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Evaluating the Roles of Teacher Variables, Pupil Gender and School Location in Realising Strengthening Mathematics and Science Education (SMASE) Training Goals in Oyo State, Nigeria

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Abstract

The study examined the teaching effectiveness of teachers trained under the SMASE programme and the moderating effects of teacher and pupil gender, and school location on achievement in, and attitudes towards Mathematics in Oyo State. Causal-comparative design of expo-facto research type was adopted. Proportionate to size sampling was employed to select 10 local government areas in the state. Schools were stratified into urban and rural, and SMASE and non-SMASE schools. Random and purposive sampling techniques were used to select 20 schools, 20 primary five Mathematics teachers and 25 pupils from each SMASE and non-SMASE schools, making a total of 40 schools, 40 teachers and 1000 pupils. The instruments used were: Pupils Mathematics Achievement Test (r=0.78), Pupils' Attitude towards Mathematics Learning Scale (r=0.88) and Teachers' Socio-demographic scale. Data were analysed using t-test and two-way analysis of variance at $\alpha = 0.05$. Teachers trained under the SMASE programme were more effective teaching mathematics than the non-SMASE teachers ($t_{(38)} = 7.78$; $p<0.05$). The moderating effects of teacher and pupil gender on SMASE and non-SMASE pupils' achievement in, and attitudes towards mathematics were not significant. However, the moderating effect of school location on SMASE and non-SMASE pupils' achievement ($f_{(1,995)} = 10.34$; $p< 0.05$) in, and attitudes ($f_{(1,995)} = 32.36$; $p<0.05$) towards Mathematics were significant. Training and re-training of mathematics teachers in primary schools should be continuous for enhanced achievement in and attitudes towards mathematics.

Keywords: Strengthening Mathematics and Science Education, Gender, School Location

Introduction

Education has been described in many ways. It is seen as a tool, a process, a legacy and so on. Education as a tool is useful for developing any nation both socially and economically, and also, it is potent in effecting behavioural and psychological changes in the society. It is observed as a process through which a person develops attitudes and abilities that are considered to have value and relevance in the society (Adeyemi, 2021). Further still, education is described as a pivot for any meaningful development (Ezekwesili, 2006) and, therefore, the best legacy a nation can bequeath to her citizens especially the youth. Not only is education regarded as a tool for accelerated national development, but also as the basis for integration of individuals into sound and effective citizens (FRN, 2004). The school curriculum which spells out the subjects and contents for a course of study becomes a tool used by the teacher in accomplishing the objectives of learning, which include, but not limited to, developing the cognitive, affective and the psycho-productive domains in learners. In this era of science and technology, introducing and implementing the SMASE programme, therefore becomes imperative.

Mathematics is one of the school subjects that is indispensable to science and technology, and invariably, nation building. The importance of Mathematics to man probably justifies its inclusion in the school curriculum as a compulsory subject for all children of school age to acquire the appropriate mathematical skills that will enable them cope with life endeavours. Also, it is observed that mathematics is a major tool for formulating theories in the sciences and explaining observations and experiments in other fields of inquiry. A few of the achievements are invention of computers, network analysis, econometrics, proffering solutions to transportation and economic problems (Fantola & Abimbola, 2012). Makarfi (2001) further noted that mathematics is

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universal not only in the way it influences the basic sciences, the applied science, engineering and technology, but also in the way it has been made relevant to the development of the social sciences and liberal arts.

