

Limiting Factors Influencing Implementation of SMASSE(ASEI and PDSI) Instructional Strategies in Teaching Biology in Secondary Schools in Kakamega North Sub County, Kenya

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Abstract: The study investigated problems limiting extent use of the instructional strategies in teaching biology in public secondary schools in Kakamega North Sub County. Performance in mathematics and sciences in the national examinations has been relatively low in Kenya. Therefore, the Kenyan government in collaboration with Japan International Co-operation Agency (JICA) launched Strengthening of Mathematics and Science in Secondary Education (SMASSE) project in July 1998 in an attempt to provide remedial measures. SMASSE embarked on in-service training of serving teachers of mathematics and science with an aim of making them better teachers and improve performance in Mathematics and Sciences, including biology. One of the SMASSE initiatives involved teachers adopting refined instructional strategies of teaching biology. However, the limitations facing the extent and scale use of the instructional strategies (the ASEI and PDSI strategies) applied is unknown. Therefore, the aim of the study was to investigate the problems affecting the level and extent use of instructional strategies of SMASSE initiative in teaching biology in public secondary schools. Research was carried out in Kakamega North Sub County of Kakamega County in Kenya, an area where the pilot phase of SMASSE had been conducted since the year 2000 by the Ministry of Education. Twenty-five public secondary schools in the area which presented candidates to the examination council in the year 2014 were used in the study. The K.C.S.E results for 2014 were used as a measure of achievement. The target population of this study was all secondary school biology students, head teachers and form four biology teachers from the 25 schools. Since SMASSE is an ongoing project, views of how the biology teachers implement initiatives of SMASSE was collected from form two and form three biology students of 2015. To be specific, the views were collected from students taught by the 2014 K.C.S.E biology teachers. The data was collected using a student questionnaire designed by the researcher. Simple random sampling of a specific class was used to select 12 students from sampled classes to complete the questionnaires. Further, the biology teachers' questionnaire was administered to the biology teachers who taught the 2014 K.C.S.E biology classes. The other tool used in data collection was observation checklist and head teachers' questionnaire, which was administered to the head teachers of the sampled schools. Interview schedules were also used to gather more information from the science teachers and laboratory technicians. Purposive sampling was used to select biology teachers who prepared the 2014 K.C.S.E biology class and were SMASSE compliant for further observation. The data collected was analyzed and presented using bar graphs and pie charts. Regression analysis at 95% confidence level and descriptive statistics was used for data analysis. The data shows indicate 84% of the teachers of biology have heavy teaching load, 32% opined preparation of experiments is unnecessary and time wasting, 60% indicated the syllabus is wide; 32% stated that students have negative attitude towards biology; 68% observe that inadequate and lack of apparatus and equipment makes it difficult to engage students in practical; and there is no time for engaging in practical preparations limited use of the SMASSE instructional strategies in teaching of biology. This implies that about 28% aspects of SMASSE improvisation has not been adopted and wholly embraced. A positive gradient was established showing performance improved with the years of SMASSE in-service training. This study provides data to form a basis to inform the education policy makers to improve the structure of instructional strategies for efficient and effective teaching and learning to strengthen the science performance in secondary schools in the country.

Keywords: Limitation factors, Japan International Co-operation Agency, Kenya Certificate Secondary Education, Strengthening of Mathematics and Science in Secondary Education, Biology.

I. Introduction

The rationale for research in teaching practices and or instructional strategies and their mode of application in improving academic performance is urgently required at different levels, especially at the secondary school. This is a global concern (Wieman and Gilbert, 2014) [1] and the Kenyan situation is no

exception. Further, no colleges and university has data on the teaching practices applied in its courses and more so, efficiently and in consistent manner [1]. The only data collected on teaching is the student course evaluations (Berk, 2005) [2] which provide little information on the instructional strategies or teaching practice and lend little guidance to the teacher/or instructor on how to improve (Cohen, 1980) [3]. The studies show the need for research data on the mode and effectiveness of particular teaching practices in science, technology, engineering and mathematics (STEM) to improve teaching and learning process in the United States of America [1]. Africa countries show similar phenomenon and need for solutions (Akyeampong, 2014) [4] and Kenya is no exception. This approaches can have the net effect in solving the poor performance in mathematics and science subjects experienced in Kenya. Thus, the approach undertaken between Kenya and Japan International cooperation agency, the Strengthening of Mathematics and Science in Secondary Education (SMASSE) project was launched in Kenya on first of July 1998 in 9 out of 72 districts in the country. The programme was implemented for 5 years to 2003. Then the project underwent three phases with the third and final phase coming to an end in May, 2014 (Waititu and Orado, 2009) [5]. However, the implementation process of SMASSE are hampered with different limitation factors. These initiatives and models of remedial measures experiences varying problems at the implementation stages worldwide, for example STEM in the United States of America (Wieman, 2012 [6], different countries of Africa [4] (Akyeampong, 2016) [7]. Thus, the problems and challenges of science education including new opportunities in science education can tackled through research approaches (McFarlane, 2013), [8]. This calls for diverse models of researches simulating SMASSE in Kenya focused on the skills acquired being relevant for self-sufficient and to the changing dynamics in the modern society. According to the Nigerian SMASSE model, the intervention and relevance derived from teacher in-service aimed at enhancing the quality of teachers in terms of positive attitude, teaching methodology, mastery of content, resource mobilization and utilization of locally available teaching and learning materials in Nigeria (Shuaib, 2016)[9]. Instructional strategies constituted one of the focus of SMASSE model in Kenya.

