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Effect Of SMASE Training On Teachers' Pedagogical Approaches In Biology In Secondary Schools, Tseikuru Sub- County, Kitui County, Kenya

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Abstract:
In any academic institution the performance of the learner is very key. The purpose of this study was to find out the effect of SMASE training on teachers' pedagogical approaches in Biology in secondary schools in Tseikuru Sub- County, Kitui County, Kenya. The research used mixed methodology, including quantitative and qualitative methods, with a descriptive survey design and constructivism theory. Four principals, 8 biology teachers, and 200 Form 2 and Form 3 Biology students were targeted. Data was collected through multistage sampling and purposive sampling, with four principals and eight biology teachers participating. The study found that SMASE-trained teachers demonstrated significantly superior outcomes across all indicators compared to their non-SMASE-trained counterparts. Specifically, students taught by SMASE-trained teachers (Group 1: n=150) showed markedly higher performance rates compared to those taught by non-SMASE-trained teachers (Group 2: n=50). Class discussion participation was notably higher in Group 1 at 74.67% compared to 50.00% in Group 2. This suggests that SMASE training has a beneficial and significant effect on teachers' pedagogical approaches. The study recommends intensifying SMASE training to foster creativity and performance in students. Teachers trained through this program tend to improvise during biology lessons and adopt a more student-centered approach. Principals should ensure their teachers attend SMASE training, as it makes biology lessons engaging. Additional resources should be allocated to help teachers overcome challenges posed by inadequate materials, which can negatively affect biology performance. Increasing the time dedicated to biology is also vital, as it allows teachers to conduct experiments thoroughly and complete the syllabus promptly. Overall, the study highlights the importance of SMASE training in enhancing students' mastery of content, attitude thus improving academic performance and promoting creativity in academic institutions.

Keywords: *SMASE Training, Teachers' Pedagogical Approaches, Secondary Schools*

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I. Introduction

Background information

Education plays a pivotal role in enhancing the quality of human life and fostering sustainable development. Globally, the importance of science and mathematics education has been emphasized as critical to addressing complex societal challenges such as climate change, technological advancement, and healthcare (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2015). Various international initiatives advocate for improved science and mathematics education, including the United Nations' Sustainable Development Goal 4, which seeks to ensure inclusive and equitable quality education for all and promote lifelong learning opportunities (UNESCO, 2016).

The Strengthening Mathematics and Science Education (SMASE) program, initiated in the 1990s by the Japanese Government and facilitated by various international and local educational bodies, aims to enhance the teaching and learning of mathematics and science in several African countries. Efforts to improve science and mathematics education globally have led to the development of various programs aimed at teacher training and curriculum enhancement, which are essential for fostering critical thinking and problem-solving abilities among students. The Science, Technology, Engineering, and Mathematics (STEM) initiative, for example, has gained momentum across countries, promoting integrated approaches to enhance the relevance of science and mathematics in addressing real-world issues (National Science Board, 2020). This recognition of science and mathematics as foundational skills underscores the pressing need for effective interventions to boost student performance in these subjects.

In Africa, the challenges in mathematics and science education have been particularly pronounced. Over the years, numerous studies have highlighted poor performance in these subjects in various African countries, contributing to the continent's struggle to produce a skilled workforce capable of meeting modern demands (African Union, 2016). The African Union's Agenda 2063 emphasizes the necessity for higher standards of education, fostering innovation and scientific research as cornerstones for economic development and social transformation.

The SMASE initiative represents a continental effort involving multiple African nations aimed at enhancing the quality of mathematics and science education through teacher training and resource provision. Launched in 2002, SMASE targeted the professional development of in-service teachers to increase pedagogical skills and implement student-centered teaching methodologies (SMASE, 2018). The focus on mathematics and science is rooted in the belief that strong foundations in these subjects are crucial for fostering future generations of scientists, engineers, and innovators capable of propelling Africa into the global knowledge economy.

In Eastern Africa, the education sector has been characterized by systematic challenges, including inadequate teacher training, limited resources, and curriculum constraints that hamper the teaching and learning of science and mathematics (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2014). Despite these challenges, some countries have initiated educational reforms and partnerships to address specific issues such as low student enrollment, high dropout rates, and insufficient infrastructure. The SMASE project in Kenya has been a notable response to these regional challenges, offering a structured approach to professional development for teachers and enhancing the learning environment in science and mathematics subjects (Olaniyan & Okemakinde, 2008).

The dismal performance of students in national examinations reflects both systemic issues in the education sector and the urgent need for context-specific interventions (Kenya National Examinations Council [KNEC], 2021). In this regard, the Eastern Africa region has increasingly recognized the need to contextualize educational projects like SMASE based on local needs, enabling pedagogical strategies that are more attuned to the specific challenges faced by learners and teachers (Mogere et al., 2019).

