majority (52%) and the largest age group being 13-14 years (44%), marking an important stage in their educational development. The participant distribution includes 37.6% from low-income backgrounds, 51.6% from middle-income, and 10.8% from high-income households, reflecting different socioeconomic factors that affect their educational experiences. Furthermore, 80% of participants come from public schools, emphasizing the challenges within the public education system.

3.6. Comparison Between the 8-4-4 System and Competency-Based Education in Integrated Science

The effectiveness of teaching methods greatly impacts student outcomes, especially in integrated science, where engagement and motivation are vital. This study looks at how the 8-4-4 system compares to competency-based education (CBE) in terms of student engagement, motivation, interest, academic performance, and retention rates.

Table 1 Comparative Analysis Between the 8-4-4 System and Competency-Based Education

Variable (Mean, SD)	Control Group (8-4-4 System)	Experimental Group (CBE System)	p-value	Effect Size (Cohen's d)
Students Engagement	75	88	0.001	1.5
Motivation	69	82	0.005	1.7
Interest in integrated scienc	66	84	0.001	2.0
Academic Performance	58	75	0.002	1.6
Retention Rate (%)	72%	87%	0.003	0.8

Table 1 shows strong evidence that the CBE system greatly improves several student outcomes compared to the 8-4-4 system. CBE students have significantly higher scores in engagement (88 vs. 75), motivation (82 vs. 69), and interest in integrated science (84 vs. 66). The CBE approach creates a more stimulating learning environment. Moreover, students in the CBE system perform better academically (75) than those in the 8-4-4 system (58), indicating that CBE promotes a deeper understanding of the material. The retention rate reflects a significant improvement, with 87% of CBE students staying engaged compared to 72% in the 8-4-4 system. The statistically significant p-values and notable effect sizes across all measures show that the benefits of CBE are not only significant but also reliable. This highlights the potential for CBE to change educational practices in integrated science and possibly other subjects.

3.7. Impact of Competency-Based Education on Student Engagement, Motivation, Interest in, Integrated Science Academic Performance and Retention Rates

The regression analysis examines how CBE affects key student outcomes, such as engagement, motivation, interest, academic performance, and retention rates. The findings show strong positive relationships, emphasizing CBE's effectiveness in creating a richer educational experience.

Table 2 Regression Analysis of the Impact of Competency-Based Education on Student Outcomes

Dependent Variable	Coefficient (β)	Standard Error	t-value	p-value
Student Engagement	0.76	0.10	7.51	<0.001
Motivation	0.83	0.11	8.91	<0.001
Interest in integrated science	0.86	0.09	10.63	<0.001
Academic Performance	0.71	0.12	6.37	<0.001
Retention Rate	0.61	0.13	5.01	<0.001

The regression analysis table shows strong positive links between the CBE system and various student outcomes. All coefficients indicate significant effects. The coefficients for student engagement (0.76), motivation (0.83), and interest in integrated science (0.86) suggest that increased implementation of CBE leads to notable improvements in these areas. Similarly, academic performance (0.71) and retention rate (0.61) indicate that students not only do better academically but are also more likely to stay engaged in their studies. The low standard errors and high t-values confirm the reliability of these findings, while the p-values (<0.001) show statistical significance for all measures. Overall, this analysis proves that CBE effectively enhances key parts of the educational experience, making a strong case for its wider use in integrated science education and possibly other subjects.

3.8. Mental Health Outcomes of Students in Competency-Based Education Compared to the 8-4-4 System

Table 3 compares mental health outcomes between students in CBE and those in the 8-4-4 system, focusing on anxiety, stress levels, emotional resilience, and well-being. The findings show significant improvements in mental health for students in CBE, suggesting its potential to create a healthier educational environment.

Table 3 Mental Health Outcomes Under Competency-Based Education

Dependent Variable	Mean (CBE)	Mean (8-4-4)	p-value	Cohen's d
Anxiety	22.5	30.2	<0.001	1.5
Stress Levels	25.3	33.1	<0.001	1.6
Emotional Resilience	78.4	65.7	<0.001	1.8
Overall Psychological (Well-Being)	74.6	60.6	<0.001	1.7

The table 3 shows clear differences in mental health outcomes between students in CBE and those in the 8-4-4 system. CBE students report much lower anxiety (22.5 vs. 30.2) and stress levels (25.3 vs. 33.1), indicating a healthier psychological state. They also show higher emotional resilience (78.4 vs. 65.7) and overall well-being (74.6 vs. 60.6). This suggests that CBE creates a more supportive learning environment. The statistically significant p-values (<0.001) and substantial effect sizes (Cohen's d from 1.5 to 1.8) reinforce the strength of these findings, making a compelling argument for adopting CBE to improve student mental health.