Poor performance in mathematics and science subjects in the national examinations was a concern in the society of Kenya for years. Mwangi (2003) [10] observes that the general poor performance by students in K.C.S.E science exams (including biology) indicates that students lack adequate scientific skills. These skills are meant to be obtained through the learning of these subjects at secondary school level. Therefore, he notes that most school leavers at this level do not possess the knowledge and skills to be able to benefit from the opportunities for further training and education. Such skills could be applicable in the labor industries and other critical sectors of the economy. This is a major barrier to the Kenyan's quest for industrialization by the year 2030 (Kenya Vision, 2030) [11]. Discussions and suggestions were posted in the public domain to the attention of the Ministry of Education and the Government of Kenya. Bishop (1985) [12] observed that many countries are strengthening and modernizing their mathematics and science courses in order to produce more and better-qualified candidates for higher-level technical and scientific studies. Kenya responded by launching the SMASSE project, a joint venture with Japan International Agency (JICA) on the 1 July 1998. The teachers were frequently in-serviced in innovative ways of teaching biology. The project aimed at addressing the quality of teaching and learning of secondary school mathematics and science with a hope of improving students' academic achievement in these subjects. In spite of percentage success the SMASSE realized, it became necessary to find out the limitations affecting the level of the projects' implementation and goal, especially with respect to the instructional strategies used by teachers to achieve better students' academic performance in biology. These limiting factors formed the basis of the present study. Thus, the research data derived would be informative to the policy makers.

1.1 Statement of the Problem

An analysis of the pattern and trends of performance in K.C.S.E biology by the Kenya National Examination Council (KNEC) between 2002 and 2012 (K.N.E.C. Reports, 2003[13], 2004[14], 2005[15]...2013[24]) show that performance in the biology subject remained poor with an overall mean score of below 50% throughout the years. Further, there was an increase in the number of candidate who sat for K.C.S.E while there was a general drop in the percentage mean score from 2007 to 2012 [23]. This is despite the enormous efforts and initiatives by the government of Kenya and her development partners to improve the quality of teaching and learning in biology and the allied subjects. The most notable initiative has been SMASSE in-service training through which thousands of biology teachers have been in-serviced in terms of preparation and use of low-cost resources in teaching.

The recommended instructional strategy by SMASSE is Activity, Student Experimentation and Improvisation (ASEI) and Plan, Do, See, Improve (PDSI) approach. The strategy focuses on student-centered learning that involves many student activities including experiments and use of improvised material (ASEI) where necessary. To achieve these, formulation and implementation of work plans, evaluation of the results, and improving the work plans are encouraged. This constitutes PDSI, which stands for plan, do, see and improve.

Nui and Wahome (2006)[25] reporting on “SMASSE project impact assessment survey of September 2004” in the 2005 SMASSE internal report indicated that through these approaches, there is a positive impact on achievement of skills, knowledge and attitude by the learners. The significant improvement in internal performance in mathematics and sciences were recorded in the piloted SMASSE districts during the project period. Despite the effort, low performance is still persistent as shown by the mean scores in biology in Kakamega North Sub County (Table 1.1).

Table 1.1 Kakamega North Sub County 2008 to 2014 K.C.S.E Mean Scores in Biology

Year	2008	2009	2010	2011	2012	2013	2014
Mean Score in Biology	3.75	4.39	4.04	3.75	3.49	3.54	4.350

Source: Kakamega North Sub County Education Office, 2015.

Consistent poor performance in K.C.S.E biology (an external examination) by the students raises a fundamental question: How effective are the instructional strategies of SMASSE project in influencing students’ performance in K.C.S.E biology? The 2006 August parliament report reinforces this question: “...is the Minister aware that strengthening of Mathematics and Science in secondary schools (SMASSE) project training service has failed to meet the objective and not provide anything new to the teachers?” (Mzalendo, 2006)[26]. The aforementioned question asked to the Minister of Education, Science and Technology in parliament in 2006, seven years after SMASSE project establishment, is a reflection of the concern on the continued poor performance in K.C.S.E biology by students in the country. This is the case in the Kakamega North Sub County curved out of the larger Kakamega district that participated in the pilot phase of SMASSE since 2000. For example, 2,517 candidates sat for K.C.S.E. biology in Kakamega North Sub County and the grades distribution is shown in table 1.2.

Table 1.2: Kakamega North Sub County K.C.S.E. biology grade distribution 2014.

Grades	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	E
Total Candidates	35	49	55	76	92	142	207	271	277	767	474	72

Source: Kakamega North Sub County Education Office, 2015.

Table 1.2, reveal that a proportion of 63.2% of the candidates scored D+ and below. Performance for other years shows a similar trend (1.2). Consequently, the attainment of SDG’s might not be possible for Kakamega North Sub County, Kenya if the performance in Kenya National Examination of Education is the measure. Therefore, it became necessary to find out the factors limiting the influence of SMASSE initiative on K.C.S.E. biology performance in secondary schools in Kakamega North Sub County, Kenya.

1.2 Purpose of the Study

This study was determine limitation factors affecting the extent of instructional strategies of the SMASSE initiative on biology performance at K.C.S.E level in public secondary schools in Kakamega North Sub County, Kenya. This was an integral component and policy regarding the SMASSE project and how far implementation process is concerned.

1.3 Objectives of the Study

Specific objectives of the study were i) to determine the limiting factors affecting the extent use of the ASEI/PDSI instructional strategy in teaching biology in K.C.S.E. secondary schools in Kakamega North Sub County, Kenya.; ii) establish if there is a significant relationship between the frequencies of SMASSE in-service training and K.C.S.E. performance in biology K.C.S.E. secondary schools in Kakamega North Sub County, Kenya.

1.4 Hypotheses of the Study

The null hypotheses tested were that i) H_1 there is no limitation affecting the implementation of SMASSE initiative in teaching biology in secondary schools in Kakamega North Sub County, Kenya; ii) H_2 there is no significant relationship between the frequencies of SMASSE in-service training and K.C.S.E. secondary schools in Kakamega North Sub County, Kenya.