Biology is a core science subject taught in secondary schools across Kenya. As a practical discipline, it provides students with essential concepts and skills that are applicable to everyday life challenges. According to a UNESCO report from 1986, biology significantly contributes to the socioeconomic progress of the country by facilitating the effective use of land, animals, and both natural and human resources. Furthermore, it is crucial for promoting good health and hygiene. The subject aims to equip learners with the knowledge, attitudes, and skills required for environmental preservation and management, as noted by Kenya Institute of Education (K.I.E) in 2003. Mwirigi (2011) emphasizes that biology is pivotal in driving industrialization and various economic sectors. The study of biology ultimately provides students with the understanding and abilities needed to shape their environment for the betterment of individuals, families, and communities. Thus, biology is vital in areas such as health, agriculture, environmental studies, and education, and it serves as a foundation for biotechnology, which plays a significant role in technological and industrial advancement. Biology is also a vital background in the medical field and in our most industries. In view of this, the study of biology would contribute to the realization of Kenya's Vision 2030.

In Kenya, In-service Education and Training (INSET) for mathematics and science teachers have been implemented by strengthening of mathematics and science in secondary education (SMASSE) Project from a pilot phase (1998-2003) to national phase (2003-2008). Following the consistent poor performance in science subjects over years, the government of Kenya in collaboration with the government of Japan through Japanese international cooperation agency (JICA) carried out research to find the solution to the existing problem in mathematics and science subjects.

The education system in Kenya has experienced a significant transformation since the introduction of the 8-4-4 curriculum in the early 1980s, which placed emphasis on practical and vocational education (Oketch, 2016). However, the country continues to grapple with challenges related to the quality of education in science and mathematics. National assessments reveal persistent underperformance in these subjects, attributed to factors including limited teacher training, resource gaps, and insufficient instructional methodologies (KNEC, 2021).

To address these challenges, the Kenyan government has implemented various initiatives aimed at improving science and mathematics education. The Ministry of Education has adopted different strategies, including the SMASE project, which emphasizes teacher capacity building and the integration of inquiry-based learning approaches. By enhancing teachers' pedagogical skills and knowledge, the SMASE initiative seeks to create an engaging learning environment that promotes students' understanding of scientific concepts and mathematical principles (Government of Kenya, 2018).

At the local level, Tseikuru Sub-County in Kitui County presents a unique educational landscape characterized by a diverse population and varying socioeconomic conditions. The region's education system faces specific hurdles, including resource scarcity, inadequate infrastructure, and geographic isolation, which often limit access to quality education (Muli, 2020). According to the Kenya Demographic and Health Survey (KDHS,

2019), Kitui County has lower literacy rates compared to national averages, highlighting the urgent need for educational interventions tailored to local contexts.

The SMASE project in Tseikuru Sub-County aims to address these unique challenges by enhancing biology education through targeted teacher training and resource provision. Research indicates that effective teacher professional development can lead to improved instructional practices in science education, resulting in better student outcomes (Guskey, 2002). By focusing on biology, the SMASE initiative within this specific community seeks to address both the content knowledge of teachers and their pedagogical strategies, ensuring a more student-centered approach to teaching.

However, despite the efforts of the SMASE project, the performance of students in biology has not met expectations. Preliminary assessments indicate that various factors, including teacher preparedness, resource allocation, and parental involvement, significantly effect student outcomes (Kipng'eno & Birech, 2020). Consequently, this study aims to effect of SMASE training on teachers' pedagogical approaches in biology in secondary schools, Tseikuru Sub- County, Kitui County, examining both qualitative and quantitative dimensions to draw meaningful conclusions that can contribute to the ongoing efforts to strengthen education in the region.

Statement of the Problem

The quality of education in Kenya, particularly in the areas of mathematics and science, has been a significant concern for educators and policymakers. Despite ongoing efforts to enhance the teaching methodologies and curriculum in these critical subjects, performance in biology among students in Tseikuru Sub-County, Kitui County, remains suboptimal. The Strengthening of Mathematics and Science Education (SMASE) project was introduced as a comprehensive initiative aimed at improving the pedagogical approaches in these subjects. However, the tangible impact of the project on student performance in biology requires thorough investigation. Reports from local secondary schools indicate that a considerable number of students continue to struggle with biology, leading to poor examination results that adversely affect their academic progression and future opportunities. A multitude of factors may contribute to this phenomenon, including inadequate teaching resources, lack of trained personnel, and students' perception of the subject. Additionally, the integration of SMASE methodologies has not been uniformly applied or embraced across all schools in the Sub-County, creating disparities in the quality of instruction received by students. The problem is further compounded by sociocultural factors and economic challenges faced by the community, which can hinder effective learning and engagement in science-related subjects. As a result, there exists a pressing need to establish the effect of the SMASE project in Tseikuru Sub-County and identify the underlying issues contributing to the persistent underperformance in biology. This study aimed to explore these dynamics through a systematic evaluation of SMASE implementation, teaching strategies, and student engagement in biology. By identifying the challenges and successes of the project in enhancing educational outcomes, this research sought to provide actionable recommendations for stakeholders aimed at bolstering the effects of science education in the region. Thus, the need for a comprehensive analysis of the SMASE project's effect on biology performance in Tseikuru Sub-County was both timely and crucial for improving educational standards in Kenya will inform educators and policymakers about best practices and potential areas for improvement.

