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SESEMAT In-service Pedagogical Strategies and Students' Achievement in Science at Ordinary Level in Tororo SESEMAT Region

Deborah Manyiraho[1,*], Dennis Zami Atibuni[1,2], David Kani Olema[1], Leonard Wamakote[1]

[1]Busitema University, Faculty of Science and Education, P.O. Box 236, Tororo, Uganda
[2]Ali Mazrui Centre for Higher Education Studies, University of Johannesburg Auckland Park Kingsway Campus, P.O. Box 524, Auckland Park 2006, Johannesburg, South Africa
*Corresponding author: dmanyiraho@yahoo.com

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Abstract Across the globe, nations have put in place interventions to boost learners' achievement in science at various levels because science plays a key role in development. In Uganda, secondary science and mathematics teachers (SESEMAT) program is one of the major interventions set up to improve students' academic performance and their attitude towards science. This study aimed to establish whether implementation of SESEMAT in-service pedagogical strategies has resulted in improved student achievement in science at secondary schools in Tororo Region. A cross-sectional survey research design was adopted. Quantitative and qualitative data were collected from a probability sample of 380 senior four students; and a non-probability sample of 20 head teachers, 12 teachers. The results revealed that SESEMAT strategies were being implemented at a moderate level (*M = 19.88, SD = 4.49*). SARB was by far the most implemented strategy while lesson study was the least. Student achievement was high (*M* = 37.96, *SD* = 5.70) while the strategies greatly enhanced teachers' knowledge and practices (*M = 35, SD = 5.40*). The indirect effects of teachers' classroom practices on implementation of SESEMAT strategies significantly improved students' achievement in science (z = .16, $p < .01$, $k^2 = .28$). In conclusion, the implementation of SESEMAT strategies enhanced teachers' knowledge and classroom practices, boosting student achievement in science in terms of attitude change, skills acquisition, and daily life application. However, the level of academic performance was still low. The study recommends improved monitoring of the implementation of SESEMAT strategies in addition to SESEMAT trainers helping the science teachers to intensify the use of interactive strategies to enhance learners' understanding of the subject matter.

Keywords: *SESEMAT, pedagogical strategies, student achievement, science*

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1. Introduction

Teaching and learning of Science has been the emphasis of both developed and developing countries because of the key role science and technology play in social and economic development [1]. However, despite the expected positive impacts of science on agriculture, health, communication and other spheres of life, there is still low achievement of students in science disciplines world over. Countries have, as a result, put in place innovations to improve students' achievement in science. For instance, in Japan, a science education promotion law was enacted to regulate the standards of teaching/learning aids so that every child has an opportunity to learn science [2]. Other developed countries such as the US, Malaysia, and Britain also put interventions in place to raise students' achievement in science. The Malaysian Ministry of Education, for this matter, has been implementing lesson study at school level [3] in an effort to boost teaching/learning of science.

On the other hand African countries established a platform for Strengthening of Mathematics and Science Education in Western, Eastern, Central, and Southern Africa (SMASE-WECSA) to share experiences in, and knowledge of, mathematics and science education [4]. Sessay [5] explains that the SMASE-WECSA platform saw the governments of Kenya and Japan (through Japan International Cooperation Agency) set up the SMASE program in response to the poor performance in mathematics and science in Kenya Certificate of Secondary Education (KCSE). Similarly, in Uganda, secondary science and mathematics teachers (SESEMAT) program is one of the major interventions set up to improve students' achievement in science.

SESEMAT program was introduced by the Ministry of Education and Sports with technical support from the government of Japan through the Japan International Cooperation Agency (JICA). The program was first launched as a pilot project in Tororo District in 2005 to help improve attitudes of both teachers and students, and help in classroom instruction. Later the program was expanded to cover the whole country during the SESEMAT Program Expansion Phases I and II in 2007 and 2009 respectively [6].

The major aim of the program is to improve the teaching ability of science and mathematics teachers at secondary school level [6]. Science, in this case, is an umbrella term for biology, chemistry, physics, and mathematics. The main SESEMAT in-service pedagogical strategies include continuous professional development workshops for science teachers, SESEMAT Activity Regional Based (SARB) initiative, lesson observation, and lesson study. Under the continuous professional development workshops program, by September 2017, over 300 trainers and 6,000 teachers had undergone training [7]. These workshops are aimed at enhancing science teachers' pedagogical content knowledge, teaching skills, and assessment practices. According to [8], science teaching is an inquiry, not only in the laboratory but also in the daily classroom methods and activities. During the teaching process, science teachers explore a teaching sequence that combines inquiry activities as emphasized in the SESEMAT pedagogical strategies as one of the ways of enhancing students' feeling of relevance of their science studies and their motivation to study science [9].

SESEMAT trainings were therefore expected to translate into improved student achievement in science and mathematics because, as affirmed by [10], teacher training has a significant, positive impact on student achievement under generally favorable conditions depending on the context and quality of the program. Student achievement in science in this study is looked at as a measure of the amount of academic knowledge and content learnt by a student in a given time. The learning is measured in terms of academic performance, skills obtained, change of attitude, and application of science in real life situations [11]. According to [12], student achievement in schools is very important to stakeholders in education and those outside the education sector as a way of achieving the 21st century skills.

Apart from training of science teachers, the other activity of SESEMAT in the region is a SARB initiative. In Tororo Region, the initiative is assessment by testing, whereby all students in S.2 are given a regional test (pre-test), marking is done and individual teachers identify areas that were not done well by students. Remedial lessons are conducted and a post-test is administered when the students are in S.3 to assess whether there is improvement in the areas that had been performed poorly.