1.5 Significance of the Study

The data would provide informed research advice to the long-standing concepts and variables in the dynamic in- service process. In particular, the applicability of ASEI/PDSI approach to instruction in biology within limits of traditional orientation of teachers would be critically examined. With regard to practice, the research data would be useful to the Ministry of Education to appreciate the impact of SMASSE if any on small schools where weakness affecting the infrastructure resources inadequacy and develop policies to help such schools excel in performance. Further, the ministry would realize the role played by SMASSE instructional strategies limitations in academic achievement and thus streamline its policies in light of SMASSE objectives

and principles. Also, the biology teachers would plan and prepare their teaching and learning activities using ASEI/PDSI approach adequately that will promote high achievement in the subject.

1.6 Scope of the Study

The study focused on the impact of SMASSE initiative. Specifically, the study examined the following aspects of ASEI: the use of activities in teaching biology, student-centered mode of teaching, use of experiments, and improvisation when materials required to conduct the experiments were absent. It also examined the following aspects of PDSI: plan where teachers are required to plan on how to teach, see where teachers are expected to evaluate their impact on students, and improve where teachers are required to improve on the areas students do not perform accordingly.

1.7 Limitations of the Study

There are three limitations. First, the study may not be generalized to all schools in Kenya, because SMASSE in-service training was not initiated at the same time throughout the country. However, the findings will be useful to biology teachers in Kakamega North district. Secondly, due to limited time frame allocated for the post graduate program, the researcher relied on information collected using the questionnaire and group focus interviews to establish the teaching strategy in use and not in-depth interviews and direct observation in all schools sampled which was more demanding and time consuming. Thirdly, in some instances, the SMASSE in-service trained teacher responsible for the 2013 KCSE biology results may have been transferred from their school. In such a situation, it was assumed that team teaching was being practiced so the research collected information from other biology teachers.

1.8 Assumption of the study

The following were assumptions: i) the K.C.S.E results in biology were a reflection of academic achievement in the subject; ii) achievement in K.C.S.E biology was a reflection of overall performance during the secondary school period; iii) the higher the degree of implementation of SMASSE in a school, the better the biology performance in K.C.S.E; iv) the teacher maintains the teaching strategies and approach employed by teachers of biology, because of SMASSE in-service training; v) a class consists of 40 students.

1.9 Theoretical Framework

The constructivist theory of learning guided the study. The theory opines that the learners use their previous knowledge to construct their own new knowledge (Kersley, 1994) [27]. Learners easily engage in sense-making activities if they begin by examining what they already know according to theory. The students are then ready to construct their own ideas if the teacher provides conducive learning environment. Students are thus responsible for their learning. The teachers' responsibility is to create a suitable learning environment for the learners to be able to raise questions and seek out solutions to such questions by designing and performing investigations as an empirical basis for constructing knowledge. Thus, the teacher is a facilitator of learning by the pupil and provides the materials and resources that help the learner to raise questions and conduct investigations. A good classroom environment promotes students' curiosity, rewards creativity, encourages questioning and promotes meaningful understanding through the construction of knowledge. Group work is a component of such classroom environment that involves students in collaboration and dialogue as they construct new knowledge together. Meaningful learning of biology is therefore a product of three interacting components, the student, the teacher and the learning environment. If well planned and executed in lessons the three components promote meaningful and permanent learning among the students. SMASSE in-service training is anchored in the constructivist theory of learning [27] that promotes student-centered learning as opposed to teacher-centered learning. The driving force is the ASEI (Activity, Student, Experimentation and Improvisation) movement and PDSI (plan, Do, See and improve) approach. In this enterprise, the role of the teacher is that of guidance while the pupils are active participants in the discovery journey. This relationship is summarized in Figure 1.1.

1.10 Conceptual Framework

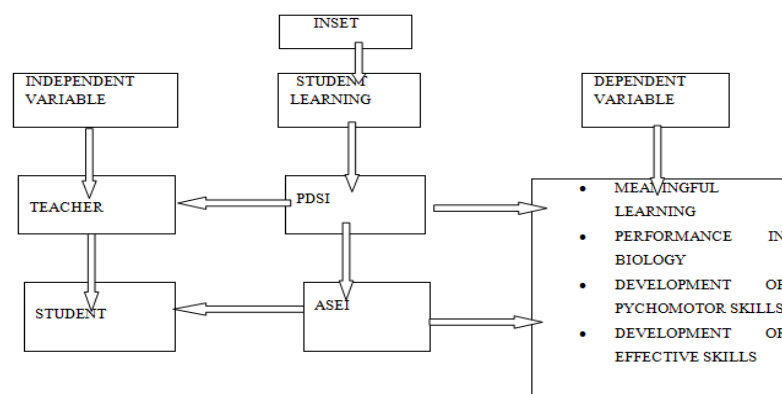


Figure 1.1: Benefits of in-service training on teachers and students' performance. Source: Modified from Mukachi (2006) [28].

From Figure 1.1, it is evident that the SMASSE initiative, as a mediating support in the teaching/learning enterprise, provides the motivation and momentum for a dynamic relationship between teachers and learners. It also provides momentum and motivation for the teaching process. The ASEI axis provides the drive for effective preparation in terms of lesson delivery, provision of relevant and effective resources, and effective learning activities. The PDSI axis provides the impetus for planning, testing of the plans, lesson delivery, evaluation of learning and remedial activities. The ASEI and PDSI mediation collectively leads to dynamic characteristics of both students and teachers. The overall result is acquisition of effective, psychomotor, and cognitive skills that are reminiscent of meaningful learning characterized by enhanced memory and high achievement in biology. Conceptual framework therefore maps out the variables for this study involves: Independent variables: integration of SMASSE instructional strategy in terms of incorporation of ASEI/PDSI approaches, whose indicators include: ASEI (student related component) (A-the type of learning activities undertaken by students; S-guidance given to students to find solutions to problems and Creative and reflective thinking; E-the type of learning activities undertaken by students in terms of investigation; I-Amount of improvisation); PDSI (teacher related components) (P-Amount of time spent in planning and quality of lesson plans in use; D-teamwork and collaborative teaching; S- evidence of evaluation of teachers work; I-revision of teaching strategies). Dependent variables include: achievement in biology; meaningful learning whose indicator are: students-students' interaction, students' interaction with apparatus, amount and type of assignment given to students; cognitive and manipulative skills. In this study, the researcher focused on integration of implementation of SMASSE instructional strategy as indicated by: team work and collaborative teaching and learning, amount of improvisation, type of learning activities; PDSI: quality of lessons plans, evaluation of teacher's work as independent variable; and achievement in K.C.S.E biology as dependent variable.