It has been observed that the realisation of the national objectives of education and the effectiveness of the teaching-learning process in the school system depends largely on the qualities of the teachers, who are the major drivers of the national curriculum in education, translating policies into action at the classroom level. While implementing the curriculum, the teacher interacts with the pupils, effecting cognitive, affective or psychomotor changes or a combination of these aspects of learning (Afe, 2003). Teachers are thus an essential instrument needed for success of the school system. Research reports indicated students' pattern of achievement in mathematics and the associated explanations for the observed patterns (Odukoya, 2013; Olatunde, 2014; Peter, 2013). Most often, teachers' and students' factors are linked with students' achievement in the subject. To ascertain the status of Mathematics and Science in Nigeria, the Federal Ministry of Education and Japan International Cooperation Agency conducted a baseline study in selected primary schools in the country in 2006. The study revealed that schools were facing serious challenges in teaching and learning Mathematics and Basic Science. Specifically, it indicated that 81.0 % of the teachers use the lecture method, which signifies that majority of them engaged in "chalk and talk" delivery that does not encourage pupils' active participation in the classroom activities. As many as 84.5%, 76.4% and 64.5% of them had never attended training workshop/seminar, subject focused conferences and In-Service Education and Training (INSET) of any type respectively. Further still, the baseline survey revealed the general dearth of teaching/learning materials. Even the available ones were obsolete and grossly inadequate. The baseline survey, therefore, empirically established the need for capacity training of teachers in Mathematics and Basic Science at the primary school level in Nigeria. Hence, the SMASE programme was introduced (UBEC, 2021).

The SMASE training is divided into three (3) cycles of trainings. Each cycle is conducted within a year. The first cycle deals with enhancing positive attitude of teachers and learners towards the teaching and learning of Mathematics and Science. The second cycle deals with enhancing classroom/laboratory activities for the effective teaching and learning of Mathematics and Science. While the third cycle is concerned with the actualisation of ASEI (Activity, Student, Experiment & Improvisation) and PDSI(Plan, Do, See, & Improve) approach in the teaching and learning of Mathematics and Science. The ASEI aims at promoting effective learning through meaningful engagement of learners through experiments/demonstrations and improvising using locally available materials in the classroom/laboratory. The PDSI focuses on learner-centred preparation, presentation and improvement of lessons (FME, 2014).

In a nutshell, the objectives of SMASE programme were two folds. First is to change teachers' attitude positively to the teaching profession in general, and the teaching of mathematics and science in particular. Two is to improve the performance of teachers in subject mastery, pedagogical skills and resource utilization and pupils' participation in classroom activities.

The programme was meant to effect a shift from teacher-centred to pupil-centred teaching; theoretical to activity-based learning and to ensure negative to positive change in attitudes. It is a paradigm shift and not a new method of teaching (CEMASTEA, 2017). Hence, this paper evaluates the SMASE teacher teaching effectiveness and the moderating effect of teacher and pupil gender, and school location on the achievement of the SMASE training goals in Oyo state.

The evaluation was hinged on the Kirkpatrick evaluation model. The four-level model is widely recognized and used for a more precise measure of evaluating training programmes. Kirkpatrick's Model asserts that the effectiveness of training programmes can be evaluated by looking at the four separate levels:

ISSN: 2714-2965 (Print)
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Reaction, Learning, Behaviour and Results. The main question asked when using this kind of evaluation is: What impact did the training have on trainees in terms of their reactions, learning, behaviour and results?

Reaction deals with what the trainees think, how they feel and react to the training. Learning is concerned with trainees' increase in knowledge or intellectual capability during and after the training. It means the extent to which trainees change attitude, increase knowledge, and\or increase skill. Behaviour refers to the extent of behaviour and capability improvement and application. It implies the extent to which change in behaviour occurs. Behaviour checks if the trainees are utilizing what they learned at their workplaces. Lastly, results interpret attainments at appropriate stages of a programme. That is, it measures the effect of the training resulting from the improved performance of the trainees. This study predominantly looks at the effectiveness of the SMASE teachers in improving learning outcomes of their pupils in mathematics in Oyo State, Nigeria.

One of the critical teacher variables in achieving improved pupils' learning outcomes is teaching effectiveness (Ingvarson 2022; Kuecken&Volfort, 2013; Ungar, 2016). Teaching effectiveness, in turn, is moderated by teachers' attitudes towards the teaching profession (Varma, Williams & David, 2019). Literature is replete on gender effects on learner's academic achievement especially in mathematics and science subjects. It has been documented that teachers' classroom practices and gender have significant effects on instructional strategy employed in teaching science subjects and mathematics and students' achievement (Egbujuo, 2020), play a crucial role in educational attainment (Kuecken & Valfort, 2013). On the contrary, Okonkwo (2000) found that whether a teacher is male or female does not make a difference in teaching effectiveness and students' achievement. The studies examined here reveal that despite the fact that both male and female teachers execute the same Mathematics curriculum and teach under similar conditions, there are differences in the achievement of students taught by male and female teachers irrespective of the student's gender. This study examined whether gender of the SMASE teachers significantly moderated pupils' achievement in and attitudes towards primary mathematics.