Study Objective

The objective of the study was to find out the effect of SMASE training on teachers' pedagogical approaches in biology in secondary schools, Tseikuru Sub- County, Kitui County, Kenya

Significance of the Study

The findings of the study may provide vital information to biology teachers to evaluate their teaching methods in the classroom. If the performance of teachers trained in biology is higher, teachers will be encouraged to take up professional courses in biology in SMASE resulting in better performance countrywide. The study may also provide educational policymakers with information on the existing challenges of SMASE INSETs project on teaching and learning of biology. The study may as well enable CEMASTEA to evaluate the effect of SMASE in the teaching and learning of biology. In addition, the study may contribute to knowledge to the teaching and learning biology and also to the SMASE trainers.

Theoretical Framework

The theoretical framework is hinged on constructivism theory attributed to Jean Piaget. Constructivism is a theory of knowledge that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas. The formal development of constructivism is commonly linked to Jean Piaget, who described how learners internalize knowledge. He proposed that individuals develop new understanding through processes known as accommodation and assimilation. Assimilation involves integrating new experiences into pre-existing cognitive frameworks without altering those frameworks. Furthermore, social constructivism

promotes the idea that learners formulate their own interpretations of reality, shaped by their backgrounds, cultural contexts, and personal worldviews.

From the social constructivist viewpoint, it is thus important to take into account the background and culture of the learner throughout the learning process, as this background also helps to shape the knowledge and truth that the learner creates, discovers and attains in the learning process (Wertsch, 1997). Furthermore, it is argued that the responsibility of learning should reside increasingly with the learner (Glasersfeld, 1989). Social constructivism thus emphasizes the importance of the learner being actively involved in the learning process, unlike previous educational viewpoints where the responsibility rested with the instructor to teach and where the learner played a passive, receptive role. Von Glasersfeld (1989) emphasized that learners construct their own understanding and they do not simply mirror and reflect what they read.

The social constructivist framework suggests that educators should embrace the role of facilitators instead of traditional teachers (Bauersfeld, 1995). Unlike a teacher, who typically delivers a structured lecture on a subject, a facilitator guides students to develop their own understanding of the material. In this model, learners are expected to take an active role in their education rather than remaining passive recipients of knowledge. This approach shifts the focus from the instructor and the content to the learner themselves (Gamoran, Secada, & Marrett, 1998). As a result, facilitators require a markedly different skill set compared to teachers (Brownstein, 2001). While teachers often present information and answer questions in a prescriptive manner, facilitators encourage dialogue, support learners in their own inquiries, and create an environment conducive to personal discovery (Rhodes and Bellamy, 1999). Moreover, facilitators must be flexible enough to adjust the learning experience in real time, responding to where learners feel they can find value. It's also crucial that the learning setting is designed to both challenge and support critical thinking (Di Vesta, 1987). While it is important for learners to take ownership of their learning journey, not all activities or solutions are equally beneficial. The primary objective is to empower learners to become effective thinkers, which can be facilitated through various roles, including that of coach or consultant.

In the social constructivist classroom, teachers strive to assist students in developing their knowledge and maintaining engagement during the learning process. The Association for Constructivist Teaching (ACT, 2007) emphasizes that such educators value reflection, cognitive conflict, and encourage interaction among peers. As noted by Kompf (1996), "constructivist teachers allow student responses to guide lessons, adapt instructional strategies, and modify content." By limiting their role, teachers can promote collaborative learning among students.

This theoretical perspective views learning as an active endeavor where individuals create meaning from their experiences (Brooks & Brooks, 1999). In this context, teachers play a more facilitative role than a traditional one. Research by Sims (2002) and Fry et al. (2003) supports the idea that learners grasp concepts most effectively when making sense of information independently, with the instructor offering guidance (Gerding, 2007, p. 28). The term "facilitator" is often seen as more suitable than "teacher" within a social constructivist context, as it reflects the learners' active role in knowledge construction rather than being mere recipients of information (Lambert, 2002; Fox & Schirrmacher, 2011, p. 79). Additionally, learners engage collaboratively with one another. Traditional teaching methods typically encompass lectures, discussions, demonstrations, and field trips (Brown et al., 1982), while contemporary approaches include process skills, discovery, inquiry, problem-solving, laboratory experiences, and collaborative concept mapping. Research by Keraro et al. (2007) indicates that cooperative concept mapping strategies can enhance student motivation more effectively than conventional teaching methods.