There is also lesson observation and lesson study where by planned lessons are observed in the classroom and positive criticism is given to the teacher for improvement in the next lesson. Lesson observation is described as a model of teacher professional development aimed at improving the teaching and learning process [3]. This development comes as a result of improving on the weak areas observed during lesson delivery. Lesson observation and lesson study can be school based or the SESEMAT trainers can come in to give technical support to science teachers in the classroom. This is all aimed at helping science teachers to improve their classroom practices to boost student achievement in science. With all these strategies in place, students' achievement in science is expected to improve significantly; but in reality is still low [13]. The poor scores in science by students in the region suggest a gap at implementation of the SESEMAT strategies at school level or in the contents of the program, hence the need for this study.

1.1. Problem Statement

The government of Uganda has invested a lot of resources in science teaching and has since 2005 pressed science teachers to attend continuous professional development workshops in a bid to improve their classroom practices which is envisaged to improve students' achievement in science and mathematics. Despite the efforts of SESEMAT, there is only a slight improvement in students' achievement in science, with little improvement at ordinary level [14]. Consequently, the numbers of students taking science related subjects at advanced level and subsequent levels are few as compared to those in non-science courses [15].

The poor performance at ordinary level has been reflected in the low pass rates of only 7.0 %, 0.4 % and 4.1 % distinctions in physics, chemistry, and mathematics respectively in the 2013 UNEB examinations [15]. Failure rates in science subjects have persistently remained above fifty per cent. In addition, Physics, chemistry, and biology were the worst done subjects in 2016, 2017, and 2018 respectively [13,16,17]. Reports from the SARB initiative exams sat by students of S.2 and S.3 in Tororo SESEMAT region also show a similar trend in performance in the same subjects since the beginning of SESEMAT program [18]. Such low achievement levels in science in Tororo Region may disadvantage the region in terms of socio-economic development and other benefits of a science and technology led economy [19].

Despite SESEMAT intervention in Tororo region since 2005, the teaching of science is still ineffective leading to poor performance in the subjects. Talemwa and Opae Papa [15] report that the reasons for poor performance in science subjects among others include lack of practical teaching, need for more assistance on the side of teachers due to poor training which does not meet curriculum demands, and negative attitude of students towards science. For the case of Tororo Region these reasons area reflection of a gap in the leadership and management of the SESEMAT program. This gap may result in poor content of the program and poor implementation of the SESEMAT strategies. There is, therefore, need for a methodical approach to investigate the persistently low performance in Science subjects in the face of the efforts of SESEMAT.

1.2. Purpose and Objectives

The purpose of the study was to establish whether SESEMAT in-service pedagogical strategies in Tororo Region have resulted in improved students' achievement

in sciences at ordinary level. The study was guided by the following objectives:

1. To determine the level of implementation of SESEMAT in-service pedagogical strategies in schools in Tororo Region.
2. To assess the level of students' achievement in science in Tororo Region.
3. To establish how SESEMAT in-service pedagogical strategies enhance teachers' knowledge and practice to boost student achievement in science subjects in Tororo Region.
4. To establish the mediation effect of teachers' classroom practice on the relationship between implementation of SESEMAT in-service pedagogical strategies, and student achievement in science in Tororo Region.

1.2.1. Research Questions

1. What is the level of implementation of SESEMAT in-service pedagogical strategies in schools in Tororo Region?
2. To what level do students in Tororo Region achieve in science?
3. How have SESEMAT in-service pedagogical strategies enhanced teachers' knowledge and practice to boost student achievement in science.
4 What is the mediation effect of teachers' classroom practice on the relationship between implementation of SESEMAT in-service pedagogical strategies and student achievement in science?

1.2.2. Hypothesis

$H_0$1 - SESEMAT in-service pedagogical strategies in the region have not enhanced teachers' knowledge and practice to boost student achievement in science.

$H_0$2 - Teachers' classroom practice does not have a mediating effect on the relationship between implementation of SESEMAT in-service pedagogical strategies and student achievement in science in Tororo region.

1.3. Implementation of SESEMAT Activities in Tororo Region

SESEMAT program has been recognized as an effective program in enhancing the quality of teaching and learning science and mathematics in secondary schools in Uganda [6]. The major SESEMAT in-service pedagogical strategies at the time of its introduction in Tororo were teacher trainings and lesson observations in individual classrooms. The training content started with attitude change for science teachers and students, followed by actualization of activity-based, learner-centered lessons with encouragement and improvisation through a cycle of planning, implementation, evaluation, and improvement (ALEI - PIEI).This content was followed by lesson study as a tool for continuous professional development, content reinforcement, linkage of lessons, teaching reference, inquiry based learning to mention but a few. The trainings focus on implementation of learner centered lessons utilizing the ALEI-PIEI conceptual framework as well as reflecting on good classroom practice, discussing challenges regarding the teaching/learning process, and developing strategies to overcome the challenges [18]. According to [5], this kind of approach involves a shift from knowledge or content-based approach, few teacher demonstrations, theoretical or lecture method (chalk and talk), teacher-centered teaching to learner- centered teaching. Teachers' classroom practice can be improved through lesson study and lesson observation which regional trainers have continued to conduct for science and mathematics lessons. Reports by regional trainers on lesson observation have indicated that despite SESEMAT intervention, science teachers still do not prepare adequately for their lessons [18]. In addition to the previously implemented strategies, the regions started implementing a SARB initiative (assessment by testing) in 2013. This was both at regional and school level with an aim of conducting remedial lessons in topics that learners perform poorly to boost their achievement [18]. SARB implementation is supervised by both regional trainers and school administrators.

