The Influence of Teacher Professional Development as a Tool for Improving Pedagogy and Creating Communities of Practice among Teachers: The Case of SMASE Program of Kenya

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ABSTRACT
The purpose of this paper is to summarize and report the findings of a study carried out by the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA), that sought to track and document classroom practices of mathematics and science teachers who had undergone INSET through strengthening of mathematics and science education (SMASE) program, and how their practices influenced learning outcomes in secondary schools. The study used a concurrent triangulation mixed method design to collect quantitative and qualitative data from 80 mathematics and science teachers in secondary school level, who had undergone SMASE training and perceived to have embraced the ideals of SMASE, 3245 students taught by these teachers and 72 principals of schools where these teachers taught. Data was collected through questionnaires, lesson observation and interviews. The data obtained from lesson observation provided the extent of the practice of ideals of SMASE by the teachers, students questionnaires gave information on the level of learner involvement in the teaching and learning process by the teachers and the students' orientation towards the subjects. The interviews with the teachers and their principals provided qualitative data that was used to triangulate the information gathered from questionnaires and lesson observation. Other forms of data included lesson plans of lessons observed, the schools' mean scores for mathematics and science in KCSE for the years 2005 - 2013, and the students' enrolment in science subjects at KCSE for the years 2005 -2013 were also analyzed for in-depth understanding of the classroom practices of the mathematics and science teachers who had undergone SMASE INSET and the influence their practices had on the learning outcomes in secondary schools.

Keywords: Teacher, Professional Development, SMASE, Practice, Kenya

1. Introduction

The need for teachers who can deliver quality education to learners cannot be over emphasized (UNESCO, 2014). Teacher professional development has been recognised as one of the ways of improving teachers' competencies in lesson delivery (Amaral, Garrison & Klentschy, 2002; Fradd, Lee, Sutman & Saxton, 2001; Supovitz & Turner, 2000). This has made teacher education and teacher professional development an area of focus by some scholars as outlined in the following review of literature.

1.1 The Influence of Professional Development on Classroom Practices of Teachers

Research has shown that there are other benefits of teachers engaging in professional development programs besides improving academic performance of learners. The benefits include development of abilities in teachers to learn from one another as well as shift in their classroom practice towards that envisioned by the professional development programs (Supovitz & Turner, 2000; Wynne, 2010). In a study by, Supovitz and Turner (2000) examined the relationship between professional development and teachers' ability to enact reform-based teaching practices in science. The study involved 3464 teachers and 666 principals of schools participating in a professional development program for teachers, the Local Systemic Change (LSC) in 24 different communities in US. The goal of the program was to reach at least 80% of the teachers within each locality with a minimum of 100 hours of professional development over the life of the project which was a maximum of five years. The study employed a survey strategy whereby data were collected from the respondents through questionnaires. Among other questions the teachers were asked about their frequency of use of a number of reform-based teaching practices such as engaging learners in hands-on activities, design or implementing their own investigations, asking students to explain their ideas to peers and having students work collaboratively with each other. They were also asked about the importance of carrying out these reform-based teaching practices as well as the principals'

supportiveness of the LSC program. On the other hand, the principals were asked about their supportiveness of the LSC program, The researchers found that teachers who had spent more hours in the PD program reported using inquiry-based teaching practices than their counterparts who had spent fewer hours. Also, teachers who felt supported by their principals reported significantly greater use of reform-based approaches in teaching science than their counterparts who did not feel encouraged by principal.
Another study conducted by Stephanie to determine the benefits of teacher professional development by utilizing semi-structured one-on-one interviews, and participant observations to collect data. Findings showed that teachers were excited about sharing experiences with each other. According to the researcher, the teachers observed that a lot of value had been added to them. The teachers particularly valued peer teaching and peer observation that gave them confidence to teach.

These two studies show that teachers appreciate the experiences shared with their colleagues as they undergo training but more important is the need for prolonged engagement and participation in professional development programs. Such a prolonged engagement and participation in professional development programs leads to enhanced practice of what teachers are exposed to during the training.

1.2 Professional Development of Teachers in the context of Kenya

Research on professional development of teachers has been conducted in Kenya. Findings arising from such research are consistent with those of studies conducted elsewhere in terms of teachers reporting that they valued professional development experiences as learning opportunities. For example, in a study that sought to establish the impact of professional development on teachers (Onguko, 2012), the researcher utilized ICT tools namely tablets through which he administered content for the teachers who participated in the study. The study involved 10 teachers teaching at primary school level from whom data was collected through one-on-one interviews. The researcher found that the teachers appreciated the experiences of participation in the professional development program. The teachers stated that they felt competent and confident to teach after participating in a professional development program. For example one of the participants, PDT1 stated "I realized that there is such a gap between what happens when you go to college for undergraduate training and the actual classroom contact with the learners, (p. 126). This means that professional development is an invaluable tool in helping teachers to realize their potential.

On the other hand, Ndeto and Bwisa (2013) investigated what motivated teachers to actively participate in professional development training courses. The study involved with 57 secondary school teachers, the County Director, and a quality assurance and standard officer from Trans Nzoia West district in Kenya. The researchers utilised questionnaires and interviews to collect data. From the analysed data, the researchers found that the majority of the teachers were not actively participating in continuous professional development as a result of lack of support by their employer and school administration. They also found that age was a factor which influenced teachers active involvement in continuous professional development such that as the age increased the percentage of teachers who were actively involved in continuous professional development decreased. Further, it was also found that more teachers with college level education participated more in continuous professional development than their counterparts who had university level of education.

The gender of the teachers was also a contributing factor to continued participation in CPD as more male teachers participated more in CPD as compared to the female teachers. Based on the findings of this study, it seems that support by stakeholders such as teacher employers and school administration were key to enabling teachers attend professional development courses. The question of whether or not teachers practice what they learn during professional development courses and what drives them into practicing the skills and knowledge learned still remains unclear .Most of the research utilized surveys to collect data and therefore it is not clear from such research the actual classroom practice of the teachers following their participation in professional development programs. It is not also clear how students view their teachers who have participated in professional development activities as well as the attitudes of students towards the subjects taught by these teachers.