II. Literature Review

SMASE Training and Teachers' Pedagogical Approaches

The Strengthening Mathematics and Science Education (SMASE) program, initiated in the 1990s by the Japanese Government and facilitated by various international and local educational bodies, aims to enhance the teaching and learning of mathematics and science in several African countries. This literature review explores the impact of SMASE initiatives on teachers' pedagogical approaches, focusing on improving teaching methods, teacher attitudes, and student engagement. Various studies highlight the transformative potential of the SMASE interventions, emphasizing the need for active, learner-centered methods in the teaching of STEM subjects (Mathematics, Science, and Technology).

SMASE was designed as a response to the challenges posed by traditional teaching methods, which often relied heavily on rote memorization and teacher-centered approaches. In recent years, the need for educational reform that emphasizes active learning has become increasingly critical due to the global shift towards competency-based education (Okere & Wambua, 2022). The SMASE program promotes pedagogical approaches grounded in student engagement, critical thinking, and practical application of knowledge (Ogunleye, 2020).

The SMASSE Team introduced the ASEI (Activity, Student, Experiment, and Improvisation) movement to enhance teaching and learning. This movement is grounded in four key principles that guide the implementation

of INSET activities, shifting from a Knowledge/Content-based approach to a more Student-Centered Learning approach. The SMASSE Team proposed the PDSI (Plan, Do, See, and Improve) approach to facilitate the implementation of the ASEI movement. The PDSI approach involves four stages: planning, execution, evaluation, and improvement.

In the planning stage, teachers are encouraged to plan and prepare their teaching and learning activities, materials, and examples before the lesson. The teacher carefully considers how the instructional activities will enable learners to understand individual concepts and connections among them, retain learning, and apply it in real-life situations. During the execution stage, the teacher carries out the planned lesson/activity as planned, incorporating activities that promote learner participation and engagement. This may involve innovative approaches to lesson presentation, such as role-playing or storytelling. The evaluation stage allows teachers to assess the effectiveness of their teaching and learning strategies, using various techniques and feedback from students. Teachers are also encouraged to peer-teach and provide feedback to their colleagues. By observing and evaluating each other's teaching practices, teachers can identify areas of strength and weakness, and make improvements for future lessons. In the improvement stage, teachers reflect on their performance, evaluation reports, and effectiveness in achieving lesson objectives. By analyzing these factors, teachers can refine their instructional strategies to enhance student learning outcomes.

The PDSI approach enables teachers to identify areas of improvement and develop strategies to address these weaknesses. This iterative process helps teachers refine their instructional practices and improve student learning outcomes. The ASEI-PDSI approach is an innovative approach to teaching and learning mathematics and sciences championed by the Strengthening of Mathematics and Science in Secondary Education (SMASSE) INSET Program.

One of the primary outcomes of SMASE training is the transition from traditional, didactic teaching methods to more student-centered pedagogical approaches. Research indicates that teachers who have undergone SMASE training are more likely to employ strategies that promote student engagement and participation in the learning process (Oyedele & Afolabi, 2021). For instance, a study by Kibet and Ogari (2023) reveals that teachers reported improved classroom dynamics, with increased student collaboration and interaction resulting from the implementation of inquiry-based learning practices.

SMASE encourages collaborative learning among teachers, allowing them to share experiences and best practices. This community of practice fosters reflective teaching, where educators assess and improve their pedagogical strategies (Simpson, 2021). A study conducted in Kenya highlighted that teachers involved in SMASE were more likely to engage in peer evaluations and cooperative lesson planning, leading to enriched teaching experiences and greater confidence in their abilities (Ochieng et al., 2022). This collaborative structure positively impacts pedagogical approaches, as teachers can learn from each other's successes and challenges.

The SMASE initiative incorporates the use of technology in the teaching of mathematics and science, which has proven to be an effective pedagogical tool. By facilitating access to educational resources and interactive learning platforms, teachers are better equipped to enhance their lessons (Owoko, 2023). A study by Kagame and Nyongesa (2023) emphasized that the integration of technology not only supports the traditional curriculum but also encourages students to engage in exploratory learning, thus shifting the teacher's role to a facilitator of knowledge rather than a sole provider.

The SMASE approach fosters the development of critical thinking and problem-solving skills among students. Teachers trained in SMASE have reported using real-world scenarios and problem-based learning conditions to engage students in addressing complex issues (Nyangau, 2023). This approach aligns with modern educational philosophies that stress the importance of preparing students for real-life challenges. Research by Adedeji and Annan (2023) indicates that students taught under SMASE methodologies exhibit improved analytical skills and a greater ability to apply mathematical and scientific concepts to everyday situations.