1.12 Ethical Considerations

None of the information was published in manner in which the individual secondary schools, teachers and students involved in the study will be identified rather are treated confidentially

II. Literature Review

The evidences from three sub-Saharan African countries (Botswana, Ghana and South Africa), show that young Africans studying science and mathematics in our schools today are not acquiring the relevant conceptual and transformative skills to secure a transformative shift in Africa's development [7]. This suggests a crisis on our hands – a learning crisis in MSE in sub-Saharan Africa. The most serious challenge hindering the development of science and technology in Africa include insufficient levels of literacy and shortage of women in science among other things. Recent study shows the percentage of students taking part in the TIMSS assessment who achieved an international minimum standard in mathematics and science is still very low [7]. At the most basic level, for mathematics, only 10% reached average achievement in South Africa (2003). In Ghana this is 19% (2011) and in Botswana 30% (2007). For Science the figures are 12% (South Africa); 20% (Ghana) and 34% (Botswana). What was also noticed from the data on learning outcomes is that the quality of experience learning mathematics and science is uneven, gendered, and location-based, i.e. the quality of experience in learning mathematics and science depends largely on whether you attend a school in a rural or urban area, or you are rich or poor. This means the experiences of MSE are highly inequitable. This is worse when gender is considered, that women education achievement is low. The same sentiments are echoed by UNESCO (1995) [29] which reports: “*Industrialization needs to be developed through science and technology education. This would support economic growth and sustainable development which can be done through strengthening the access of women and girls who make up at least 51% of the population to science and technology*”, Pp. 39. This is because of the girls' poor performance in science subjects as compared to other subjects.

According to Eshiwani (1982) [30] and Changeiywo (2000) [31], girls in developing countries have less access to education than boys do. Girls also under-achieve in science and mathematics at the secondary school level in Kenya. There is a problem with the science education in the secondary schools of many developing countries and the same education tends to focus on abstract principles and theories that are not the countries' economic potential needs or requirements (Bude, 1995) [32]. The criteria of determining dissemination of relevant knowledge to the learners and its application in really life situations demands quick remedial action by policy makers. For example, only 1% of South African learners who participated in TIMSS 2011 had achieved the advanced benchmark – i.e. the ability to apply understanding in relatively complex situations and explain reasoning (Reddy, Zuze, Visser, Winnar, Juan, Prinsloo, Arends and Rogers, 2015)[33]. In the case of Ghana, performance in both mathematics and science has improved only slightly with gender and rural and urban gaps widening. Such inequitable progress means Ghana will not be able to maximize benefits

for all young people even if it managed to improve the quality of MSE. When we compare the three sub-Saharan African

Countries that have participated in TIMSS to Latin American countries, for example, Chile are making good progress and closing the equity gap in learning the basics in mathematics and science. Thus, Chileans are achieving more equitable and meaningful access to mathematics and science education. Finally, there is need for SMASSE and like-tailored models of the MSE type to be relevant and equip young Africans with skills in interpreting, analyzing and manipulating information or data to harness opportunities for sustainable development. Currently, instructional practices currently used in many schools are expository type in which the teacher dominates the lesson and is constantly in the process of narration (Tiffin, 1994[34]; Gray, 1998) [35] [33]. This is the ‘Jug and Mug’ method [18] where the teacher is the ‘jug’ filling the student, the ‘mug’ with knowledge. However, students could learn science better if the teaching methodology would enable them to be actively involved in the class activities [32]. Learning science by doing requires a continuously active interaction between learners and their environment [32]. Therefore, there is need to find out if learning in our biology classes is student centered with students interacting amongst themselves and their environment as proposed by SMASSEs.

2.2 Performance in Science Education

A steady decline in academic performance of high school students in the science subjects as well as low enrolment has caused much concern in many developing countries. For instance, the KNEC examination reports [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] indicate that the overall performance of students in science at K.C.S.E level is low compared to other subjects. Performance in science is generally poor in developing countries due to many problems ranging from under-funding of science education programs to language and science versus cultural conflict [36]. These factors affect the quality of science and mathematics education negatively. Analysis of the K. C. S. E. report in science, mathematics and other subject indicates that the students’ performance in science and mathematics is poorer than in other subjects and that girls even perform worse than boys overall (Table 1.3).

Table 1.3: Candidate’s performance by gender in the years 2005 and 2006 K. C. S. E. examination in science and few selected subjects

Year	2005				2006			
	Female		Male		Female		Male	
	No. sat	Mean score	No. sat	Mean Score	No. sat	Mean score	No. sat	Mean score
Mathematics	118,898	12.97	140,414	18.49	113802	15.78	12323	21.87
Biology	113,605	27.24	121,370	32.01	108065	25	109863	29.84
physics	19,288	32.85	50,136	35.99	21376	39.07	51123	40.82
Chemistry	116,826	24.54	136,684	29.44	111969	22.56	124932	27.01
Hist. & Govt.	64,826	46.85	78,851	54.84	66228	46.72	78206	54.04
Geography	45,185	38	61,088	43.7	41929	38.16	56088	44.38
C.R.E	67,883	57	52,004	57.74	82613	55.63	61678	55.4
Art & Design	375	59.39	662	57.37	358	61.26	750	61.93
Comp. Studies	1708	51.37	1696	57.33	1874	52.09	2309	56.87