This study adopted a mixed methods strategy where both quantitative and qualitative data were collected. Teachers who had participated in SMASE INSET were observed to determine their actual classroom practices. They were also interviewed to determine their experiences as they undergo training and practice what is learned during the training. Students as the direct beneficiaries of the teaching and learning process were also involved in this study. Their perceptions about these teachers as well as their attitudes

towards the subjects taught by these teachers were an important aspect of this study. Therefore this study adds to knowledge in the area of teacher education and professional education of teachers in terms of actual classroom practice of teachers following professional development as well as the influence of their practice on students' attitudes and how students' perceive them.

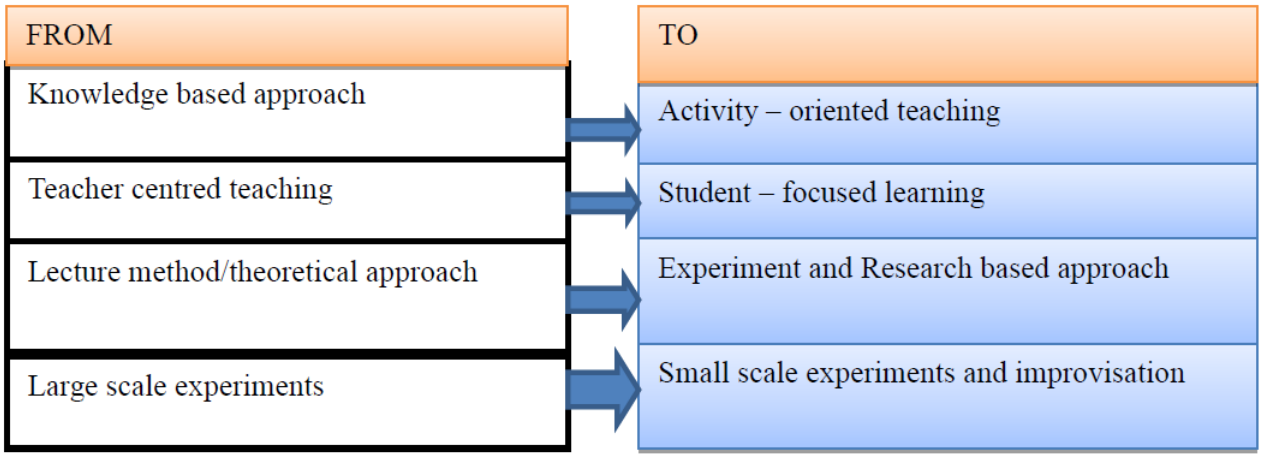
2. Empirical Case Study

2.1 Background of SMASE Program

Strengthening of Mathematics and Science Education (SMASE) is an in-service education and training (INSET) program for mathematics and science teachers that started in 1998 as a project. It was started as a joint venture between the Government of Kenya through the ministry of education (MOE) and the Government of Japan through Japan International Cooperation Agency (JICA), as an intervention to address the consistently low achievement of learners in mathematics and science, and the challenges observed through a Baseline Survey report (1998) such as: teacher-centred teaching methodologies and neutral students' attitudes in mathematics and science. This was done through in-service education and training for secondary school mathematics and science teachers using innovative approaches to improve lesson delivery. The goal of the project was to upgrade the capability of young Kenyans in mathematics and science education. After a successful implementation of the first phase that involved 15 sub-counties in 2003, the project was expanded to cover the rest of the country in 2005. The project period ended in 2013 and SMASE became a program fully funded by the Ministry of Education.

The SMASE program is managed by the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) whose mandate is to continuously build the capacity of teachers in mathematics and science education. The program uses a two tier cascade model of training for wider and faster outreach. In this model, key mathematics and science teachers from all regions of Kenya are trained by CEMASTEA. Following their training they go back to their Sub-counties and train the rest of the teachers. The training is aimed at building the teachers' capacity to implement learner-centred teaching strategies through Activity, Student, Experiment & Improvisation (ASEI) approach which is actualized through the process of Plan, Do, See and Improve (PDSI). ASEI-PDSI is anchored on four basic tenets which describe a pedagogical shift as shown below

Pedagogical Shift through ASEI lessons



The PDSI is a cyclic process of checking the process of ASEI lessons against a plan and answering the question of how lesson activities are being carried out in relation to the intended objectives through evaluation and improvement.