In addition to SMASE teacher effectiveness and their gender, pupil gender and school location, were two other variables of interest in this study. Adigun, Irunokhai, Sada and Adesina (2015) discovered in their study that male students perform better in computer studies compared with the female students, though the difference was not too wide. Also, Ezeudu (2013) indicated that the male students achieve better than their female counterparts in chemistry. This implies that there is a significant difference in the mean achievement scores of students in chemistry in favour of the male students. With reference to school location, Awodun and Oyeniyi (2018) deduced that there was no statistically significant difference in the academic achievement mean scores of male and female students in the rural and urban areas, but Owoeye (2004) found a statistically significant difference in the achievement mean scores of students in urban and rural schools. Whereas Yinyinola (2008) concluded that location of school does not pose a barrier to achievement, the influence of learning environment on the academic achievement of learners was confirmed by Quadri (2012) who found that there was a significant difference in the Mathematics achievements of students in urban and rural schools.

Statement of the Problem

Poor achievements in Mathematics across all levels of education have been the bane of science and technological advancement in Nigeria. As a result, the Federal Ministry of Education and Japan International Cooperation Agency carried out a baseline study in 2005 to ascertain the status of Mathematics and Science in selected primary schools in Nigeria. The study linked the serious gaps identified in teaching and learning of Mathematics and Basic Science to poor pupil achievement in the two subjects. Hence, this study underscored the need to re-establish a strong retraining programme for teachers in Mathematics and Basic Science at the primary

ISSN: 2714-2965 (Print)
ISSN: 2714-3449 (Online)

school level. Therefore, the Strengthening Mathematics and Science Education intervention was initiated by the government to solve the consistent poor achievements in science and mathematics.

Although it is widely acknowledged that there are other factors contributing to the abysmally-poor achievement, the government chose to focus on the teacher who plays a key role in the curriculum implementation. Specifically, SMASE programme represents a paradigm shift from teacher-centred to pupil-centred, theoretical to activity-based learning and negative to positive change in attitudes. It is believed that pupils' achievements in mathematics and primary science will improve, and both the teacher and pupil attitudes towards mathematics will change positively if the programme were properly implemented. This study set out to substantiate this assumption.

Therefore, the study evaluates the effectiveness of the SMASE training on the primary school mathematics' teachers. It further investigates the moderating effects of the teacher and pupils' gender, and school location in improving pupils' achievement in and attitudes towards Mathematics in Oyo State, Nigeria.

Research Questions

This study was designed to answer the following research questions:

1. Is there any significant difference in the teaching effectiveness of SMASE trained teachers and non-SMASE trained teachers?
2. Did teacher and pupil gender significantly moderate the effect of SMASE training on pupils'
    a) Achievement in Mathematics, and
    b) Attitude towards Mathematics?
3. Did school location significantly moderate the effect of SMASE training on pupils'
    a) Achievement in Mathematics, and
    b) Attitude towards Mathematics?

Methodology

Design

The researchers employed the Causal-comparative design of *expo-facto* research type, since the research was to establish cause-effect links among the variables of interest (Gay & Airasian, 2000). In this situation, the researchers did not have control over the variables since they had already occurred; hence, the variables were not manipulated. Therefore, two groups: SMASE trained teachers and non-SMASE trained teachers were compared in the study.

Population

The target population comprised all primary five pupils and their mathematics teachers in the public primary schools in Oyo State.

Sampling Technique and Sample

The multistage sampling technique was used to select the sample for the study. Oyo State has three senatorial districts namely: Oyo North, Oyo Central and Oyo South; each comprises 13, 11 and 9 Local Government Areas (LGAs) respectively, making a total of 33 LGAs. Proportionate to size sampling was used to select 30% of the LGAs, roughly four LGAs from Oyo North, three from Oyo Central and three from Oyo South totalling ten LGAs. The ten LGAs were stratified into urban and rural on the basis of location. From the list of schools that participated in the SMASE training programme, one school each was purposively selected from urban and rural areas making twenty SMASE schools. Also, from the non-SMASE schools, simple random sampling technique was used to select 20 schools from urban and rural areas. From both SMASE and non-SMASE schools, simple random sampling technique was used to select 25 pupils each across the 40 schools totaling 1000 pupils. In all, 40 schools (20 SMASE and 20 non- SMASE schools), selected across the 10 LGAs, participated in the study. However, only 997 out of the 1000 pupils selected, fully completed the instruments represent the sample.