Source: Kenya National Examination Council 2007; the year 2006 K.C. S. E. report

From the table 1.4, it is clear that the students’ mean score in chemistry and biology for both years was below 35%. In the year 2006, the mean score for girls in biology was 25.00% while that of the boys was 29.84%. The data reveals that Science subjects and Mathematics are performed poorly as compared to other subjects. This opposes the fact that the many curriculum changes carried out [39] should be functional and vision-oriented. Some of the causes of the poor performance are attributed to poor instructional approaches used in teaching. Further, the challenge facing innovations aimed at changing teachers’ attitudes and classroom practices is how to provide powerful images of applying science (and mathematics) to solve basic environmental and social problems which pupils can easily identify with and make sense of (Akyeampong and Kuroda, 2007) [37]. It is not that teacher educators do not know or are not aware of the importance of these skills [37]. But, studies have shown there is a gap between desired competences that mathematics and science should foster, and what happens in the actual process of teaching and learning the subjects [7]. Thus, how do we ensure that the innovations and creative ideas about effective MSE are at the heart of how teachers learn to teach mathematics and science to secure these desirable competences? To be specific, 85% of the instructions consist of lectures and give students low chances of interaction (Johnson & Johnson 1991)[38], creative and critical thinking to solve complex situations.

Teachers’ professional development in Nigeria, however, has long been criticized for its lack of sustainability and ability to produce effective change in teaching and students achievement [7]. Education theorists today believe that a critical component of educational reform lies in providing teachers with various

opportunities and supports structures that encourage ongoing improvement in teachers' pedagogy and discipline-specific content knowledge. However, the ongoing reforms in education sector and the need to refocus the Nigeria education system towards the goal of the National Economic Empowerment and Development Strategies (NEEDS) demand that the existing In-service and Education Training (INSET) in Nigeria be refocused. For teacher education to produce teachers who can foster desired mathematics and science competences, it should focus improvements in four areas: Resources, Innovation, Curriculum and Assessment (RICA) according to [7]; where resources means that the teacher education requires adequate and relevant instructional resources to support changes to how teachers learn to teach mathematics and science in schools. Thus, effort should deliberately be done to find ways in which technology can be used as an instructional resource to solve routine and complex problems that require application of mathematics and science concepts; embrace innovation by finding ways to infuse mathematics and science teacher education with innovative teaching and learning ideas/practices; review MSE curriculum for a closer alignment between goals and pedagogical practices; provide systems to review and introduce innovations in assessing mathematics and science in teacher education. In an effort to fill the gaps and improve on performance, the Ministry of Education Science and Technology (MOEST), in conjunction with Japan International Co-operation Agency (JICA), launched SMASSE project in 1998.

The SMASSE Project

SMASSE is an acronym for Strengthening of Mathematics and Science in Secondary Education [25]. It is a joint venture between the Kenyan government through MOEST and the government of Japan through JICA. The SMASSE (Strengthening of Mathematics and Science in Secondary Education) initiative in Kenya was in response to students continued poor performance in the mathematics and sciences, despite a number of efforts that had been implemented to address some of the challenges facing the mathematics and science education. These efforts included: providing schools with qualified mathematics and science teachers; improving remuneration and terms of service for the mathematics and science teachers; providing schools with science equipment and even constructing laboratories. The Ministry of Education considered evolving appropriate pre- and in-service training so as to raise relevance and quality in secondary education (MOEHRD, 1997)[39]. Indeed, MOEST (2003) [40] (Pp.19) considered developing and operationalizing focused in-service programs as one of the indicators for attainment of enhanced quality of education [5]. According to [25], SMASSE came into being when there was consistently poor performance in Mathematics and Science because of the broad curricular, lack of facilities, ill equipped teaching skills and inadequate staffing. In an effort to intervene, the Ministry of education came up with the SMASSE project.

The project applied two approaches in strengthening quality of Education: mounting capacity development workshop for school managers' and conducting INSET to strengthen quality of teaching force in mathematics and science. INSET is one of the approaches employed to up-grade teachers' skills and competence the world over (Karega, 2008)[41] and is in conformity with worldwide consensus that improving quality of education depends on improvement of quality of classroom practices (Kibe, Odhiambo and Ogwel, 2008)[42]. Lack of adequate textbooks, teaching materials, science teachers, congestion of the curriculum and the high Education budget compromised the quality of education with greatest decline being in Sciences and Mathematics. As a result, the Kenyan government announced the need to strengthen the teaching and learning in these areas as one of its priorities in the seventh and eighth National Development Plan. The implementation of INSET for teachers of science and mathematics was identified as a top priority in the human resource development program. Thus, the aim of the SMASSE project was "*quality improvement of incumbent teachers in science and mathematics through INSET.*"

Upon implementation of the project, the SMASSE team carried out a baseline survey in the nine pilot districts. The baseline survey revealed several factors that directly or indirectly contributed to poor performance in mathematics and science. 'Looking at the factors, it cannot be lost on any keen observer that the teaching and learning of these subjects need a new orientation in terms of approaches and methodologies and in terms of priorities and policies (Kisaka, 2003)[43]. Therefore, the SMASSE project undertook several activities aimed at realizing the goal of enhancing the capability of young Kenyans in Mathematics and Science (Kogolla, 2003) [44]. This was achieved through in-service education and training (INSET) for serving teachers of Mathematics and Science to focus on the instructional approaches used in the schools and advocate for student-centered learning activity-oriented.