1.4. Students' Achievement in Science

In many studies, student achievement is looked at in terms of academic performance which can externally be observed. However, personal competences result from both intellectual and non-intellectual variables. According to Crow and Crow cited in [19] academic achievement is the extent to which a learner is profiting from instructions in a given area of learning (*i.e.*, achievement is reflected by the extent to which skill or knowledge has been imparted to him). Furthermore, academic achievement could denote the knowledge attained and skill developed in a particular learning area. Therefore, student achievement in science means that the students understand the basic concepts and knowledge in the subjects, have developed a good attitude, have acquired the necessary skills, and can apply science in real life situations.

It is important that students achieve in science because science and mathematics are important learning areas to achieve the 21st century skills. It is therefore necessary that teachers use practical examples instead of abstract problems to help students achieve in these subjects. A study carried out by [5] using standard tests and evaluations revealed that despite the vital role played by science in advancing the society and the much government support at all levels, students' performance in science was still below the expected level. This means that it is important for teachers to take care of the processes that occur during teaching and learning since they play a big role in developing students' pedagogical skills. This is possible if science teachers in the region adopt learner centered pedagogical approaches as emphasized by SESEMAT. Moreover, studies have shown that science knowledge is abstract rather than concrete which results in low mastery among learners. This, therefore, calls for creativity on the part of the teacher hence the necessity of continuous in-service training and development.

1.5. How SESEMAT In-service Pedagogical Strategies Enhance Teachers' Knowledge and Practice to Boost Student Achievement

Empowering teachers to exercise effective teaching

skills in their classrooms as a strategy of improving student achievement has positive results. In many developing countries, teachers have little or no pre-service preparation before starting to teach, and Uganda is not an exception which explains the need for teachers' training programs in upgrading teachers' skills, knowledge and performance as well as enabling them to be more effective. Teacher training programs play a crucial role through training to change teachers' skills and attitudes for the better. The government of Uganda, through the ministry of education has since used the SESEMAT program to enhance teachers' skills and as well as passing on the latest innovations in teaching methods such as inquiry-based learning and the 5Es instructional model. However, findings from a study carried out by [20] revealed that in Uganda, teachers generally shun learner-based methods claiming the methods consume a lot of time. However, to some extent science and mathematics teachers employ learner-based methods of teaching because the practical nature of the subjects dictate so.

Lesson study and lesson observation are supposed to equip teachers with teaching skills, and ability to demystify the abstract concepts in their subjects, predict students' misconceptions and therefore prepare better lessons. However, the two activities have not been common because there are few science teachers in the region, shared among schools [18], and therefore cannot get adequate time for lesson study and lesson observation.

Finally, the SARB initiative enhances teachers' skills of assessment (setting, scoring, analysis and giving feedback to students) as well as helping teachers improve in their preparation and delivery of remedial lessons.

1.6. Mediation Effect of Teachers' Classroom Practice on the Relationship between Implementation of SESEMAT Pedagogical Strategies and Student Achievement

Teachers in their respective subjects of specialization are a source of encouragement to their students. Therefore, it is important that every school recruits high quality teachers in order to improve on the knowledge, skills and general performance of its students. However, to achieve this, the high quality teachers combined with good teacher classroom practice play a central role. Teacher classroom practice such as, specific teaching strategies and utilizing best institutional practice have been linked to student achievement. The results of a study carried out by [21] to examine the relationship between teacher practices and student growth suggested a strong relationship between teacher practice and student growth while controlling for teacher and school characteristics. This implies that good teacher practice, which more often than not proceed from quality training and teachers' knowledge and skills, most likely translate into raised student achievement in science, other teacher and school factors remaining constant. This assumption has been represented in Figure 1.

Assessment for learning on the other hand, introduced in the classroom, as it is in the SARB initiative, improves student learning [23]. Besides this, teachers are expected to use better classroom practice when handling remedial lessons so that students can improve in the areas they had performed poorly.

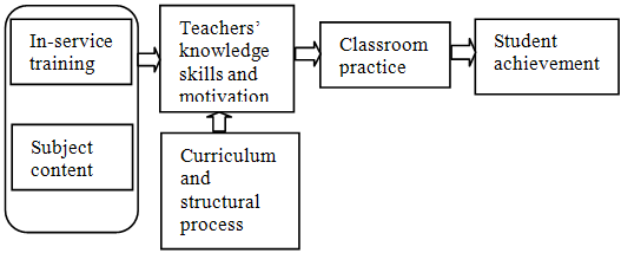

Figure 1. Professional Development Training Logical Model (Adopted from Yoon et al. cited in [22])

2. Materials and Methods

2.1. Research Design

This study adopted a cross-sectional survey design employing both quantitative and qualitative approaches. The design was envisioned to provide a greater depth in understanding the variables and analysis of data obtained at a specific point in time [24,25].

2.2. Study Population

The study population comprised head teachers, teachers of science subjects (Biology, chemistry, and physics) and mathematics and students of Senior 4 in Tororo and Butaleja districts. Tororo SESEMAT region has 75 schools with a population of 9184 students in Senior 4, and 162 teachers of science and mathematics. Students of Senior 4 from the selected schools participated in the study because they have already sat for both the pre-test and post-test of SARB.

2.3. Sample Size and Sampling Strategies

The schools in the region were stratified according to geographical location, ownership, source of funding, sex of students and whether they were day or boarding. A random selection of schools was done ensuring that all categories were represented. Krejcie and Morgan's [26] table of sample size determination was used to select 368 participants from 9,184 students. The head teacher, selected purposively from each of the selected schools filled a questionnaire specifically designed for them. The questionnaires for head teachers were analyzed differently from the one of students to compare the findings. Four groups of teachers randomly selected from schools in the region participated in focus group discussions to further triangulate information obtained from the students.