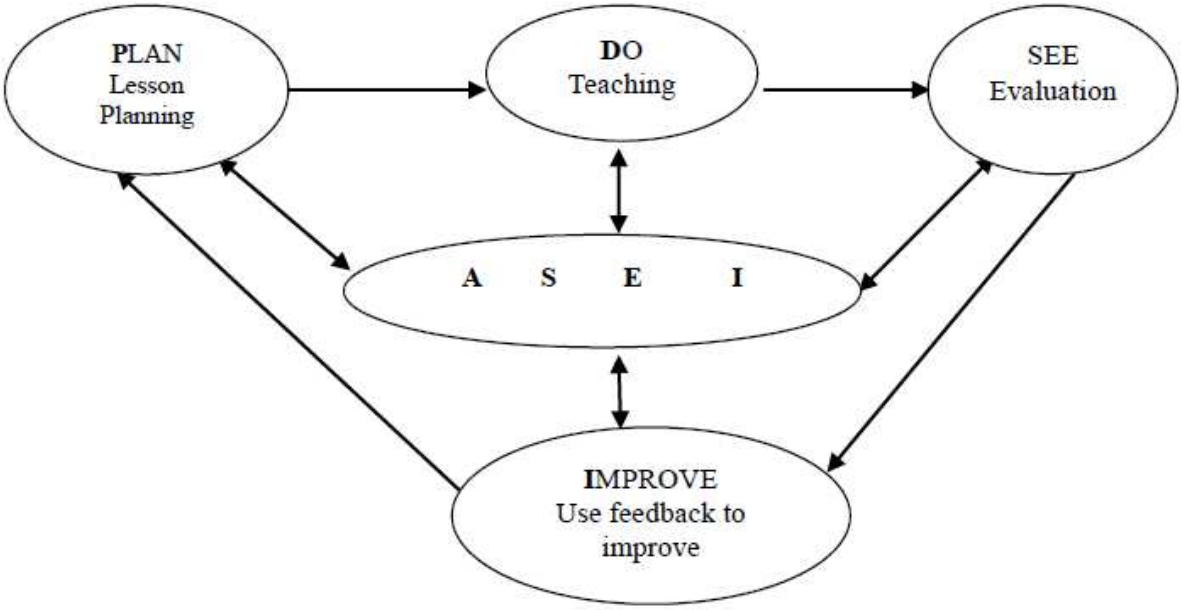


Figure 1:: The PDSI cycle
Source: Developed by CEMASTEA

The ASEI-PDSI principles socializes teachers into the culture of consistent planning for lessons that are learner-centred, evaluating the achievement of learning outcomes and constant improvement of lessons as well as attitude change. The practice of ASEI-PDSI is expected to make learning more experiential and hence meaningful for the learners. Such learning aims at improving students' attitudes towards mathematics and science as well as achievement. As a consequence, more students are likely to not only enjoy learning these subjects but also enroll and take these subjects up to Kenya Certificate of Secondary Education (KCSE).

2.2 Conceptual Frameworks

The study focused on the teacher in the classroom as a learning environment. According to Winberg (2006), a learning environment is a setting that is influenced by a variety of variables such as availability of teaching/learning resources, attitude towards learning, pre requisite knowledge, and instructional strategies. This means that the teacher is an important component of the learning environment because how s/he plans and presents the lesson activities will influence the learning outcomes. For instance Winokur and Worth (2006) observed of science teachers, “conducting and facilitating fruitful discussions in science requires a great deal of thought and skill on the part of the teacher” (p. 46). SMASE training is therefore likely to influence how a teacher organizes the classroom as a learning environment and how the students in the classroom as a learning environment are not only influenced but also how they perceive the influence is important for this study. Figure 2 shows the conceptual framework guiding this study

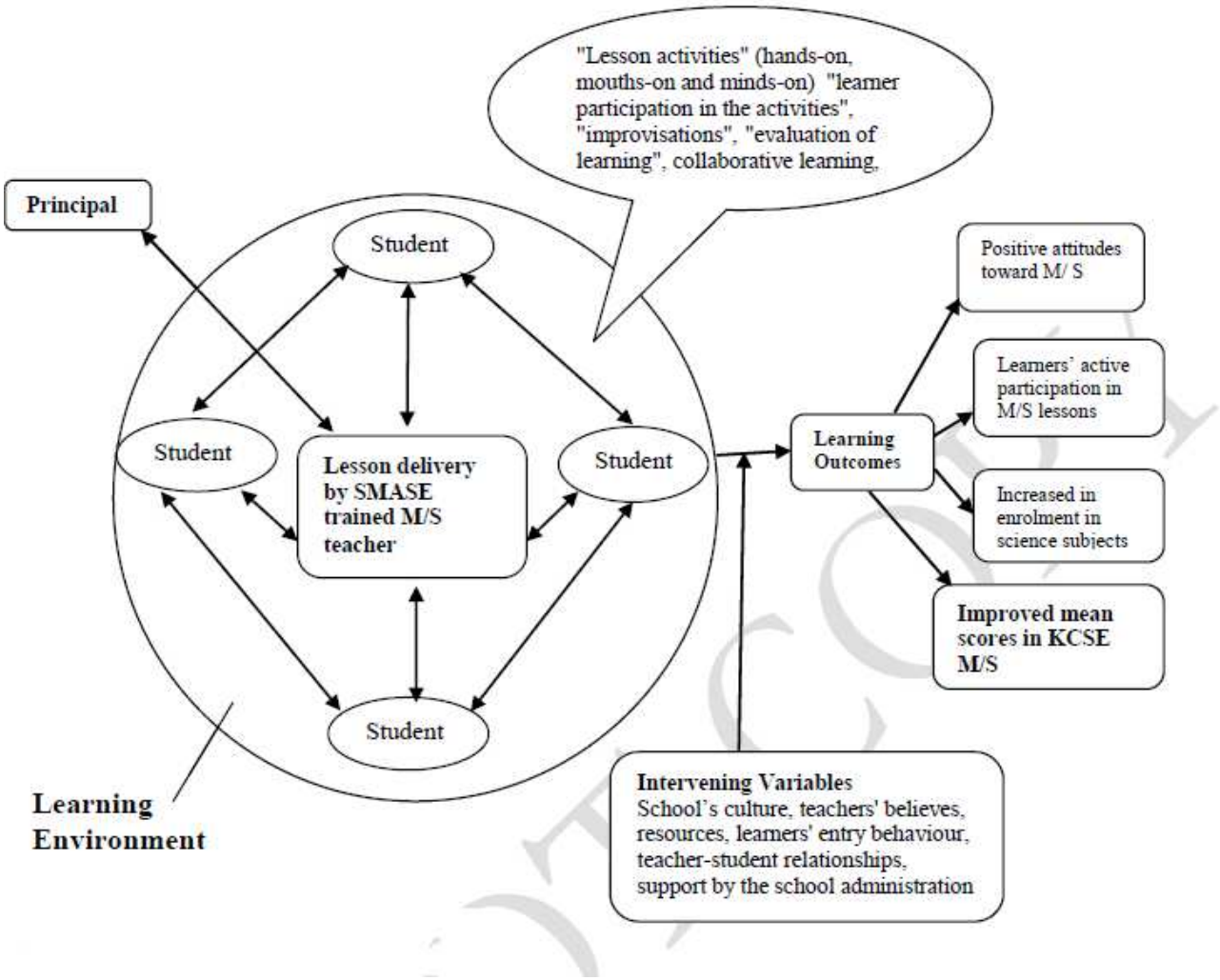


Figure-2: Conceptual Framework

Based on Figure-2, a classroom of a teacher who has undergone SMASE training and embraced the inherent ideals is expected to have well designed lesson activities (i.e. hands-on, mouths-on) which are conducted by learners. Such a classroom therefore affords the learner an opportunity for active participation in the teaching learning process. Also, there is likely to be a use of improvised apparatus and materials as well as continued evaluation of the teaching and learning process by the teacher. The overall and long term outcomes of the learning from such a classroom would include: Learners' active participation in mathematics and science lessons, Positive attitudes toward mathematics and science, increased in enrolment in science subjects,
And improved mean scores in mathematics and science in KCSE

3. Research Methodology & Data Analysis

This study adopted a concurrent triangulation design of the mixed methods research methodology. Mixed methods designs in research have the potential of helping researchers develop a deeper understanding of the research problem. In addition, mixed methods help in addressing limitations of adopting either quantitative or qualitative methodology alone (Creswell, 2009).