Three cycles were recommended by the Project Design Matrix (PDM) and a fourth cycle by the stakeholders meeting in May 2002. Each cycle had a main theme [44]. After the success of the pilot phase, the SMASSE project activities were adopted nationally (SMASSE Phase II, SMASSE Report, 2003[45], 2004[46], 2005[47], 2006[48], 2007[49], 2008[50]). As a follow-up of SMASSE, Kenya personnel conducted monitoring and evaluation of application and impact of the principles of ASEI movement and PDSI approach in the classroom in Malawi, Zambia, Rwanda and Zimbabwe in May 2005 [27] for comparison and rationalization. Then,

national wide Survey was taken to access the impact of INSET [47] was to establish the SMASSE activities practices in the classroom and subsequent translation into academic achievement. However, the available information suggests that this was done in Mathematics, but it was not correlated to the final achievement of the students [25]. The SMASSE guiding philosophy for change is Activity, Student, Experimentation, Improvisation and aims at assisting teachers to shift classroom practice from: i) content based to activity based, ii) lecture / theoretical approach to experiments and research based approach where experience rather than events are emphasized; iii) recipe type large scale experiments to scale down experiments and improvisation. The concept envisage more responsibility placed on student during teaching. This is because the quality of classroom activities is critical for effective teaching and learning (Odalo, 2000 [51]; Oswald, 2002 [52]). This necessitates that while planning for teaching and learning activities, a teacher should target at insightful learning as opposed to rote learning that was revealed by the baseline studies carried out by the SMASSE team in 1998 (SMASSE Report, 1999)[53].

Studies show that students learn science better when teaching methodology enables them to get actively involved in the classroom activities [32]. Thus, the ASEI and PDSI of SMASSE philosophy encourages hands-on and Hearts-on-learning. According to Haury and Rillero (1994) [54], hands-on-learning ensures that the learner is "doing" science allowing her or him to be involved in a total learning experience that enhances critical thinking. Hands-on-learning allows for in-depth investigation with objects, materials, phenomena and ideas. This makes students to directly observe and understand science hence learn the "what", "how", "when" and "why" of things with which they interact. SMASSE advocates for a range of teaching strategies to address diversity in the contemporary biology class. This includes discussion, small group experiments that allow students to interact with one another as well as the apparatus, project work, field excursion, role-play, use of assignment etc., which is aimed at enhancing development of creative thinking and problem solving ability. Hands-on-science therefore is the philosophy guiding when and how to use the broad range teaching strategies. Thus, the study was geared towards finding out the limitations affecting the extent use of the hands-on, minds-on and hearts on activities carried out in biology classes and how this relate to performance in biology.

2.4 Research Findings in Biology Education

Studies show that biology practical work is still teacher-centered Kipkorir (1996) [55] and negative attitude towards science persists (28). [28] recommended that improvisation should be done to solve the problem of facilities in our schools and in-servicing of teachers is required. However, recent studies revealed student centered learning in physics (Kahare, 2011) [56], a case not documented in biology. Further, learning activities in the recommended textbooks were never taken up. Also, it was reported that resources such as laboratory, laboratory apparatus, and materials may have been available in the schools studied but the frequency of use was low [55]. In addition, Githui (1996) [58] indicated that lack of in-service training contributed to low performance. No recent study has been carried out to determine the limiting factors affecting instruction strategies in biology education in the country.

In the literature, it was cited that facilities contributed to lack of practical work and poor performance. Improvisation was recommended, therefore, in this study, the researcher wanted to find out limitation factors that affect the level of improvisation being done as suggested by SMASSE and how this relates to biology achievement. Similarly, lack of in-service training was cited as contributing to low performance and in-service was recommended as a measure to improve on performance. Therefore, the researcher wished to establish the relationship between the frequencies of in-service and achievement in biology. It was also cited that learning was teacher-centered, SMASSE advocates for student-centered learning which is to be achieved by ASEI movement and PDSI approach used in teaching biology. Much of these information on impact of SMASSE is in the area of Mathematics but very little information is available in the area of biology. Therefore, the researcher wished to attempt to fill up the gap in the teaching of the biology subject. This was done by investigating the relationship between the limitation influencing the level of implementation of SMASSE initiatives and achievement in K. C. S. E. biology in Kakamega North Sub County. It was also notable that there is little literature on the benefits of ASEI/PDSI instructional strategy in teaching biology.

III. Research Design and Methodology

3.1 Research Design

The ex-post-facto research design was adopted for this study. In an ex-post-facto research, inferences are made concerning relationship among variables without direct control of the independent variable because their manifestations have already occurred and cannot be changed (Kerlinger, 1973) [59]. In this study, the level of implementation of SMASSE, as an independent variable could not be controlled by the researcher.

3.2 Area of study

The area of study was Kakamega North Sub County of Kakamega County, Kenya. Kakamega North Sub County was carved out of the larger Kakamega on the south and borders Lugari District (Matete) on the North, on the East is the Nandi escarpment. The main economic activities in this area are farming where inhabitants practice both crop farming and animal husbandry. The Sub County had 36 secondary schools at the time of the study of which 35 are public and one private. The reason for carrying out the study in this area was that the researcher was stationed in one of the schools in the Sub County thus making the study economical in terms of finances and time. Besides the area had also shown poor performance in K.C.S.E and especially in biology yet it was carved out of the larger Kakamega North Sub County where the pilot phase of SMASSE was conducted since the year 2000.

3.3 Population

The target population of the study was all biology students in the 35 public secondary schools in existence in the Sub County since 2008. This was used to establish the trend in K.C.S.E biology achievement from the year 2008 in the Sub County. The accessible populations were all form three and form two biology students in the sampled schools. Form two and form three students were used to allow the researcher get views from students who had been taught by SMASSE in-serviced teachers who also taught the 2014 K.C.S.E biology classes. Twenty-five out of the 35 public schools were in existence before SMASSE Inset and presented candidates for the K.C.S.E examination during the study.

3.4 Sampling, Instrumentation and Data Collection

The sample and sampling procedure, instrumentation (standardized test, questionnaires, interview schedule and observation checklist) and data collection procedure, piloting of research instruments, validity and reliability of instruments followed methods of (Sikolia and Sikolia., 2016) [60].