2.4. Instruments of Data Collection

The students' questionnaire consisted of three sections. Section A the demographic information sought to document the age, gender, and school type of the participant. Section B had twenty five closed questions that generated quantitative data. The items were structured in such a way that six items focused on implementation of

SESEMAT strategies, nine items on how SESEMAT has enhanced teachers' practice and ten items on the relationship between SESEMAT strategies and student achievement. These items were scored on a 5-likert scale as strongly disagree, disagree, not sure, agree and strongly agree. Section C had open ended questions that sought information on the subject passed most by the participant, the reasons for passing the subject and whether schools had in place other programs to boost achievement in science.

The questionnaire for head teachers consisted of closed questions on availability of resources in their schools for implementation of the program, enhancement of teachers' knowledge and practice, and their perception on students' achievement with a provision of further explanation on the responses where necessary.

The focus group discussion guide for science teachers had six questions seeking information on implementation, and how they had gained from the program but more responses were generated during the discussion.

2.5. Validity and Reliability

The content validity of the instrument was ascertained by two regional trainers as technical persons in the SESEMAT program and then the research supervisors. The CVI = Number of relevant items (25)/Total number of items (30) was calculated and found to be .83. The instrument was therefore considered to be valid. The items that were considered not relevant were either reconstructed or dropped.

Reliability of the students' questionnaire was tested by piloting the questionnaire in two schools which did not participate in the study. Cronbach's alpha was obtained and the overall value of $\alpha = .81$.

2.6. Data Management

All the questionnaires were collected from all the schools. Those that were fully filled were sorted and coded in preparation for entry in the statistical package for the social sciences (SPSS) system version 25 for analysis.

Open ended responses and data from the focus group discussions was organized according to the objectives for analysis using discursive and thematic methods.

2.7. Data Analysis

The data were analyzed following the objectives of the study. For Objectives 1, 2, and 3, descriptive statistics such as the frequency, mean, standard deviation, and percentages were used to determine the level of implementation of SESEMAT strategies (*i.e.* whether it is low, moderate or high), level of student achievement, and how much SESEMAT had enhanced teachers' knowledge and practice to boost student achievement. Chi-square test statistics on responses from head teachers were performed to establish whether there was significant variation in their responses. These results were triangulated with qualitative data from the focus group discussions and open-ended questions. For Objective 4, the study established whether there was significant correlation along the paths of the model followed by running multiple linear regression analysis (Model 4) in SPSS using the Process plugin by [27].

2.8. Ethical Considerations

During the planning, collection, and processing of data, informed consent of the respondents was sought before administering data collection instruments. It was made known to the respondents that their participation was voluntary and they were free to withdraw from the study at any time or may not answer questions they were uncomfortable with. Due respect was given to the respondents' privacy and confidentiality, in which case, the names and identities of the participants were concealed.

Permission was sought from District Education Officers to gain access to the schools, followed by officially writing to the head teachers, requesting them to allow the study to be conducted in their schools. Objectivity was one of the guiding principles to the study to avoid bias as well as display a high level of confidentiality with data collected from the respondents. The academic documents such as journal articles, reports, books, and book chapters used in the study as sources of information were all duly credited by citing in text and referencing.

3. Results and Discussion

3.1. Demographic Characteristics

Demographic information was obtained on school location, school type, gender, sex and age of the respondents, and tabulated to show the distribution of the participants. For example, the respondents were nearly evenly distributed across the different categories of the schools and in each of the four geographical locations of the region. Geographically, the region with more school categories had more participants. The majority of the student respondents were aged between 17-19 (66.8%). There were more males (54.2%) than females (45.8%). The school type also depended on the categorization; a higher representation of the rural (65.0%), private (55.0%), USE (60.0%), and mixed (80.0%). The detailed demographic information is presented in Table 1

Table 1. Demographic Information of the Participants (N = 380)

Characteristic	Category	*n*	%
Geographical Location	Butaleja	95	25.0
	Tororo County	76	20.0
	Tororo Municipality	76	20.0
	West Budama	133	35.0
Area Location	Rural	247	65.0
	Urban	95	25.0
	Semi-urban	38	10.0
School Ownership	Government	171	45.0
	Private	209	55.0
School Type	Day	95	25.0
	Boarding	76	20.0
	Both Day and Boarding	209	55.0
Funding Policy	USE	228	60.0
	Non USE	152	40.0
Sex of Students	Mixed	304	80.0
	Boys only	38	10.0
	Girls only	38	10.0
Gender of Respondent	Male	206	54.2
	Female	174	45.8
Age of Respondent	Below 17 years	58	15.3
	17-19	254	66.8
	Above 19 years	68	17.9

3.2. Level of Implementation of SESEMAT Pedagogical Strategies

The level of implementation was determined by analyzing students' responses. The scores ranged from 10 to 30 (M = 19.88, SD = 4.49). This shows a moderate level of implementation of SESEMAT activities. The implementation of SESEMAT strategies is evidenced by regular INSETs, regional SARB examinations, lesson observation, and ability of teachers to conduct simplified experiments in a bid to promote practical teaching [5,6]. However, the moderate level implies that there is still more to be done in the implementation of the strategies such that student achievement is improved. Results of cross tabulation of the demographic characteristics and level of implementation of SESEMAT in-service strategies are shown in Table 2.

Results in Table 2 indicated a high level of implementation in Tororo Municipality compared to other regions. Implementation was also high in boarding schools and in girls' schools. The level of implementation was assessed further using independent chi-square tests on responses from school administrators and the summary is given in Table 3.