The design adopted for this study enabled the research team to develop an understanding of the extent to which mathematics and science teachers perceived to have embraced the ideals of SMASE practice those ideals as well as their experiences during training and practice thereafter. It also helped the team to

determine the extent of involvement of learners in the teaching and learning process as well as their attitudes towards subjects taught by mathematics and science teachers perceived to have embraced ideals of SMASE. Last but not least this design helped the research team understand the perceptions of principals about those teachers. In this study, both quantitative and qualitative data were collected concurrently. The data were collected through questionnaires, lesson observation and interviews. In this study, both quantitative and qualitative data were collected concurrently. The data were collected through questionnaires, lesson observation and interviews.

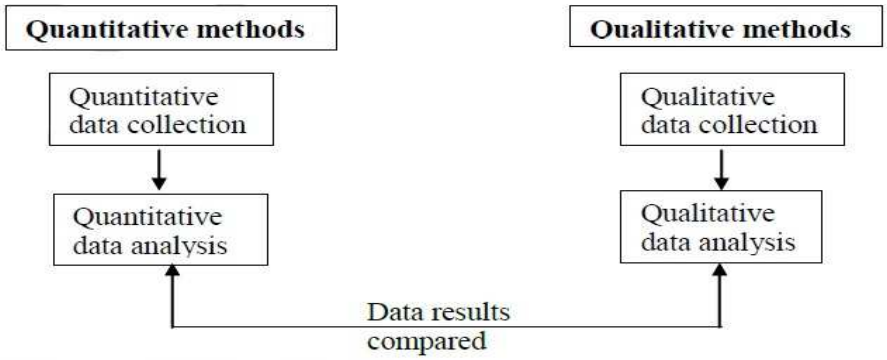


Figure-3: Summarize the research design and process for this study

2.3 Key Findings

2.3.1 Extent of practice of ideals of SMASE

The lesson observation guide was used to gather data on the extent of practice of ideals of SMASE The lessons observer(s) rated the lessons in terms of incorporation of the various aspects of ASEI in the lesson on a scale of 1 through 4 based on the following key 1- poor, 2- satisfactory, 3 - good and 4 - very good

Table 1:: Aspects of ideals of SMASE in lessons observed and their mean ratings

Item No	Item description	Mean	Std. Deviation
10	Teacher gave clear instructions on activities	3.15	0.732
11	Teaching/learning resources were appropriate and effectively used	3.14	0.738
12	Bridging of activities to the concept being taught was done	3.01	0.864
13	Teacher guided the students through practical activities	3.07	0.769
14	Activities were learner-centred	3.04	0.860
15	Learners expressed and explained their ideas related to content/concepts	2.79	0.822
16	Learners' attention was sustained during the lesson	3.31	0.682
17	Learners were meaningfully engaged in the learning activities	3.17	0.770
18	Experiments/activities were relevant to the lesson objectives	3.42	0.649
19	Learners carried out the experiment/activity in small groups	3.20	0.930
20	The experiment/activity aroused learners curiosity	3.12	0.797
21	The teacher made use of locally available materials	2.86	0.879
22	Teaching /learning methods were varied	2.88	0.756
23	Small-scale experiments were adequately used	2.71	0.991

Items 16 and 18 had the highest mean ratings of 3.31 and 3.42 respectively. This means that lessons observed had a high extent of incorporation of activities/experiments that were relevant to the lesson objectives and sustained the learners' attention during the lesson. Based on the findings of the Baseline

survey (1998), mathematics and science lessons were mainly teacher-centred with minimal learner involvement in the teaching and learning process. The level of incorporation of activities in mathematics and science lessons as revealed by this study shows that SMASE training influenced teachers in positive ways leading to their planning for activities and hence involving students in the teaching and learning process.

The aspect of students' expressing and explaining their ideas related to content/concepts had the second lowest mean rating of 2.79. Based on this finding, teachers did not give students opportunities to express their ideas to a satisfactory extent. This therefore becomes an area of focus for future INSETs. Indeed, Darling-Hammond (1995) argues that teachers' capacity needs to be built especially in the area of understanding of students. She observed, "Teachers need to build a rich knowledge base and develop tools for accessing students' thinking, for understanding students' prior knowledge and backgrounds and for connecting to students' families and communities. If teaching fails to connect with students' there is no learning" (p. 12).