Instrumentation

Three instruments constructed by the researchers and used to generate data from the respondents were:

ISSN: 2714-2965 (Print)
ISSN: 2714-3449 (Online)

- Pupils' Mathematics Achievement Test (PMAT)
- Teachers' Socio-demographic scale (TSS).
- Pupils' Attitude towards Mathematics Learning Scale (PATMLS).

The PMAT consists of 50 items with four-point response options. Its content validity was established using experts to judge the adequacy and relevance to the content. Also, the reliability coefficient was established with KR20 formula, which yielded a value of 0.78. The test was dichotomously scored manually, each correct response attracted 1 mark, while a wrong option attracted zero. Data on the teacher gender and other socio-demographics such as age, level of education, teaching experience and classes taught were sourced from the TSS. For gender, male was assigned 1, while female was assigned 2. The PATMLS, with four options: Strongly Agree – 4, Agree – 3, Disagree – 2, Strongly Disagree – 1, was developed to measure pupils' attitude towards Mathematics learning. Content and face validity was established with expert judgment, while the reliability coefficient was 0.88 using Cronbach alpha.

Data Collection and Analysis

The instruments were administered to the sample with the help of trained field assistants after due permission was granted by the school heads. Data collected were analysed using *t*- test and two-way Analysis of Variance (ANOVA).

Results

1. Is there any significant difference in the teaching effectiveness of SMASE programme teachers and non-SMASE programme teachers?

Table 1. Comparison of SMASE and Non-SMASE Teachers' teaching effectiveness

Group	Mean	Std	Df	T	p-value
SMASE	73.15	12.93			
Non-SMASE	45.90	8.84	38	7.78	0.000*

*Significant at P<0.05

Table 1 displays the *t*-test analysis of the teaching effectiveness of teachers trained under the SMASE programme and those who did not undergo the training (non-SMASE teachers). It indicates that the teachers trained under the SMASE programme were more effective teaching mathematics than the non-SMASE teachers. Independent t-test statistic ($t_{(38)}$ =7.78; p<0.05) shows that the difference between the two groups is statistically significant. The mean score and standard deviation of the SMASE and non-SMASE teachers were 73.15± 12.93 and 45.9±8.843 respectively.

2. Did teacher and pupil gender significantly moderate the effect of SMASE programme on pupils'
   a) Achievement in Mathematics, and
   b) Attitude towards Mathematics?

Table 2(a): SMASE Pupils' Achievement in Mathematics moderated by Teacher's gender

Source	Type III sum of squares	Df	Mean square	F	Sig.
Corrected model	359.125a	3	119.71	3.33	0.019
Intercept	343662.7	1	343662.70	9564.59	0.000
Teacher gender	1.836	1	1.84	0.05	0.821
Group	317.93	1	317.93	8.85	0.003
Teacher gender * group	54.272	1	54.27	1.51	0.219(NS)
Error	35679.22	995	25.93		
Total	387982	997			
Correctional total	36038.35	996			

Significant at p<0.05, Not Significant

ISSN: 2714-2965 (Print)
ISSN: 2714-3449 (Online)

Table 2(a) highlights the summary of Analysis of Variance (ANOVA) of SMASE and non-SMASE pupils' achievement in Mathematics as moderated by teachers' gender. The table reveals that the moderating effect of teacher gender on SMASE and non-SMASE pupils' achievement in Mathematics is not significant ($f_{(1,995)} = 0.219$; $p > 0.05$). This means that the SMASE and non-SMASE pupils' achievement in Mathematics is not moderated by the teacher gender.