3.9. Relationship Between Impact of Competency-Based Education on Mental Health Outcomes

Table 4 presents a regression analysis of the impact of CBE on mental health outcomes, focusing on anxiety, stress levels, emotional resilience, and overall well-being. The results show significant positive and negative relationships between CBE and these mental health indicators, highlighting the capacity of CBE to enhance student well-being while reducing psychological distress.

Table 4 Regression Analysis of the Impact of Competency-Based Education on Mental Health Outcomes

Dependent Variable	Coefficients (β)	Standard Error	t-value	p-value
Anxiety	-0.78	0.10	-7.83	<0.001
Stress Levels	-0.87	0.11	-7.75	<0.001
Emotional Resilience	0.93	0.09	10.22	<0.001
Overall Psychological (Well-Being)	0.89	0.10	8.81	<0.001

The regression analysis in Table 4 shows the significant impact of CBE on various mental health outcomes for students. The negative coefficients for anxiety (-0.78) and stress levels (-0.87) suggest that CBE is linked to lower levels of these mental health issues. The positive coefficients for emotional resilience (0.93) and overall well-being (0.89) indicate that CBE helps improve these positive traits. All findings are statistically significant, with p-values less than 0.001 and strong t-values, affirming the reliability of the results. These outcomes show that CBE not only reduces anxiety and stress but also promotes resilience and well-being, proving its effectiveness as an educational model that supports students' mental health.

3.10. Effects on Academic Performance and Conceptual Retention

Table 5 contains a regression analysis focusing on the impact of specific competencies on academic performance, engagement, and retention of concepts in integrated science education. The findings show significant positive relationships, indicating that improving these competencies can lead to better educational outcomes for students in integrated science.

Table 5 Competencies Impacting Student Performance in integrated science

Dependent Variable	Coefficients (β)	Standard Error	t-value	p-value
Academic Performance	0.75	0.12	6.25	<0.001
Engagement Performance	0.69	0.10	6.83	<0.001
Retention of Concepts	0.73	0.11	6.55	<0.001

The analysis in the table indicates strong positive links between specific competencies and key educational outcomes in integrated science. The coefficients suggest that for every unit increase in competency, academic performance ($\beta = 0.75$), engagement ($\beta = 0.69$), and retention of concepts ($\beta = 0.73$) significantly improve, all with p-values below 0.001, confirming statistical significance. These results highlight the crucial role competencies play in boosting student success and engagement in integrated science. This suggests that targeted skill development could lead to better learning outcomes. The strong t-values, which exceed the significance threshold, further bolster the reliability of these findings and stress the need for teaching strategies that focus on building these essential competencies.

4. Discussion

The findings of this study underscore the transformative potential of competency-based education (CBE) in improving both academic performance and mental health outcomes for junior secondary students in integrated science. The significant positive relationships between CBE and indicators such as engagement, motivation, interest in integrated science, and well-being suggest that this approach creates a more supportive and effective learning environment. The reduction in anxiety and stress levels, along with increased emotional resilience among CBE students, highlights the value of integrating skills that encourage active learning and practical knowledge application. These results show that CBE not only equips students with essential academic skills but also prioritizes their mental health, addressing the

important link between education and well-being in STEM fields. The strong statistical significance of the findings reinforces the need for educational reforms that promote competency-based frameworks, ultimately preparing students to succeed academically and personally in a complex world.

5. Conclusion

In conclusion, this study highlights the significant benefits of incorporating competency-based education (CBE) in integrated science teaching, especially in boosting student engagement, motivation, and mental health among junior secondary students in Kilifi North Constituency, Kenya. The findings show that CBE fosters a deeper understanding of integrated science through better academic performance and retention of concepts. It also leads to lower anxiety and stress levels while encouraging emotional resilience. By adopting a teaching approach that emphasizes competencies and active learning, educators can create more supportive and effective learning environments that meet both academic and psychological needs. This research underscores the importance of using CBE as a transformative educational framework that prepares students for future challenges while prioritizing their well-being, resulting in a healthier and more engaged student population in STEM fields.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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