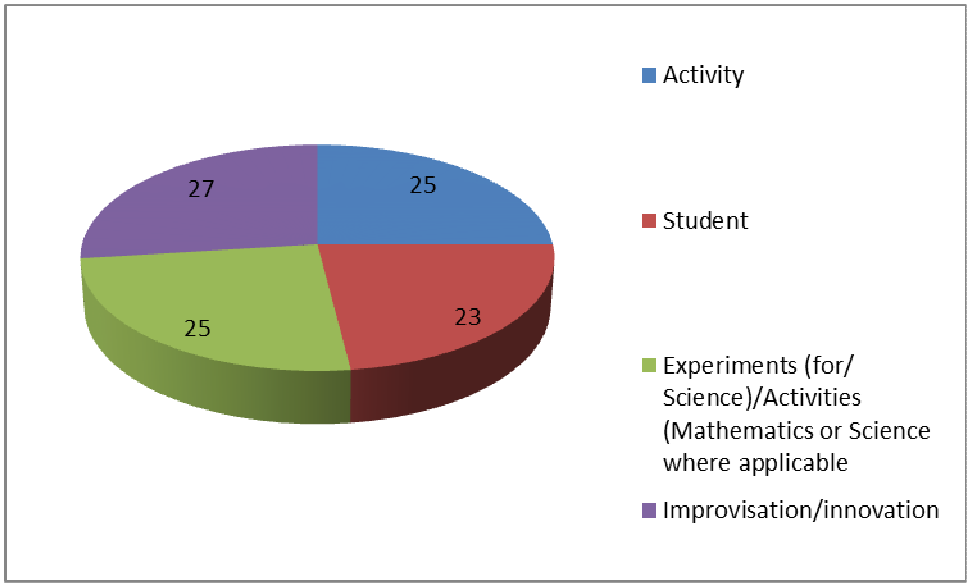


Figure 4: Level of incorporation of ideals of SMASE in lessons

All aspects of ideals of SMASE were incorporated in the lessons almost on equal levels

2.3.2 Categorization of teachers based on the extent of practice (EOP) of ideals of SMASE

The teachers were distributed into three categories of practice of ideal of SMASE based on the following criteria $3.49 < m \leq 4.0$ high extent of practice of ideals of SMASE, $2.49 < m \leq 3.49$ medium extent of practice of ideals of SMASE and $1.00 < m \leq 2.49$ low extent of practice of ideals of SMASE where m is the mean. Teachers who practiced the ideals of SMASE to a high extent were placed in category 1 and labelled transformers, while those whose practice was medium and low were placed in category 2 and 3 and labelled applying practitioners and emerging practitioners respectively

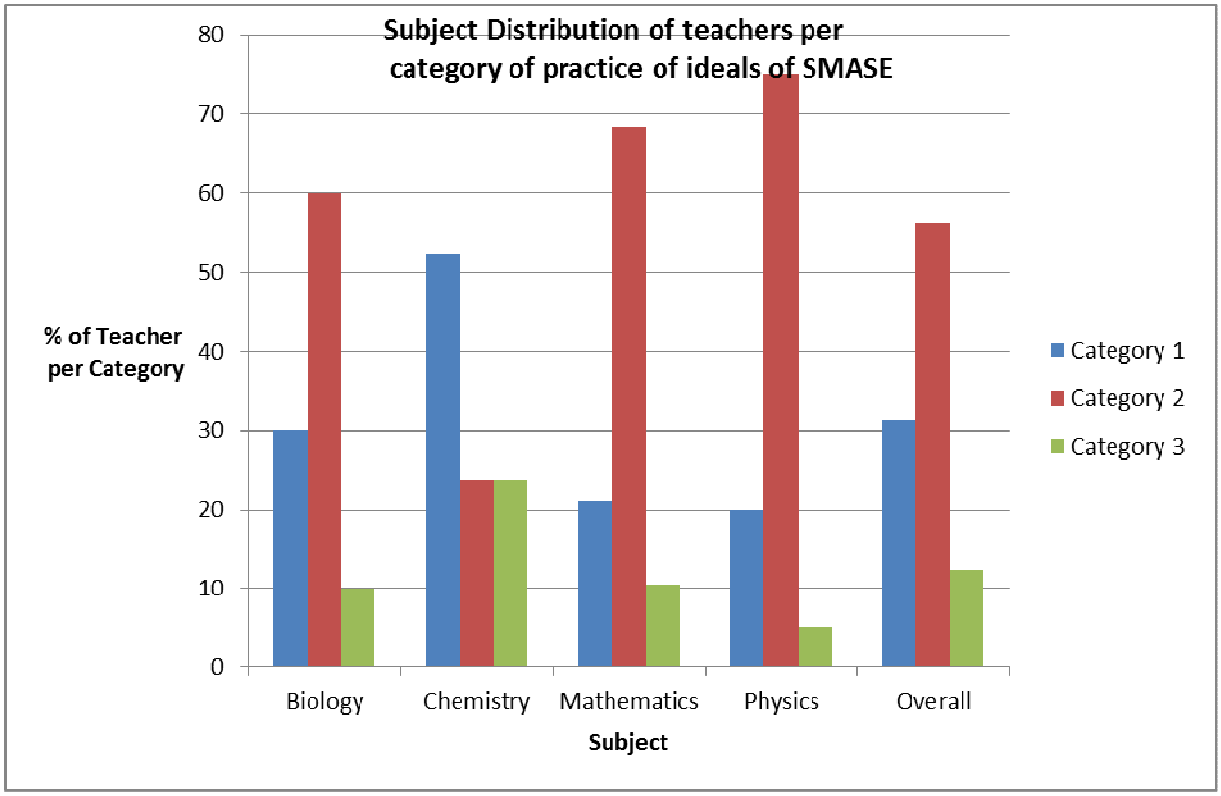


Figure 5: Distribution of teachers per category of practice of ideals of SMASE

The majority of teachers who participated in this study were transformers and practioners with a combined percentage of 87.6% of all the teachers. 31.3% being transforming practitioners who practice of ideals of SMASE to a high extent, while 56.3% were applying practitioners with medium extent of practice of ideals of SMASE and only 12.5% were emerging practitioners of ideals of SMASE. This finding shows that teachers put to practice what they learned during the training. Chemistry had the highest number of teachers in the transformers category at 52% of the teachers who participated in this study. In the Baseline survey of 1998, it was found that chemistry teachers least involved the students in the teaching and learning process for fear of conducting some of the experiments perceived dangerous such as those involving poisonous gases like chlorine. This led to training for chemistry teachers that addressed specifically how to conduct small scale experiments as well as those experiments involving poisonous gases. This could have contributed to the higher number of teachers of chemistry being transformers with regard to the practice of ideals of SMASE

2.3.3 Extent of involvement of students in teaching and learning

The questionnaire for students was used to determine the extent of involvement of students in the teaching and learning process as well as attitudes of students towards mathematics and science subjects. The extent of involvement of students in the teaching and learning process was measured through items 6 to 19 in the questionnaire for students. Numerical values were first assigned to the criteria as follows 5 – always, 4 – often, 3 – sometimes, 2 – rarely and 1– not at all. Following this assignment, mean scores for each of the items were calculated for all the students in each of the subjects, biology, chemistry, mathematics and physics and the overall mean for all the items per subject was calculated.