Results in Table 3 indicate statistically significant variations in the responses of the head teachers regarding the implementation of the different SESEMAT strategies in the regions. This implies that the head teachers had different opinions about how effectively the program was being implemented in their schools. For example, one head teacher expressed "If SESEMAT program is implemented during teaching, the syllabus will not be completed," meaning that in a bid to complete the syllabus, the school preferred not to implement the strategies. Yet another said that, "SESEMAT program has demystified the nature of science subjects in my school which has changed the attitude of the learners towards science subjects," in which case the school chose to implement the program.

Further, the head teachers reported that SARB (exams and remedial lessons) was the most widely 18(90.0%) implemented activity while lesson study was the least, 09(45.0%). Furthermore, the results indicate that six out of ten, 12(60.0%), of the schools did not have enough teachers of science and 11(55.0%) of the schools were found not to enough laboratory equipment and text books. This shortage of teachers of science and laboratory equipment could explain why implementation of pedagogical strategies was still low in some schools.

Mugo [28] explains that actualization of learner centered pedagogical strategies was higher among science and mathematics teachers who attended INSETs regularly. However, for Tororo Region teachers' attendance to regular INSETs was not 100% which also explains the moderate level of implementation. These findings agree with what the Ministry of Education and Sports [29] reported during evaluation of SESEMAT phase III that improvements in teaching and learning practices were observed in schools where SARB had been actively implemented. Science teachers in the region who attend regular INSETs make effort to put in practice what is emphasized to them during INSETs. As emphasized by [30], in-service pedagogical strategies are very important for teachers as a tool for professional development and to enhance their knowledge and quality of teaching and learning. Therefore, stakeholders need to manage the implementation of in-service pedagogical strategies for them to translate into improved student achievement [6].

Table 2. Demographic Characteristics and Level of Implementation of SESEMAT Strategies

Characteristic	Category	Level of Implementation		
		Low	Moderate	High
		n (%)	*n* (%)	*n* (%)
Geographical location of school	Butaleja	6(6.3)	53(55.8)	36(37.9)
	Tororo County	5(6.6)	48(63.2)	23(30.3)
	Tororo Mun.	2(2.6)	27(35.5)	47(61.8)
	West Budama	6(6.3)	53(55.8)	36(37.9)
Area location	Rural	28(11.3)	149(60.3)	70(28.3)
	Urban	4(4.2)	44(46.3)	47(49.5)
	Semi-urban	0(0.0)	16(42.1)	22(57.9)
School Ownership	Government	19(11.1)	88(51.5)	64(37.4)
	Private	13(6.2)	121(57.9)	75(35.9)
School Type	Day	14(14.7)	58(61.1)	23(24.2)
	Boarding	3(3.9)	28(36.8)	45(59.2)
	Both Day & Boarding	15(7.2)	123(58.9)	71(34.0)
Funding Policy	USE	23(10.1)	130(57.0)	75(32.9)
	Non USE	9(5.9)	79(52.0)	64(42.1)
Sex of Students	Mixed	29(9.5)	172(56.6)	103(33.9)
	Boys only	2(5.3)	28(73.7)	8(21.1)
	Girls only	1(2.6)	9(23.7)	28(73.7)
Gender of participant	Male	19(9.2)	123(59.7)	64(31.1)
	Female	13(7.5)	86(49.4)	75(43.1)
Age of participant	Below 17 years	2(3.4)	23(39.7)	33(56.9)
	17-19	20(7.9)	149(58.7)	85(33.5)
	Above 19 years	10(14.7)	37(54.4)	21(30.9)

Table 3. Chi-Square Test Statistics on Responses from Head teachers

Item	Observed *N*		$\chi 2$	*df*	*P*
Do you have the required number of science and mathematics teachers in your school?	No	12	.800[a]	1	.371
	Yes	8			
What is the average teaching load of your science and mathematics teachers?	Less than 16	1	14.000[b]	3	.003
	16-19	12			
	20-23	4			
	24 and above	3			
How regularly do your science and mathematics teachers come to school	1-2 days a week	8	7.900[c]	2	.019
	3-4 days a week	11			
	Everyday	1			
Does your school give science subjects and mathematics special attention compared to other subjects?	No	4	7.200[a]	1	.007
	Yes	16			
Do you have enough resources (lab. apparatus, materials and finances) in the school to facilitate the teaching/learning of science?	No	11	.200[a]	1	.655
	Yes	9			
What proportion of your science teachers attend SESEMAT INSETS?	Less than 30%	5	.400[a]	3	.940
	30%-60%	5			
	60%-90%	4			
	over 90%	6			
How often do your science teachers carry out lesson study?	Never	11	10.800[b]	3	.013
	Once a year	4			
	Once every Term	4			
	Once every Month	1			
How many lessons have your science teachers been observed in the classroom by an administrator, ministry personnel or SESEMAT trainers in the past one year?	None	3	12.100[c]	2	.002
	1-3 times	14			
	4-6 times	3			
Does your school have updated SARB files?	No	10	.000[a]	1	1.00
	Yes	10			
Does your school have a laboratory technician to assist in preparation of practical lessons?	No	4	7.200[a]	1	.007
	Yes	16			
Are there enough textbooks for science in the school?	No	12	.800[a]	1	.371
	Yes	8			

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 10.0.
b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 5.0.
c. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.7.

3.3. Level of Students' Achievement in Science

The level of students' achievement was found to be high with scores ranging from 19 to 49 (M = 37.96, SD = 5.70). Table 4 shows chi-square test results from administrators' responses on student achievement in science.