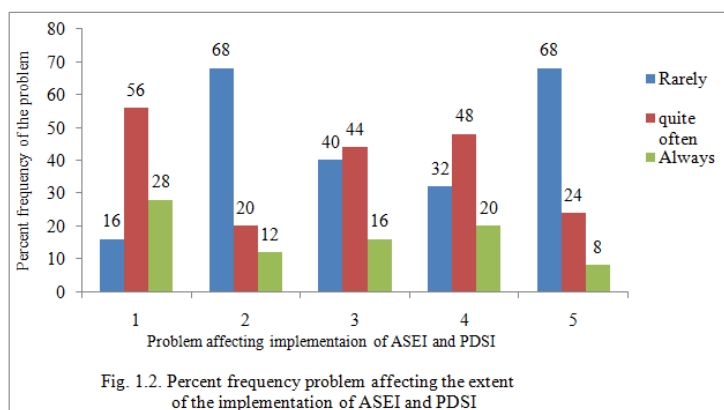
3.5 Data Analysis

Quantitative and qualitative data were generated from the field and data were analyzed using inferential and descriptive statistics. The analysis was mainly presented in the table form and using bar graphs. For quantitative data, Regression analysis was computed at a 95% confidence interval to establish the relationship between the variables for the quantitative data, where necessary in the present study. The same technique was also used to test for the hypotheses of the related variables. The Microsoft Office Excel software was used to analyze the data.

IV. Results And Discussion

4.1 The Problems Affecting the Extent of the SMASSE Implementation of ASEI and PDSI

Fig. 1.2 shows problems affecting the extent of the implementation of ASEI and PDSI in Kakamega North Sub County. The bar graph indicate 84% of the teachers of biology have heavy teaching load, 32% opined preparation of experiments is unnecessary and time wasting, 60% indicated the syllabus is wide; and there is no time for engaging in practical preparations. Still, 68% observe that inadequate and lack of apparatus and equipment makes it difficult to engage students in practical work which implies that the aspect of improvisation in SMASSE has not been adopted and wholly embraced. Further, 32% stated that students have negative attitude towards biology while 68% show positive attitude as shown in Fig.1.2. This defines the ability SMASSE instructional strategies in improve learning process. Also, shows that the problem of students' attitude is being addressed. This empowers the youth to interact with their environment and change their attitude towards different phenomena in life. The youth becomes prepared for the challenges and opportunities in the labour market to support Africa's development which is increasingly demanding modern knowledge and skills of mathematics and science education, ability to solve problems and to innovate products and processes in future (Bethell, 2016) [61]. It prepares them to develop critical thinking level and being creative in the different circumstances they engage in life. However, both critical thinking and 21st-century skills are indeed necessary in a curriculum for a 21st-century education but there are not sufficient, even in combination.



The role of knowledge and an understanding of differing cultural perspectives and values indicate that education should also fit local contexts in a global world and meet the specific needs of students in diverse cultures. It should also fit the particular technical and historical demands of the 21st century in relation to digital skills. Finally, SMASSE made significant effort to improve mean score performance in biology. 68% of the SMASSE in-service trained teachers observed that preparation of experiments is necessary and not time wasting as shown in Fig.1.2. Generally, three major problems were cited namely teaching heavy load, syllabus too wide and no enough time for practical preparation; and inadequate and lack of apparatus and equipment. The other problems being addressed include negative attitude towards the subject of biology and curriculum examination oriented. For example, the impact of K.C.S.E. results are the terminal indicators of upgrading in learners’ abilities based on the results of the national examination. However, MOE (2007) [62] observes that, the curriculum and teaching are geared to preparing students for higher education, which is only a fraction of the students aspire for. The KCSE examination therefore serves as a screening devise: disqualifying a large majority and selecting a small minority of graduates for tertiary education.

This implies the SMASSE inset was addressing its set objectives. Thus, novel initiatives like Third-Country Training Programme (TCTP) for MSE educators and sharing of information on education cooperation in Africa are education strategies advised in providing mitigations to the SMASSE instructional strategic limitations pointed out. This will improve the scientific and mathematical skills of the youth and prepare them to make the correct decisions in the daily life.

Table 1.4. Percent frequency teacher attendance by biology teachers of annual SMASSE INSET trainings in Kakamega North Sub County

Number of SMASSE annual trainings	0	1	2	3	4	5	6	7	8
Percent frequency teacher attendance	23.3	6.0	30.0	16.7	10.0	6.7	0.7	0.6	0.6

Table 1.4 shows the low percent frequency of attendance of SMASSE IN-SET by teachers of biology for the project period. The highest percent frequency attendance was two times (30%) as shown in Table 1.4. Generally, rarely was the percentage above 1% for five to eight opportunities of attendance provided by the SMASSE project. This was attributed to lack of financial support to trainee either by the school or the SMASSE project, lack of sustainable appraisals and positive package related to the trained SMASSE teacher for instance promotion. Consequently, ensuing low motivation and interests in the instructional strategies might affected the efficiency and effectiveness of the instructional strategies in the biology classroom and therein performance during the K.C.S.E. performance. Deliberate and measured efforts should be employed to promote peer-learning of SMASSE and JICA’s intervention in different African countries, such as “Teacher Professional Development and Management” in Ghana, “Learning Achievement and Assessment” in Ethiopia, and “Pre-service Teacher Training, Teaching Material Analysis (Kyozaï-Kenkyu)” in Zambia (Cemestea, 2016) [63].

Hudson’s advocacy of *an action-oriented and issues-based curriculum* is proposed [8] as the key to renewing and activating scientific literacy to increase students’ performance and national competitiveness in the global economy. He opines that not only is there strong rationale for the renewal and transformational of science education in terms of perspective and approach, but also takes a critical approach in examining some of Hudson’s (2011) [64] contentions regarding strategies in confronting socio scientific issues as major pathways to the teaching and learning of science. It is imperative that teachers must have access to sustainable, high quality professional development in order to improve teaching and student learning. Further, there is need to update the curricula and the syllabus to match reoriented teaching styles and upgrade pedagogy of SMASSE trainers. Thus, there are some limitations observed during the study that limit the implementation of SMASSE instructional strategies, the ASEI and PDSI strategies. Therefore, reject null hypothesis and conclude that there

are limitations affecting the implementation of SMASSE initiative in teaching biology in secondary schools in Kakamega North Sub County.