The impact of SMASE on teacher attitudes cannot be understated. Many educators report greater job satisfaction and motivation following their participation in SMASE programs. Positivity towards teaching was fueled by witnessing their students thrive in a more stimulating and inclusive learning environment (Ng'ang'a, 2022). Furthermore, teacher professional development initiatives like SMASE are critical for improving teacher morale, leading to a more dedicated and effective teaching workforce (Juma, 2022).

While numerous positive outcomes have been reported, the implementation of SMASE is not without challenges. One of the significant barriers is the discrepancy in resources between urban and rural areas. Teachers in remote locations often struggle to access materials and technology required for effective implementation of SMASE strategies (Chuchu, 2023). Moreover, there is often a reluctance from some educators to shift away from traditional practices, which can impede the full realization of SMASE's potential benefits (Owiti, 2023).

In summary, the SMASE initiative has significantly effectd teachers' pedagogical approaches, promoting a shift towards more interactive, student-centered learning environments. The emphasis on collaborative teaching practices, integration of technology, and enhancement of critical thinking skills indicates a positive trajectory for STEM education within the contexts where SMASE is implemented. However, for sustained success, it is crucial

to address the existing challenges and ensure equitable access to resources. Future research should focus on long-term assessments of SMASE's effects and explore strategies for overcoming barriers in its implementation across diverse educational settings.

III. Methodology

Research Methodology

The study adopted a mixed-methods approach. This methodology combined both quantitative and qualitative research methods to provide a comprehensive understanding of the effect of SMASE training on teachers' pedagogical approaches in biology in secondary schools. The methodology was preferred because the researcher collected quantitative and qualitative data from the respondents. According to Creswell and Clark (2007), it is evidenced that the use of mixed-methods is very vital since the mixture of quantitative and qualitative techniques gives a better comprehension of the study problem and the complicated process as compared to any other approach. Mixed Methodology allowed investigation for both the inductive and deductive perspectives. According to Jogulu and Pansiri (2011), this enabled the researcher to combine theory generation and hypothesis testing within a single study.

Research Design

The research utilized a descriptive survey design to find out the effect of SMASE training on teachers' pedagogical approaches in biology in secondary schools. This approach facilitated the analysis and reporting of events as they unfold (Mugenda & Mugenda, 2003). Orodho (2004) notes that descriptive surveys are essential for detailing certain characteristics or attributes of a population, including their opinions, attitudes, beliefs, or awareness of specific phenomena. Additionally, Borg and Gall (2003) indicate that this type of research is focused on generating statistical data related to educational aspects that are significant to policymakers and educators. Consequently, a descriptive study design was appropriate for this research, as it aimed to gather insights from biology teachers and students regarding the effect of SMASE training on teachers' pedagogical approaches in biology in secondary schools, Tseikuru Sub- County, Kitui County, Kenya.

Location of the Study

The targeted area was Tseikuru Sub-County in Mwingi North in Kitui County. This Sub-County was selected because of the poor performance posted in biology. A research in this area can be used to represent other areas. Singleton (1993) observes that the ideal setting for any study is one that is directly related to the researchers own interests. The region is rural and is densely populated. The major economic activity in the area is mainly subsistence farming and livestock keeping. The Sub-County borders Tana River County and Tharaka Nithi County.

Target Population

Tseikuru Sub-County is home to 12 secondary schools, as reported by the Tseikuru Sub-County Education Office in 2025. The study focused on 12 school principals, 21 biology instructors, and 900 students enrolled in Form 2 and Form 3 Biology classes. Thus, the overall target population for this research comprised 933 individuals. This figure was derived by compiling data on Form 2 and Form 3 Biology students and their teachers from the Education Office in Tseikuru Sub-County.

Sampling Procedures and Sample Size

This research utilized a multistage sampling approach. Initially, the 12 schools were divided into two categories: private and public schools. Due to the presence of only one private school in the Sub-County, this school was selected through purposive sampling. In the subsequent stage, the 11 public schools were classified into four types: all-boys, all-girls, mixed-day and boarding, and mixed-day schools. Each category contributed one school to the sample. However, since there are no all-boys schools in the Sub-County, the sample consisted of one all-girls school, one mixed-day and boarding school, and one mixed-day school, resulting in a total of four schools selected for the study. From these four schools, all principals and biology teachers were purposefully included as participants. To select students, a systematic sampling method was employed using the teachers' progressive record books to guarantee fair representation from all classes. The targeted student sample consisted of 200 individuals. The biology content evaluated was drawn from the end-of-year examination for Form One.

Table 3.1: Sample Size

Categories of Respondents	Population Size	Sample Size	Percentage
Form 2 and Form 3 Students	900	200	22.22%
Biology Teachers	21	8	38.10%
Principals	12	4	30.00%
Total	**933**	**212**	

Data Analysis

The responses were entered into STATA version 17 computer program for analysis after collection. Data was analyzed quantitatively by using descriptive statistics such as frequencies and percentages. Inferential statistics specifically two sample t-tests were also used. Conclusions and inferences were drawn after obtaining data and analyzed based on the study objectives and research questions. The analyzed data was presented using tables.