Table 2: Extent of involvement of students in teaching and learning

Item No	Item	Mean			
		Biology	**Chemitry**	**Maths**	**Physics**
6	I ask questions during the lesson	3.31	3.44	3.22	3.31
7	I seek clarification on areas that I don't understand	3.88	4.04	3.95	3.91
8	I answer questions posed by the teacher	4.06	4.10	3.92	3.96
9	I offer explanations to other students	3.54	3.72	3.76	3.67
10	I give suggestions on how to carry out an activity in class	3.03	3.29	3.06	3.18
11	I demonstrate an activity to other students	3.02	3.35	3.03	3.24
12	I make observations during an activity in class	4.32	4.38	3.89	4.26
13	I record observations during an activity in class	4.26	4.34	3.60	4.26
14	I analyse observations made during an activity	4.00	4.18	3.52	4.04
15	I interpret information arising from an activity	3.63	3.91	3.49	3.84
16	I discuss results of an activity with my classmates	3.92	4.10	3.70	3.89
17	I write a report of an activity or experiment done in class	3.02	3.25	2.73	3.03
18	I present a report on a group activity to the whole class	2.82	3.04	2.67	2.88
19	I write my own notes in addition to those given by the teacher	4.34	4.26	3.81	4.04
	Overall	**3.65**	**3.81**	**3.45**	**3.68**

The overall means for all the subjects were in the range 3.45 and 3.81 with chemistry having the highest overall mean and mathematics having the lowest overall mean of 3.45. The extent of involvement of students in teaching and learning tended towards "often" for all the subjects except mathematics. This means that teachers actually involved students in the teaching and learning process. This finding corroborate the findings based on the lesson observation guide previously discussed above which showed that students were meaningfully engaged in the teaching learning process through relevant activities as observed by the research team.

2.3.4 The attitudes of students towards mathematics and science subjects

The questionnaire for students was used to gather information on the students' attitudes towards mathematics and science subjects. The items utilised a five point Likert scale in which the students were required to respond to each of the items by choosing one of the five options, strongly agree, agree, not sure, disagree, or strongly disagree. In analysing the students' responses, numbers were assigned to them as follows: 1 – strongly agree, 2 – agree, 3 – not sure, 4 – disagree and 5 – strongly disagree for negative statements and 5 – strongly agree, 4 – agree, 3 – not sure, 2 – disagree and 1 – strongly disagree for positive statements. mean scores for each item both in the positive and negative categories for all the respondents per subject were calculated. The overall mean which is a mean of means for item in each category was also calculated.

Criteria for interpretation of mean scores for both positive and negative statements

Criteria	Attitudes
3<x≤5	Positive
x=3	Neutral
1≤x<3	Negative

Where x is the item mean score

Table 3: Mean scores for negative & Positive items for biology, chemistry, mathematics and physics

Nature of item	Item No.	Item	Mean			
			Bio	Chem	Maths	Phy
Negative	**20**	I do not need **this subject** to understand other subjects	3.87	4.16	4.20	4.09
Positive	**21**	I never get tired of studying **this subject**	4.11	3.95	3.81	3.98
Positive	**22**	I like studying **this subject** even when I am out of school	4.29	4.13	3.97	4.16
Positive	**23**	I like thinking about **this subject** even when I am out of school	3.99	3.88	3.73	4.00
Negative	**24**	Only those people who make important decisions need to understand **this subject**	4.07	4.00	3.97	3.88
Negative	**25**	I get tired when studying **this subject**	4.40	3.81	3.90	4.15
Positive	**26**	Knowledge of **this subject** makes it easier for me to learn other subjects	4.17	4.18	4.21	4.19
Negative	**27**	**This subject** is a boring subject to me	4.71	4.59	4.36	4.53
Negative	**28**	I do not like thinking about **this subject** when I am out of school	4.44	4.23	4.02	4.24
Negative	**29**	I do not like studying **this subject** when I am out of school	4.40	4.30	3.99	4.24
Positive	**30**	**This subject** is useful in real life situations	4.83	4.63	4.45	4.60
Positive	**31**	It is important to understand concepts taught in **this subject** in school	4.76	4.68	4.50	4.52
Positive	**32**	**This subject** is not necessary for me to understand issues in the society	4.37	4.24	4.01	4.13
Positive	**33**	I need **this subject** for my studies beyond secondary school	4.42	4.44	4.37	4.42
Negative	**34**	**This subject** has no application in real life	4.70	4.68	4.43	4.57
Positive	**35**	Every person in the society needs to understand **this subject**	3.82	3.83	4.11	3.63
Negative	**36**	I do not need to understand **this subject**	4.74	4.67	4.50	4.50
Positive	**37**	I cannot succeed in life without understanding **this subject**	3.39	3.43	3.99	3.23
Negative	**38**	I would avoid studying **this subject** if it was an optional subject	4.57	4.14	4.06	4.24
Positive	**39**	**This subject** will determine the career I will choose in future	4.46	4.21	4.26	4.40
Positive	**40**	People who understand **this subject** get better jobs	3.95	4.03	3.95	4.06
Overall mean			**4.31**	**4.20**	**4.13**	**4.18**

All the items for all the subjects had an overall mean rating in the range $3<x\leq5$ where x is the overall mean for all the items. This meant that students' attitudes towards the subject for which they responded to the questionnaire were favourable since they disagreed with the negative items and agreed with the positive items. Attitudes towards subjects students learn have an influence on the learning as well as outcomes such as academic achievement (Ayere, 2000; Gichura, 1999). The findings of this study show that the students who participated had positive attitudes towards these subjects and they were likely to engage meaningfully in the teaching and learning process and as a consequence, achieve better academic performance in the subjects. This was confirmed by the data on Kenya Certificate of Secondary

examination (KCSE) mean scores collected from the schools visited. All the four subjects, had mean scores in the range 6.03 and 8.14 for all the years 2005 -2013. The KCSE results were generally good for the years 2005-2013 for all the schools. According to the KCSE grading system mean scores in the range 6.0 to 8.0 would have grades C and B- respectively and any student who scores such grades in mathematics and science should be able to enrol in science oriented course in institutions of higher learning and pursue education even at degree level. All the teachers and principals who participated in this study attributed the good academic performance in mathematics and science to the practice of ideals of SMASE, as shown by some of the excerpts from the interviews with teachers and principals