Source	Type III sum of squares	df	Mean square	F	Sig.
Corrected model	2546.654a	3	848.89	3.98	0.008
Intercept	5805846	1	5805846	27213.05	0.000
Group	733.005	1	733.01	3.44	0.064
Teachers' gender	1481.887	1	1481.89	6.95	0.009
Group*teacher gender	138.509	1	138.51	0.65	0.421(NS)
Error	211854.4	995	213.35		
Total	6133933	997			
Corrected total	214401.1	996			

Significant at P<0.05, NS = Not Significant

Also, Table 2(b) highlights the summary of Analysis of Variance (ANOVA) of SMASE and non-SMASE pupils' attitudes towards Mathematics as moderated by teacher gender. The table reveals that the moderating effect of teacher gender on SMASE and non-SMASE pupils' attitudes towards Mathematics is not significant ($f_{(1,995)} = 0.65$; $p > 0.05$). This means that SMASE and non-SMASE pupils' attitudes towards Mathematics is not moderated by the gender of their teachers.

Table 2(c):SMASE Pupils' Achievement in Mathematics Moderated by Pupil's Gender

Source	Type III sum of squares	Df	Means square	F	Sig.
Corrected model	779.488a	3	259.83	7.195	0.012
Intercept	298763.160	1	298763.16	8273.64	0.000
Group	768.042	1	768.04	21.27	0.021
Sex	0.018	1	0.02	0.00	0.341
GROUP* SEX	28.759	1	28.75	0.80	0.512(NS)
Error	29899.282	995	36.11		
Total	332248.000	997			
Corrected total	30678.769	996			

*Significant at P < 0.05, NS=Not Significant.

Table 2(c) shows SMASE and non-SMASE pupils' performance in Mathematics as moderated by their gender. The table reveals that the moderating effect of pupils' gender on SMASE and non-SMASE pupils' performance in Mathematics is not significant. This implies that pupils' performance in Mathematics is not moderated by the pupils' gender.

ISSN: 2714-2965 (Print)
ISSN: 2714-3449 (Online)
The African Journal of Behavioural and Scale Development Research
AJB-SDR Vol. 3, No 2, 2021

Table 2(d): SMASE Pupils' Attitude towards Mathematics Moderated by Pupils' Gender

Source	Type III sum of squares	Df	Means square	F	Sig.
Corrected model	1956.152a	3	652.05	3.85	0.009
Intercept	4998490.94	1	4998490.94	29509.57	0.000
Group	1913.880	1	1913.88	11.30	0.001
Sex	0.628	1	0.63	0.004	0.951
GROUP* SEX	2.085	1	2.09	0.012	0.912(NS)
Error	140251.126	995	169.39		
Total	5214865.000	997			
Corrected total	142207.218	996			

*Significant at P < 0.05, NS=Not Significant.

The SMASE and non-SMASE pupils' attitudes toward mathematics as moderated by their gender are highlighted on Table 2(d). The table illustrates that the moderating effect of pupils' gender on SMASE and non-SMASE pupils' attitude towards Mathematics is not significant. This means that SMASE and non-SMASE pupils' attitude towards Mathematics is not moderated by the pupils' gender.

Research question 3: Did school location significantly moderate the impact of SMASE programme on pupils'

a) Achievement in Mathematics, and
b) Attitude towards Mathematics?

Table 3(a): SMASE Pupils' Achievement in Mathematics Moderated by School Location

Source	Type III sum of squares	Df	Mean square	F	Sig.
Corrected model	2929.3620	3	976.45	30.65	0.000
Intercept	343376.8	1	343376.80	10778.28	0.000
Group	358.959	1	358.96	11.27	0.001
School location	2226.627	1	2226.63	69.89	0.000
Group*school location	329.267	1	329.27	10.34	0.001*
Error	30775.03	995	31.86		
Total	3764.66	997			
Correctional total	33704.4	996			

***Significant at p<0.05**

Table 3(a) shows the SMASE and non-SMASE pupils' achievement in Mathematics as moderated by school location. The table shows that the moderating effect of school location on SMASE and non-SMASE pupils' achievement in Mathematics is significant ($f_{(1,995)} = 10.34$; $p < 0.05$). This indicates that the SMASE and non-SMASE pupils' achievement in Mathematics is moderated by the location of their schools.