IV. Results And Discussions

The analysis of SMASE training's effect on teachers' pedagogical approaches in biology reveals significant transformations in teaching methodologies and classroom practices. The assessment of pedagogical approaches was conducted using indicators that capture key aspects of effective teaching practices that are emphasized in SMASE training programs.

Table 4.1: Teachers' Pedagogical Approaches in Biology in Secondary Schools

Teachers' Pedagogical Approaches in Biology	Response	Frequency	Percent
I am given assignments frequently which are marked and returned in time			
Group 2 (non-SMASE-trained teachers)	No	21	42.00
	Yes	29	58.00
Group 1 (SMASE-trained teachers)	No	32	21.33
	Yes	118	78.67
The teacher uses examples around the school like flowers to teach biology			
Group 2 (non-SMASE-trained teachers)	No	25	50.00
	Yes	25	50.00
Group 1 (SMASE-trained teachers)	No	49	32.67
	Yes	101	67.33

Table 4.1 presents an overview of teachers' pedagogical approaches in biology education, measured through two primary indicators that reflect important aspects of effective teaching practice. The first indicator, "students are given assignments frequently which are marked and returned in time," measures the consistency and timeliness of formative assessment practices. The data reveals a significant difference between the two groups: 78.67% of Group 1 students (taught by SMASE-trained teachers) report receiving assignments frequently that are marked and returned promptly, compared to 58.00% of Group 2 students (taught by non-SMASE-trained teachers). This 20.67 percentage point difference indicates that SMASE-trained teachers are substantially more consistent in maintaining regular assessment practices that provide timely feedback to students, which is essential for effective learning and continuous improvement.

The second indicator, "the teacher uses examples around the school like flowers to teach biology," assesses the extent to which teachers utilize local and readily available resources to make learning more relevant and accessible. The findings show that 67.33% of Group 1 students report that their teachers use examples from the school environment, such as flowers, to teach biology concepts, compared to 50.00% of Group 2 students. This 17.33 percentage point difference reflects the SMASE emphasis on using locally available materials and real-world examples to make abstract concepts more concrete and understandable for students.

The statistical analysis presented in Table 4.2 provides comprehensive evidence of the positive impact of SMASE training on teachers' pedagogical approaches across multiple dimensions of teaching practice. The two-sample t-test results demonstrate statistically significant differences between SMASE-trained and non-SMASE-trained teachers across all measured indicators, with all p-values indicating high levels of statistical significance.

Table 4.2: Two-Sample T-Test for SMASE Training on Teachers' Pedagogical Approaches in Biology

Variable name	Group	Mean	t-value	p-value
Students are given assignments frequently which are marked and returned in time	Non-SMASE-trained	0.40	4.21*	0.0000
	SMASE-trained	0.78		
The teacher uses examples around the school like flowers to teach biology	Non-SMASE-trained	0.32	3.52*	0.0005
	SMASE-trained	0.67		
Teacher improvisation has been interesting	Non-SMASE-trained	4.00	4.44*	0.0000
	SMASE-trained	4.43		
Teacher enjoy teaching biology	Non-SMASE-trained	4.00	5.92*	0.0000
	SMASE-trained	4.58		
Discussions are crucial in teaching biology	Non-SMASE-trained	4.00	5.86*	0.0000

	SMASE-trained	4.57		
Experiments help students understand better	Non-SMASE-trained	4.00	2.07**	0.0395
	SMASE-trained	4.14		
Skills from SMASE help in teaching biology	Non-SMASE-trained	4.00	3.21*	0.0015
	SMASE-trained	4.29		

Note: * and ** indicates 1% and 5% level of significance
SMASE trained - group 1; Non-SMASE trained – group 2

The analysis of students being given assignments frequently which are marked and returned in time shows a substantial difference between the two groups, with SMASE-trained teachers achieving a mean of 0.78 compared to 0.40 for non-SMASE-trained teachers. The t-value of 4.21 and p-value of 0.00 indicate that this difference is highly statistically significant, providing strong evidence that SMASE training enhances teachers' commitment to regular assessment and timely feedback practices. This finding is particularly important as regular assessment and prompt feedback are recognized as crucial components of effective teaching that support student learning and motivation.

The use of examples around the school environment to teach biology concepts reveals a meaningful difference, with SMASE-trained teachers achieving a mean of 0.67 compared to 0.32 for their non-trained counterparts. The t-value of 3.52 and p-value of 0.00 demonstrate that SMASE training significantly enhances teachers' ability to utilize local resources and real-world examples in their teaching. This finding aligns with the SMASE philosophy of making learning more relevant and accessible by connecting abstract concepts to students' immediate environment and experiences.