The positive students' attitudes were reflected in their responses to items 2 in the questionnaire which sought to determine the level of students' enjoyment in the teaching and learning of mathematics and science. The students indicated their level of enjoyment as being "enjoy a lot", "enjoy a little" or "do not enjoy". In analyzing the responses, numbers were assigned to the students' responses as follows: 1- do not enjoy, 2 - enjoy a little and 3 - enjoy a lot. Both the frequency counts as well as the percentages of students for each of the levels were calculated **Percentage of students in the levels of enjoyment by subject**

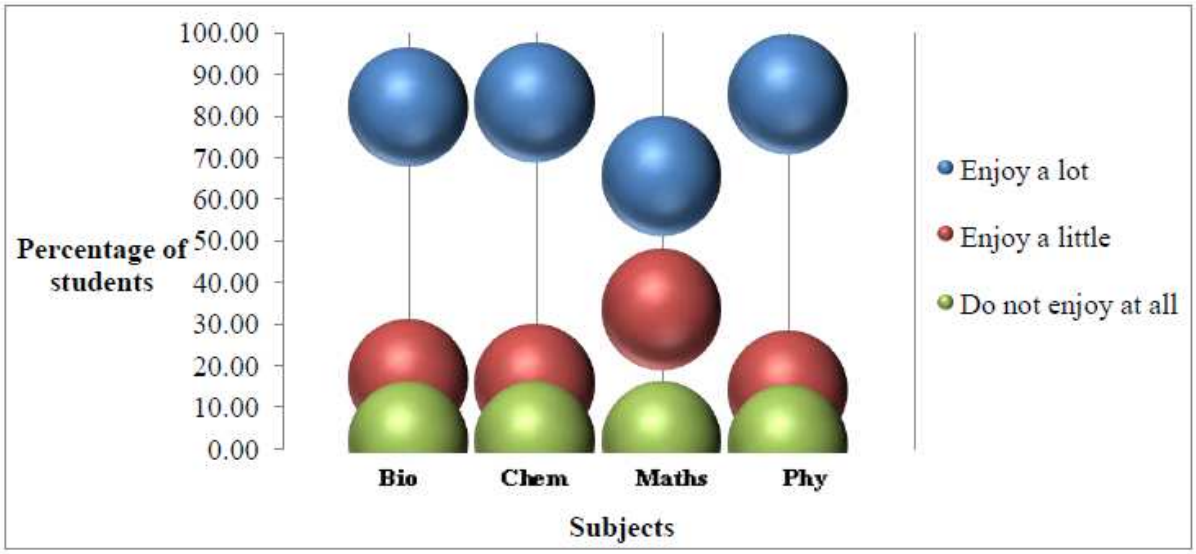


Figure-6: Percentage of students in the levels of affect by subject

Majority of students who participated in this study enjoyed a lot learning mathematics and science as shown by the high percentage of students in the "enjoy a lot" category in each of the subjects (i.e., 81.9%, 83.2, 65% and 85% for biology, chemistry, mathematics and physics respectively). For those who enjoyed a lot in learning mathematics and science, their reasons were related to the teacher's way of teaching and the need for the subject for future careers as well as its application to real life situations.

2.3.5 Mathematics and science teachers' lived-experiences while training and practicing what they learn

Mathematics and science teachers were interviewed using the interview guide. Following the analysis of the interview transcripts, it was clear that the teachers who participated in this study valued the SMASE training. For instance the question of whether or not they would like to continue incorporating the ideals of SMASE in the teaching and learning process, they all affirmed that they would continue teaching by incorporating SMASE ideals in the teaching and learning process. In response to the question, CT03 stated "That's not a question because where would you go? There is nowhere to go because you're not teaching. So you cannot go back". This means that CT03 had been influenced by the training in ways that made him feel that he had not been an effective teacher prior to the SMASE training.

2.3.6 SMASE training and building of communities of practice among mathematics and science teachers

SMASE training allowed mathematics and science teachers from different schools to meet and interact with each other. This promoted "professional socialisation" in the words of CT03. In explaining what professional socialisation is CT03 stated, "It is the time you look forward to wherever you've come from in relation to the others. So you share your experiences to compare with the others. It is also a time to benchmark". MT19 stated, "We consult and discuss . . . we share how we can overcome some challenges either by the use of the models, how maybe to introduce some topics at the same time even how to organize students in class and those who may not be having the motivation of doing mathematics". Based on this statement by MT19, SMASE training is not only a time to share experiences but also one where teachers learn from each other. The sharing of experiences during training did not stop with the training for example, CT22 stated "I have all the names of the teachers, chemistry teachers who were attending . . . I call them, they call me and we continue the network". Beyond sharing experiences and forming networks with teachers from other schools, it was also clear that mathematics and science teachers who participated in this study extended the sharing of experiences and continued to build communities of practice even when they went back to their schools after the training. For instance, MT16 stated, "We do co-operate . . . the topics you find you are not sure of, the other teacher comes in . . . and also team-teaching. Other teachers attend your class to observe". Similarly BT04 observed, "We have found that we are able to have what is called team-teaching, where a class is taught by more than one teacher, so that we open the door. We don't say we are owning the class". Based on these testimonies, SMASE training is "a professional socialisation site". The training helps build a network of teachers who share experiences and learn from each other. The idea of learning form one another (Vygotsky, 1978) seems to be a valuable aspect of SMASE training.