In terms of academic performance, there is a significant variation in the responses (Table 4). For instance, according to Respondent 11, "Learners have improved because science lessons have now been made practical instead of theoretical" while Respondent 6, said that, "SESEMAT has not helped learners because their grades in science are still poor compared with other subjects." This implies that head teachers did not agree on the extent to which the performance of the learners had improved as a result of SESEMAT intervention. However, there was no significant variation observed when it came to the general attitude of students towards science. Six out of ten (60%) of the head teachers said that the attitude of students towards science was still poor. This perception by the head teachers is contradictory to the perceptions of the teachers and students.

The teachers generally perceived learner achievement to be improving. For instance a participant in FGD 1 had this to say,

The learners' performance now, is improving because if I consider learners I taught three years back and compare with the class I have now, the current lot is much better

In FGD 2, one of the participants explained that, "frequent testing done at school as a way of implementation of the SARB initiative encourages learners to revise." While another participant said that "application of hands on in class, helps learners to enjoy the lesson."

Table 4. Chi-Square Test Results of Head teachers Responses on Student Achievement

Item	Observed *N*	$\chi 2$	*df*	*P*	Item
How do you rate the general trend of performance of your students above?	Poor	10	7.300[c]	2	.026
	Fair	9			
	Good	1			
What would you consider the general attitude of students towards science at this school to be?	Negative	12	.800[a]	1	.371
	Positive	8			

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 10.0.
c. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.7.

The poor academic performance (*i.e.,* the scores) of the learners in science as perceived by the head teachers, could imply that the SESEMAT strategies are not very effective. The ineffectiveness of the strategies to improve academic performance could be as a result of many factors including social norms and inter temporal choices factored in the design of educational policies when two or more drivers are combined [31]. This makes it necessary for teachers to encourage students to manage their own learning and engage in cooperative tasks in order to improve their academic performance [19].

Students' response on whether their schools had other programs to boost the teaching/learning of science and mathematics were generally not in the affirmative. Fundi bots program and science clubs were active in only two out of the twenty schools sampled. When asked which science subject was performed better, learners' response showed that they performed best in biology followed by Mathematics as shown in Table 5.

Table 5. Percentage of Subject Passed Most by Participants

Subject	Percentage
Biology	42.1
Chemistry	11.3
Mathematics	31.8
Physics	13.7
None	01.1
Total	100

Participants' views on why they performed better were many including their own hard work, the teacher factor, and other factors. These views were ranked basing on the frequency of the responses and the results for the different subjects are shown in Table 6.

The four common reasons that ranked best for students passing science subjects are the nature of the subjects, students' determination or commitment and daily practice, future study and career, and good teaching methods. This implies that in-service pedagogical strategies have equipped teachers with good teaching methods and with skills to demystify the abstract nature of science subjects so that they are interesting to the learners. However, teacher commitment, availability of resources, and consultation with teachers and fellow students ranked worst. This means that science teachers are not committed to their work. And this, coupled with limited resources could explain why the academic performance of students in science is still poor.

The poor performance in science seen both in regional SARB examinations and in UNEB examinations could be as a result of moderate implementation of SESEMAT pedagogical strategies. Results in Table 2 show that in certain school categories the implementation is low which definitely affects students' achievement especially in the grades attained. The poor grades explain why enrolment in science combinations is still low. However, the findings about change in attitude agree with [6] that SESEMAT program had tremendously improved teacher and student attitudes towards science and mathematics. Besides this, education evolving memo [32] observes that students achieve in education when they acquire knowledge, skills and attitudes that will prepare them to lead happy and successful lives which explains the high achievement levels in attitude change, acquisition of skills and application of science in daily life despite poor scores by students in science subjects.

3.4. How SESEMAT Strategies Enhance Teachers' Knowledge and Practices to Boost Student Achievement in Science

The learners' perceived that SESEMAT strategies had aided teachers' knowledge and practices to a high level (M = 35.03, SD = 5.40) to boost students' achievement in science. Most learners' responses showed that science teachers often engaged them in practical activities during lessons, used interactive methods, encouraged students to learn, and linked new lessons to what learners already knew. This agrees with the perceptions of the head teachers; 14(70.0%) of them agreed that SESEMAT strategies had enhanced teachers' skills greatly while 13(65.0%) agreed that SESEMAT strategies had greatly impacted on teachers' classroom practices). Table 7 shows chi square test results from administrators' responses.

The results in Table 7 show a statistically significant variation in the responses ($p < 0.05$); therefore, the null hypothesis was rejected. It was concluded that there is a statistically significant variation in responses on how SESEMAT strategies enhanced teachers' knowledge and practices with many of them agreeing that it was great enhancement.

Table 6. Rank of Reasons why Participants Performed Better in Biology, Chemistry, Mathematics and Physics

Reason	Biology		Chemistry		Mathematics		Physics		Mean Rank	Final Rank
	Tally	Rank	Tally	Rank	Tally	Rank	Tally	Rank		
Daily life application	46	1	-	-	14	7	02	8	5.3	5
Future study and career	45	2	10	3	21	5	17	2	3.0	2
Good teaching methods	44	3	09	4	30	3	16	3	3.3	4
Nature of the subject (interesting topics and easy)	33	4	14	1	31	2	21	1	2.0	1
Students determination/commitment and daily practice	23	5	13	2	47	1	08	4	3.0	2
A lot of practical work	18	6	02	9	-	-	02	8	7.7	8
Discussions	14	7	04	7	16	6	03	7	6.8	7
Motivation/encouragement by the teacher	10	8	07	5	24	4	04	6	5.8	6
Consulting teachers and fellow students	08	9	04	7	10	8	02	8	8.0	9
Teacher commitment	07	10	01	10	10	8	01	11	9.8	11
Availability of resources	06	11	05	6	05	10	06	5	8.0	9

Table 7. Chi-Square Test Results on how SESEMAT Enhance Teachers Knowledge and Practices

Item	Observed *N*	χ2	*df*	*P*	Item
To what extent has SESEMAT enhanced your science Teachers' knowledge and skills?	Not at all	2	18.000[b]	3	.000
	Small	4			
	Great	13			
	Very great	1			
To what extent has SESEMAT impacted on the classroom practices of science teachers in your school	Not at all	1	10.900[c]	2	.004
	Small	6			
	Great	13			

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 5.0.
c. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.7.