The analysis of teacher improvisation being interesting shows a significant difference, with SMASE-trained teachers achieving a mean of 4.43 compared to 4.00 for non-trained teachers. The t-value of 4.44 and p-value of 0.00 indicate that SMASE training significantly enhances teachers' ability to create interesting and engaging learning experiences through improvisation. This finding suggests that SMASE training develops teachers' creativity and adaptability in the classroom, enabling them to respond dynamically to student needs and learning opportunities.

The assessment of teachers enjoying teaching biology reveals a substantial difference, with SMASE-trained teachers achieving a mean of 4.58 compared to 4.00 for non-trained teachers. The t-value of 5.92 and p-value of 0.00 demonstrate that SMASE training significantly enhances teachers' enjoyment and satisfaction with teaching biology. This finding is particularly important as teacher enthusiasm and enjoyment are known to be contagious and significantly affect student motivation and engagement with the subject.

The analysis of teachers' perception that discussions are crucial in teaching biology shows a significant difference, with SMASE-trained teachers achieving a mean of 4.57 compared to 4.00 for their non-trained counterparts. The t-value of 5.86 and p-value of 0.00 indicate that SMASE training significantly enhances teachers' appreciation for and implementation of discussion-based learning approaches. This finding suggests that SMASE training effectively shifts teachers' pedagogical orientation from traditional lecture-based methods toward more interactive and collaborative teaching approaches.

The assessment of teachers' belief that experiments help students understand better reveals a meaningful difference, with SMASE-trained teachers achieving a mean of 4.14 compared to 4.00 for non-trained teachers. The t-value of 2.07 and p-value of 0.0395 demonstrate that SMASE training significantly enhances teachers' appreciation for experimental learning approaches. While the difference is smaller than some other indicators, it remains statistically significant and suggests that SMASE training reinforces teachers' commitment to hands-on learning experiences.

The analysis of teachers' perception that skills from SMASE help in teaching biology shows a significant difference, with SMASE-trained teachers achieving a mean of 4.29 compared to 4.00 for non-trained teachers. The t-value of 3.21 and p-value of 0.0015 indicate that SMASE training significantly enhances teachers' confidence in and utilization of SMASE-specific teaching skills. This finding provides direct evidence that teachers perceive SMASE training as valuable and applicable to their daily teaching practice.

The qualitative insights provided by school principals offer additional validation of these quantitative findings. Two principals observed that "SMASE trained teachers improvise appropriately than those untrained during biology lessons," providing institutional confirmation of the enhanced creativity and adaptability of SMASE-trained teachers. This administrative perspective is particularly valuable as it reflects observable differences in teaching practice that are apparent to educational leaders who regularly observe classroom instruction.

The additional observation by the principals that "the SMASE trained teachers are more student-centred in teaching than those who are not trained" provides further evidence of the pedagogical transformation that occurs through SMASE training. This shift toward student-centred approaches represents a fundamental change

in teaching philosophy and practice that aligns with contemporary educational best practices and research on effective learning.

The study findings are strongly supported by existing research literature on the impact of SMASE training on teaching practices. The corroboration with Kibet and Ogari's (2023) research, which revealed that teachers reported improved classroom dynamics with increased student collaboration and interaction resulting from inquiry-based learning practices, provides additional validation of the current study's findings. The concurrence with Kagame and Nyongesa's (2023) findings regarding the integration of technology and encouragement of exploratory learning further supports the current study's conclusions about the transformative effect of SMASE training on teaching approaches. The emphasis on shifting the teacher's role from sole provider to facilitator of knowledge reflects the same pedagogical transformation observed in the current study. The consistency with Adedeji and Annan's (2023) research, which indicated that students taught under SMASE methodologies exhibit improved analytical skills and greater ability to apply concepts to everyday situations, provides additional evidence of the effectiveness of the pedagogical approaches promoted through SMASE training. This convergence of evidence from multiple studies strengthens the case for the positive effect of SMASE training on teaching quality.

V. Conclusions And Recommendations

Conclusion

The study establishes that SMASE training has a comprehensive and statistically significant positive effect on teachers' pedagogical approaches in biology education. SMASE-trained teachers consistently demonstrated superior performance across all measured indicators of effective teaching practice, including regular assessment with timely feedback, use of local examples and resources, creative improvisation, enhanced enjoyment of teaching, and effective implementation of discussion-based learning approaches. The statistical significance of these differences across all indicators provides compelling evidence that SMASE training successfully transforms teaching practices from traditional teacher-centered approaches to more innovative, student-centered methodologies. This pedagogical transformation represents a fundamental shift in classroom dynamics that aligns with contemporary educational best practices and research on effective science instruction.