2.3.7 SMASE training and enhancement of teaching and learning of mathematics and science

The teachers who participated in this study indicated that their ability to teach mathematics and science had been enhanced as a result of undergoing SMASE training. According to BT03 stated, "Now in the teaching of biology, the training has given me new approaches to teaching, making [the subject] easier to teach and learn, and making it more interesting, when you are having variation other than the chalk and talk".

Most of the teachers who participated in this study observed that they were able to involve students in the teaching and learning process through use of hands-on activities. For example, CT14 stated, "I've become more practical oriented in my teaching. Number two, I've allowed the students to be my focus of the teaching. We go to the lab and I'd like to supervise more than anything else. So I let the students do [the practical] on their own, I only come in as the supervisor . . . I want them to be a part of their learning. Not the teacher just going there and telling them this is what happens". Based on this statement, CT14 not only involves students in the learning process through practical work but also views students as people who need to take charge of their own learning with the teacher only acting as a "supervisor" in his own words. This is an important realization in teaching because this is one way in which learning can be made meaningful for students.

SMASE training has also enabled teachers to come to the realization that they can have activities in almost every topic or subtopic in the syllabus. Regarding the idea of activities in every topic or subtopic, BT19 stated, "I've come to learn that, you can do an activity in almost every topic, or even sub topic. You just need time to do proper research. But before SMASE there were some areas that I never thought you'd do an activity. I thought it is lecturing and lecturing and you finish the topic. You and the students are like I've finished but I'm not satisfied with the way I've delivered. And you can imagine the students themselves, if they were on the receiving end they were not understanding. So it has really helped us".

Regarding the idea of not requiring a laboratory in order to do a practical, CT14 who also teaches physics stated, "You can teach anything practically in class. You don't need any laborratories. I have a pendulum out here. So when I teach the pendulum, we don't need to go to the laboratory. We have a stone hang out there, let the boys swing it and let them time it. That is why that stop clock is down there. You just do it straight away and the students find it very interesting. So, SMASE opens the teacher who wants to change**.** Improvisation was cited by teachers as one of the areas they had benefited from SMASE training. Improvisation with regard to SMASE training involves the use of unconventional materials and

apparatus to teach given concepts. In talking about how SMASE training has enhanced his skill to improvise, CT19 stated, "there're times we learn how to even improvise and we are able to do a practical, you can't say that, "I can't do this practical because I don't have apparatus". So there're times they come up with a practical and then you see that surely, this one can be done. You don't have to have all, those apparatus. Further, BT19 explained how she has been able to use improvisation. She stated, " there's an area we were wondering what we can do. This is on the chromosomes in form 4 in genetics. Now we just came to the tailor, get the zips, show them how to open the chromosome, how it closes. And I've done it with my teachers . . . just showed them this unzipping of the DNA, the zipping duplication, and it was very interesting even to them" …..[the training] opens even ones way of thinking. You see there're so many things that you can really use, only like our minds were in a box before SMASE".

It was also clear from the teachers' interviews that SMASE training has contributed to their ability to enhance students' understanding of mathematics and science through integration of ICT in the teaching and learning process. For instance, BT03 observed, "Like this new idea brought by SMASE on ICT integration, it is really making the students to have a lot of interest in Biology. And it is also able to make those concepts that appear abstract to concretize them and it also brings reality into the classroom". Similarly BT19 explained how ICT integration in teaching and learning makes it easier to teach. "So an aspect or a concept that was not very clear gets to be very clear to the students. Like at times when you are teaching like a topic on pollution, I was wondering what activity one can do. But get clips of smoke, or burning houses, or an industry producing smoke, come and show it to the students, you see they are understanding. And also me as a teacher I get to understand better". It was also clear from the interviews with the teachers that the students themselves appreciate learning when ICT is integrated and even go to the extent of asking for it if they do not see it. For example, BT02 stated, "When I go sometimes teaching without having a video clip they will ask, Mwalimu this time we don't have anything to watch?" Based on this statement, it seems that students feel that no meaningful learning will occur without integrating ICT in the teaching and learning process.

It is clear from these testimonies that SMASE training enhances pedagogical skills of teachers in ways that realise that students need to take the centre stage in the teaching and

2.3.8 The perceptions of the principals about teachers who have undergone SMASE training

An interview guide was used to gather information about principals' perceptions regarding teachers who had undergone SMASE training in terms of their teaching, and ways their teaching had influenced the school environment. From the analysed data, majority of the the principals perceived the teachers who participated in this study as people who had brought change in the teaching and learning of mathematics and science in their respective schools and promoted improved attitudes and performance in mathematics and science. For example, in talking about CT16, the chemistry teacher who participated in this study CP16 stated, "We encourage team-teaching, and now she is at the centre of coordination. Whatever is done in all the chemistry classes, they organise, they plan, and they do what we call a common presentation". Similarlyin talking about BT04, the biology teacher who participated in this study BP04 stated, "She's the head of science department. Let me say that when she came in, that department is now getting streamlined

3. Conclusion

It can be concluded from the findings of this study that mathematics and science teachers who had undergone INSET through SMASE program

1. Practiced the ideals of SMASE to a satisfactory extent and had improved mathematics and science teaching methodologies in ways that made them to place students at the centre of the teaching and learning process.
2. enabled teachers to develop a vibrant community of practice as it afforded them opportunities to meet and learn from one another not only during the training but also after the trainin
3. impacted positively on students' attitudes towards mathematics and science subjects. This is reflected in the findings that indicated that the majority of the students enjoyed learning these subjects

4. the mathematics and science teachers have become good role models to both students and other teachers
5. SMASE training as a teacher capacity development program has the ability to transform teachers and teaching in ways that enhance students' meaningful participation and engagement in the teaching and learning process.

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Author's Background

Ms. Gladys Mwugusi is a seasoned Teacher Trainer with extensive knowledge in innovative pedagogies. Her career spans over ten years of hands-on experience in designing and delivering training programs for mathematics & Science teachers and education managers in 34 African countries. This has accorded her a deeper understanding of education in African context and pedagogical issues related to classroom practice. She is ISO 9001:2015 Lead Auditor and coordinates the activities of the quality management system in CEMASTEA.