Furthermore, results in Table 6 indicated good teaching methods as one of the strong reasons learners' have for improved performance. This means that science teachers deliver activity-based lessons and practice good teaching methods which encourage students to learn. For instance, one of the teachers in FGD 1 expressed that

> For last four years I have served, I think to a larger extent I have done a lot and I have got a lot from SESEMAT, at least when it comes to SARB, we set tests and organize remedial lessons. Then we have now learnt a number of ways of handling science subjects we engage students in practical work my lessons are now practical for example as I'm teaching soil in S.2 every time I carry soil.
>
> In addition, a participant in FGD 3 expressed, "SESEMAT program has helped me to simplify concepts in physics from abstract to reality."
>
> The responses of the head teachers were also in agreement for instance one head teacher stressed that, "The SESEMAT program has improved science teachers' skills of improvisation using local materials as well as their testing skills."

These findings are in line with studies by Ekpoh, Oswald, and Victoria cited in [30], which show that, teachers who attend in-service training perform effectively in their work especially in terms of knowledge of the subject, classroom control, teaching strategy and assessment of students. In addition, findings of a study carried out by [33] on the perceptions of secondary science and mathematics teachers towards SESEMAT program in Mbarara District also revealed that most teachers perceived the program to have positively impacted on their teaching skills. This means that SESEMAT pedagogical strategies have improved the improvisation skills of science and mathematics teachers as well as raising the level of their content knowledge, and helping them develop hands-on/minds-on activities for their lessons. This agrees with findings from the focus group discussions where science teachers confessed that they have learnt better ways of engaging learners in practical activities, and besides this, they have improved a lot in assessment practices and remedial teaching.

3.5. Mediation Effect of Teachers' Classroom Practice on the Relationship between Implementation of SESEMAT Pedagogical Strategies and Student Achievement

To determine the mediation effect of teachers' classroom practice on the relationship between implementation of SESEMAT strategies and student achievement in science, a structural equation modeling (Model 4) using multiple regression with the Process plugin in SPSS by Hayes [27] was involved. This was after establishing that the correlation coefficients for each path were statistically significant. The multiple regression revealed that the direct path *c* of regressing student achievement on core implementation of SESEMAT pedagogical strategies was significant, $\beta = .42$, t (378) = 6.87, $p < .01$, with a significant overall model, F (1, 378) = 47.23, $p < .01$, $R^2 = .11$. Path *a* showed that implementation of SESEMAT strategies significantly predicted teachers' classroom practice, $\beta = .53$, t (378) = 9.45, $p < .01$, with a significant overall model for the path, F (378) = 89.35, $p < .01$, $R^2 = .19$.

Path *b* of regressing student achievement on teachers' classroom practices was also significant, $\beta = .52$, t (377) = 10.46, $p < .01$.

In the indirect path c^1, the regression of student achievement on implementation of SESEMAT strategies while controlling for teachers' classroom practice was significant, $\beta = .15$, t (377) = 2.44, $p < .01$, with a significant overall model, F (377) = 85.11, $p < .01$, $R^2 = .31$. The results showed that c-$c^1$was significantly different from zero, z = .16, $p < .01$, $k^2 = .28$.

In addition, the effect of implementation of SESEMAT strategies on student achievement shrinks (from .42 to .15) upon the inclusion of teachers' classroom practice to the model. These results imply that teachers' classroom practice strongly positively mediate the relationship between the implementation of SESEMAT strategies and student achievement in science. Thus the null hypothesis 2 was rejected. Instead, the alternative hypothesis that teachers' classroom practice has a mediating effect on the relationship between implementation of SESEMAT strategies and students' achievement is upheld. Figure 2 shows a diagrammatic representation of the mediation.

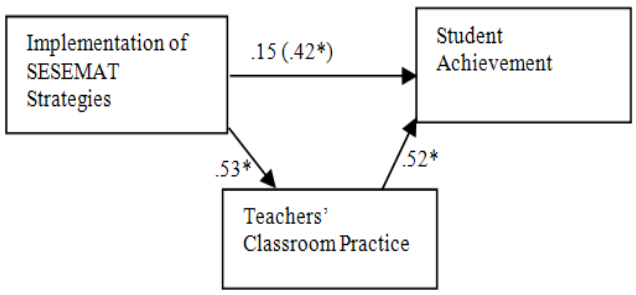

Figure 2. Indirect Path of Implementation of SESEMAT Strategies on Student Achievement through the Effect of Teachers' Classroom Practice (Note. * = p<.01)

The mediated relationship in Figure 1 indicates that an improvement in the teachers' classroom practice will improve the relationship between implementation of SESEMAT strategies and student achievement in science. However, the correlation coefficients for the paths were not strong and the effect of implementation of SESEMAT pedagogical strategies on student achievement in science does not shrink to zero. This means that student achievement in science does not depend only on pedagogical strategies. Other factors which are school related, student related, or teacher related (*e.g.*, conducive environment, social economic status, teacher qualification *e.t.c.*) can also affect student achievement.