Table 3(b): SMASE Pupils' Attitudes towards Mathematics Moderated by School Location

Source	Type III sum of squares	Df	Mean square	F	Sig.
Corrected model	7947.672a	3	2649.22	14.30	0.000
Intercept	5803708	1	5803708	31334.20	0.000
Group	1169.253	1	1169.25	6.31	0.012
School location	5992.796	1	5992.79	32.36	0.000
Group*school location	783.006	1	783.01	4.23	0.040*
Error	178922.1	995	185.22		
Total	5988004	997			
Corrected model	186869.8	996			

*Significant at P<0.05

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ISSN: 2714-3449 (Online)

Table 3(b) highlights SMASE and Non-SMASE pupils' attitude towards Mathematics as moderated by school location. The table indicates that the moderating effect of school location on SMASE and non-SMASE pupils' attitude towards Mathematics is significant ($f_{(1,995)} = 32.36$; $p<0.05$). Similar to achievement, this result implies that the attitude of pupils, taught by SMASE trained teachers and those of non-SMASE teachers, is moderated by their school location.

Discussion

The overarching goal of SMASE was to upgrade the teaching skills of primary school teachers and to improve the learning skills of pupils in Mathematics and Science thereby improving their achievement and ensuring positive change in attitudes towards the school subjects. As revealed by this study, the SMASE-trained teachers were effective in improving the achievement of their pupils in mathematics. Implicitly, the ASEI (Activity, Student, Experiment, & Improvisation) and PDSI (Plan, Do, See & Improve) approach adopted (FME, 2014) in facilitating and cascading the training to teachers was effective to shift from teacher-centred to pupil-centred teaching. This way, teaching became more effective and learning more rewarding for the pupils. Therefore, improved pupils' achievement in mathematics could be attributed to effective training the teachers received. The finding supports those of Ungar (2016) and Varma, Williams, and David (2019) who linked teaching effectiveness to the professional development processes teachers go through. Teachers who undergo sound training are most likely to be equipped to improve the achievement of their learners as in the case of SMASE training programme and confirmed by this study.

However, the effect of SMASE on pupils' achievement in and attitudes towards mathematics was not significantly moderated by the gender of the trained SMASE teachers. The finding corroborates that of Onokomaya (2012) who found out that teacher's gender did not affect pupils' achievement in Mathematics. Likewise, pupils' gender did not significantly moderate the effect of SMASE teacher training on pupils' achievement in and attitudes towards mathematics. It is likely that the training received by the teachers under the SMASE programme might have masked the moderating effect of pupil gender. This finding contradicts that of Ezeudu (2013) who inferred that the male students achieved better than their female counterparts in chemistry. Also, the finding did not support that of Adigun et al. (2015) who revealed that the male students perform better compared with the female students in computer studies, implying that there was significant difference in the achievement of male and female students in both chemistry and computer studies. Conversely, the effect of SMASE training on pupils' achievement in and attitudes towards mathematics was significantly moderated by the location of the pupils' schools. With respect to school location, irrespective of whether the pupils were taught by the SMASE trained teachers or not, in this study, location of school significantly affected the result of the SMASE training on pupils' achievement in mathematics. This finding is in line with that of Owoeye (2004) and Yinyinola (2008) that indicated significant differences between the academic achievement of rural and urban secondary school students.

Conclusion and Recommendations

The teacher training conducted under the SMASE programme was effective in satisfying its goals. In summary, gender of the teachers trained under the programme as well as the pupils' gender did not moderate the SMASE training to affect pupils' achievement in primary mathematics. However, school location did moderate the effect of the training on pupils' achievement. From the findings, pupils' schooling in the urban areas performed better than those in the rural areas. Therefore, it is recommended that there should be continuity in training and re-training programmes for Mathematics teachers in primary schools. It will provide a basis for teachers' professional improvement in Mathematical knowledge and eventually lead to improvement on the achievement of their pupils. Furthermore, school environment should be made conducive to learning, whether the school is located in the urban or rural areas. To achieve this, stakeholders (government, community leaders, parents and teachers) need to work as a team to

ISSN: 2714-2965 (Print)
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narrow the gaps between urban and rural schools in terms of provision of amenities and distribution of teaching force.

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