4.3 Frequency of SMASSE in-service Training and K.C.S.E Performance in Biology

The experience of the teacher obtained from SMASSE in-service training is very significant in teaching subjects in classroom. This led to the need to find out whether experience obtained from SMASSE had an effect on K.C.S.E biology achievement. It follows that data collected for the study was analyzed to establish the objective mentioned before. This was achieved by focusing on schools that had their students taught by SMASSE in-service trained teachers. The frequency of SMASSE training was used as the predictor variable in this analysis. A regression analysis was computed at a 95 % confidence interval to establish the relationship between the two variables. Results were also obtained from a study that analyzed whether the experience obtained from SMASSE in-service training had an effect on the students results. The schools from group J had their mean scores from the year two thousand and eight to thousand and fourteen averaged. The outcomes (the averages) were recorded alongside the frequencies of annual experience from the teachers (Table 1.5).

Table 1.5: Frequencies of annual experience from the SMASSE in-service trained teachers and their corresponding K.S.C.E. mean score 2008-2014

Secondary School	A	B	C	D	E	F	G
Number of Years of SMASSE Training	7	3	4	6	6	5	4
Mean Score	5.302	3.75	3.61	3.58	6.09	4.33	4.10

Using regression analysis, the frequency of training acted as independent variable while the school means was the dependent variable. The excel output for the regression analysis is represented by the Table 1.6.

Table 1.6: Regression of school mean scores against the annual experience of SMASSE in-service trained teachers

Regression Statistics							
Multiple R	0.62567						
R Square	0.39146						
Adj. R Square	0.26976						
Std. Error	1.20851						
Observations	7						
ANOVA							
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Sign F</i>		
Regression	1	4.69756689	4.70	3.216	0.13288		
Residual	5	7.30243311	1.46				
Total	6	12					
	<i>Coefficients</i>	<i>Std. Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>
Intercept	0.93580	2.31171787	0.41	0.702	-5.006657	6.878263	-5.006657
X Variable 1	0.92513	0.51584189	1.79	0.1329	-0.400881	2.251147	-0.400881

The results from the regression output above indicate that there is a moderate positive relationship between the frequency of SMASSE in-service training and the K.C.S.E. results. This owes to the reality that Taneja (2009) [65] reveals that a correlation coefficient that is close to positive one means there is a strong positive relationship between the two variables under study. Consequently, a correlation coefficient of 0.626 implies that there is a moderate positive relationship between the frequencies of SMASSE in-service training and K.C.S.E. results. This is enhanced by the positive gradient of 0.936. The output also provides a p-value of 0.133. The p-value of 0.133 is greater than 0.05. Therefore, null hypothesis and conclude that there is a significant relationship between the frequencies of SMASSE in-service training and K.C.S.E. performance in biology at a 95% level of significance.

This research-based study observed several challenges facing the SMASSE instructional strategy teaching and implementation ranging from internal to external environment with respect to classroom activities. These include: heavy teaching load, lack of equipment and apparatus, students' negative attitude towards biology, poor financial support of the SMASSE project at the grass root level, conflict of interests because SMASSE being only for mathematics and science teachers and being conducted during the holiday when other teachers are free to attend their personal interests, lack of effective incentives beyond getting students to do well in their studies, lack of administrative support, high staff turnover and transfer of trainers to non-curriculum implementing posts, interferences in recruitment process of INSET trainers- failure to use specified criteria, limited opportunities for further training for trainers. However, these issues and/or challenges are manageable in the education sector and Kenyan society. The future of SMASSE instructional strategy adoption is promising with the support of the Government of Kenya and international partners for better skill equipped citizenry in the world.

V. Summary, Recommendations And Suggestions

The study revealed there are problems limiting the implementation of SMASSE instructional strategies for example time and lack of financial support. Further, there is a significant relationship between the frequency of SMASSE training and the K.C.S.E results, at 95%. The study shows there is moderate positive relationship between the frequency of SMASSE training and the K.C.S.E. results. SMASSE In-Set is an intervention strategy that the government put in place to ensure effective teaching/learning of biology as part of mathematics and science subjects. The study shows there was improvement in the performance of biology during SMASSE instructional strategic period and the teachers' skills improved/enhanced classroom delivery of lessons. The goal of the project to both upgrades capability of learners in biology while the purpose/objective to strengthen quality of biology through In-Service Education and Training (INSET) of teachers was attained.

From the findings of research, the following conclusions are reached: Firstly, the introduction of SMASSE in-service training led to an improvement of performance in biology in Kakamega North Sub County. Secondly, it is also clear that teachers apply the skills obtained from SMASSE in-service training to influence active learning by the students. Thirdly, there is a positive linear relationship between the number of years of SMASSE in-service training and achievement in the K.C.S.E results. In other words, there is an increase in the achievement of K.C.S.E results with an increase in the number of years taught. Fourthly, there is a significant relationship between the frequency of SMASSE in-service training and achievement in the K.C.S.E results. This reveals that the higher the frequency of SMASSE in-service training from a teacher, the higher the chances of the teacher producing better results.

It is recommended that novel and informative regional SMASSE-like activities should be initiated to integrate SMASSE compliant teachers into their training programmes for SMASSE educators and sharing of information on education cooperation and collaboration in Kenya, East Africa and Africa. That SMASSE teacher should be encouraged to lay strong emphasis on student centred approach during the retraining of the non-SMASSE compliant. Further, provide current trends and nexus innovations which have synergistic effect to improve SMASSE instructional strategies in Kenya and Africa. Further, recommendation is to emphasize quality and equity in school choice by encouraging innovation in staffing and teaching methods; support collaboration and sharing of promising and proceed with caution on virtual charters/e-learning; and the challenge of too wide a syllabus, exam-oriented curriculum, high workloads, cultural diversity, student absenteeism and insufficient facilities in schools should be addressed to facilitate better biology performance among the students.

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