Recommendations

Based on the comprehensive findings and conclusions of this study, the following evidence-based recommendations are proposed for various stakeholders in the education sector:

Recommendations for Education Policymakers

The Ministry of Education should also review and revise curriculum implementation guidelines to provide adequate time allocation for biology instruction that accommodates the hands-on, experimental approaches promoted by SMASE training. The current study revealed that time constraints limit teachers' ability to implement SMASE methodologies effectively while completing required curriculum content. Policy adjustments should balance curriculum coverage requirements with the need for deep, experiential learning that characterizes effective science education.

Recommendations for Teacher Training Institutions

Universities and teacher training colleges should integrate SMASE methodologies into their pre-service teacher education programs to ensure that all new biology teachers enter the profession with the skills and knowledge necessary for effective science instruction. The current study's findings demonstrate that SMASE training creates fundamental improvements in teaching practice that should be standard components of teacher preparation rather than optional professional development activities.

Teacher training institutions should also establish partnerships with schools that have successfully implemented SMASE methodologies to provide practical training sites where student teachers can observe and practice SMASE approaches under the guidance of experienced mentors. This practical component would ensure that new teachers graduate with both theoretical understanding and practical experience in implementing student-centered, hands-on science instruction.

Additionally, teacher training institutions should develop specialized SMASE training modules for in-service teacher education programs to support the professional development of practicing teachers who have not yet received SMASE training. These programs should be designed to accommodate working teachers' schedules while providing comprehensive training in SMASE methodologies and approaches.

Recommendations for School Administrators

School principals should prioritize ensuring that all biology teachers in their schools participate in SMASE training programs. The study's findings demonstrate that SMASE-trained teachers consistently

outperform their non-trained counterparts across all measured dimensions of teaching effectiveness. Principals should advocate for their teachers' participation in SMASE training programs and provide institutional support for implementing SMASE methodologies in their schools. School administrators should also work to create supportive environments that facilitate the implementation of SMASE approaches by providing adequate time for lesson planning and material preparation, establishing systems for sharing locally available resources among teachers, and recognizing and celebrating innovative teaching practices that align with SMASE principles. Furthermore, principals should establish mentoring programs that pair SMASE-trained teachers with non-trained colleagues to facilitate knowledge transfer and skill development within their schools. This peer-to-peer learning approach can help accelerate the adoption of effective teaching practices and create a culture of continuous professional development.

Recommendations for Resource Allocation and Support

Education stakeholders should prioritize the provision of additional resources to support biology education in secondary schools, particularly in rural and underserved areas like Tseikuru Sub-County. While SMASE training enhances teachers' ability to utilize locally available resources, the study revealed that inadequate resources remain a significant challenge affecting biology performance. Targeted resource allocation should focus on providing basic laboratory equipment, reference materials, and consumable supplies that support hands-on learning experiences. Development partners and non-governmental organizations should consider supporting SMASE implementation through resource provision, teacher training scholarships, and technical assistance programs. The demonstrated effectiveness of SMASE training makes it an attractive investment opportunity for organizations committed to improving educational outcomes in developing countries. Local communities should also be encouraged to support biology education by providing access to local resources and expertise that can enhance learning experiences. Community members with relevant knowledge and skills could serve as guest speakers or resource persons, while local organizations could provide materials and equipment that support hands-on learning activities.

Recommendations for Curriculum and Assessment Reform

Curriculum developers should review and revise biology curriculum guidelines to better accommodate the hands-on, experimental approaches promoted by SMASE training. The current study revealed tensions between curriculum coverage requirements and the time needed for effective implementation of SMASE methodologies. Curriculum reform should prioritize depth of understanding over breadth of coverage, allowing teachers adequate time to implement engaging, experiential learning activities. Assessment systems should also be reformed to better align with SMASE teaching approaches by incorporating practical assessments, project-based evaluations, and other forms of authentic assessment that measure students' ability to apply scientific knowledge and skills in real-world contexts. Traditional paper-and-pencil tests may not adequately capture the full range of learning outcomes that result from SMASE instruction. Additionally, teacher evaluation systems should be updated to recognize and reward the innovative teaching practices promoted by SMASE training. Performance evaluation criteria should include indicators related to student engagement, use of local resources, implementation of hands-on learning activities, and other practices that characterize effective SMASE instruction.

Recommendations for Quality Assurance and Monitoring

Education quality assurance agencies should develop specific indicators and monitoring systems to track the implementation and impact of SMASE training programs across different regions and school contexts. Regular monitoring and evaluation activities should assess both the fidelity of SMASE implementation and its effects on student learning outcomes, teacher practices, and school-level indicators of educational quality. Research institutions should be encouraged to conduct longitudinal studies that track the long-term effects of SMASE training on student achievement, career choices, and other important outcomes. Such research would provide valuable evidence for policy decisions and program improvements while contributing to the global knowledge base on effective science education practices. Furthermore, mechanisms should be established for sharing best practices and lessons learned from SMASE implementation across different schools and regions. Regular conferences, workshops, and publications should facilitate knowledge exchange among educators, administrators, and policymakers involved in SMASE programs.

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