Results showed in Figure 2 indicate that teachers' classroom practice is a strong positive mediator of the relationship between the implementation of SESEMAT strategies and student achievement in science. This implied that an improvement in the teachers' classroom practice will improve the relationship between implementation of SESEMAT strategies and student achievement in science. These findings agree with [34] that improved teaching behaviors were positively related to student achievement in science directly as well as mediated the relationship between student achievement in science and teacher training. According to [35], good classroom practice that engage students in academic activities, as emphasized in SESEMAT training workshops, lead to increased student achievement. Apparently, each classroom practice can have a significant mediation between SESEMAT pedagogical strategies and student achievement in science. This means that professional development programs for science teachers in the region are very important for them to improve their classroom practices. According to [36], field based programmes of continuous professional development meet the practical needs of teachers because teachers will be equipped with modern methods of teaching which improves the quality of lesson delivery therefore supporting the constructivist view of the teaching and learning process. World Bank [37] report highlights that though 90% of secondary school teachers in Uganda have the required qualification; they do not have sufficient content, knowledge and pedagogical skills to teach. Findings from the focus group discussions also indicate that teachers' skills of assessment had been enhanced greatly through the SARB initiative.

However, the findings of [21] indicated a significant correlation between teacher practice and student growth while controlling for teacher and school characteristics. In fact recent reviews suggest that teachers' instructional practice make a big difference to students' learning compared to other factors such as conducive environment, student related factors and teacher related factors [38]. Teachers are necessary to guide and encourage the learner as well as manage the teaching and learning process. Due to the enormous effects of classroom practice in the teaching and learning process. Wenglinsky [39] summarizes that teachers can contribute as much to student learning as the students themselves which implies that without the teacher, learning may not easily take place.

4. Conclusions

Based on the findings above, the study therefore concludes that;

SESEMAT in-service pedagogical strategies are moderately being implemented in schools in Tororo region. This means that science teachers strive to attend SESEMAT workshops, schools participate in the SARB initiative, and lesson observation and lesson study are also carried out in the region.

Student achievement in science in the region is moderate and is mainly in terms of improved attitude towards science and application of science in daily life. The academic performance is still poor in terms of scores which implies that stakeholders in the SESEMAT program have to devise other means to improve students' academic scores as well.

SESEMAT in-service pedagogical strategies have greatly impacted on the science teachers' knowledge and practices to boost student achievement in science. Science teachers in the region have improved their attitude about the learners and the subjects they teach. Teachers' classroom practices have also been enhanced. Science teachers employ good teaching methods which simplify subject content, thus, raising learners' interest. However, teachers' commitment is still low and resources for teaching and learning are not readily available. This explains why academic performance is still low.

Finally, teachers' classroom practice play a central role in student achievement in science by strongly mediating the relationship between implementation of SESEMAT strategies and student achievement. This means that, as stipulated by the constructivist theory [40], if SESEMAT in-service pedagogical strategies were implemented to a high level, science teachers' classroom practices would be improved greatly and consequently, more students will achieve highly in terms of attitude, application and scores in science. In other words, implementation of SESEMAT strategies to a high level will enable science teachers' facilitate the learning process better, using the ALEI-PIEI approach to help learners' construct their own knowledge and meaning of the subject matter.

4.1. Recommendations

The moderate level of implementation of SESEMAT in-service pedagogical strategies call for the responsible organizations and stakeholders increasing the monitoring of the program in all schools if its aim is to be achieved. Other factors notwithstanding, the success of teachers' pedagogical practices are highly dependent on the manner in which they are supervised [20].

In addition, schools should emphasize good teaching methods; teachers in the region should ensure that they simplify the nature of science subjects by demystifying abstract concepts for easy understanding by the learners. Teachers should make science subjects interesting by using interactive methods (learner centered) to enable learners obtain better grades (scores) in science subjects. Science teachers should facilitate learners' daily practice in their subjects by giving them exercises and tests and should guide learners on their future career as a way of improving their attitude towards science and motivating them to learn.

Furthermore, stakeholders should continue exploring avenues to enhance teachers' knowledge and practice especially during INSETs because the science teacher has a key role to play in student achievement.

Finally, Tororo SESEMAT Region should put more emphasis on strategies that improve teachers' classroom practice, especially lesson study and lesson observation. Science teachers should be encouraged to link their subject content, use invitational practices, and more of constructivism approaches in the teaching and learning of science.

4.2. Areas for Further Research

Replication of the study in other SESEMAT regions to give an overall picture of implementation of SESEMAT in service pedagogical strategies and student achievement in science nationwide. This will influence better decision making.

A detailed study on challenges to implementation on SESEMAT in service pedagogical strategies and how they can be overcome.

A study to explore other causes of low achievement in science apart from pedagogical approaches.

Statement of Competing Interests

The authors have no competing interests.

List of Abbreviations

ALEI - Activity based, Learner centered, Encouragement, Improvisation.

INSET - In-service Education and Training.

JICA - Japan International Cooperation Agency.

KCSE - Kenya Certificate of Secondary Education.

PIEI - Planning, Implementation, Evaluation, Improvement.

SARB - SESEMAT Activity Regional Based.

SESEMAT - Secondary Science and Mathematics Teachers Program.

SMASE - Strengthening Mathematics and Science Education.

SPSS - Statistical Package for Social Sciences.

UNEB - Uganda National Examinations Board.

WECSA - Western, Eastern, Central and Southern Africa.

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