An Investigation into Mathematics Teachers' Roles in Stem Education Teaching Approaches

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Abstract- ***The success of any nation in this 21st century continues to depend on ideas and skills. Increasingly, the influence of technology and the availability of information always shape ideas and skills, resting in large part on how well we address science, technology, engineering, and mathematics (STEM) in education system. STEM education is widely promoted by governments around the world as a way of boosting students' interest and achievement in science, technology, engineering, and mathematics and preparing STEM-qualified workers for twenty-first century careers. However, the role of mathematics in STEM education often appears to be of paramount one. This study looks into mathematics teachers' roles in STEM education teaching approaches. This study was conducted in Lagos State Educational District III of Lagos Nigeria. 120 secondary schools mathematics' teachers were the subjects of the study. Questionnaire was used to get information from the subjects. Four hypotheses guided the study and t- test statistics was used to test the hypotheses. The result shows that mathematics teachers were not using STEM integrated teaching approach to impact knowledge to students and only few of the teachers used STEM embedded approach. Recommendation was made for future improvement.***

Indexed Terms- ***Interest and achievement, mathematics teachers' roles, teaching approach, STEM Education***

I. INTRODUCTION

The acronym for science, technology, engineering and mathematics is STEM, this term was coined by Judith Ramaley of the American National Science Foundation. Initially, STEM was more or less a short hand for the four subjects in the acronym, but in recent years, the definition has changed beyond being an acronym. STEM presently describes a 'meta discipline' which is a creation of other disciplinary knowledge into a new 'whole', achieved by bridging the gaps in the subjects' boundaries. STEM has different definitions from many educators and researchers within and outside of its area. The difference in the definitions comes as a result that many do not share same view in the unified understanding and interdisciplinary of STEM (Brown, Brown, Rearden & Merrill, 2011, Breiner, Harkness, Johnson & Koehler,2012,).

Governments promote STEM education as a means of addressing social and economic challenges and creating a scientifically, mathematically, and technologically literate citizenry. In developed countries, policies and reports by governments and business groups aim to incorporate STEM into the schools' curriculum encourage youths to engage in STEM education, and advocate for STEM careers (Department of Education and Skills, Ireland, 2017; Education Bureau of Government of HKSAR, 2016; European Schoolnet, 2017).

STEM has been the main emphasis of government policy development and education research for more than a decade in some developed countries (Maass, Geiger, Ariza & Goos, 2019). The general inclination to adaptively, critically, and creatively use science, technology, engineering, and mathematics skills when encountered with real-world problems is central to productive participation in personal and civic life as well as in the field of work (Kayan-Fadlelmula, Sellami, Abdelkader & Umer, 2022, Oritiz-Revilla, Aduriz-Bravo & Greca, 2020, Maass & Engeln, 2019). This joint integrated consideration is of good sense and essential against the background of a critical and reflective participation, which is made of rapid technological, industrial, and social change.

Teaching mathematics well is an important part of a comprehensive STEM program. Mathematics that students learn in school includes content and thinking that can be used as instrument for tackling integrative STEM problems. But mathematics also includes content that might be considered "just any-how" or might be connected to non-STEM disciplines. Problems involving mathematical models of finance might or might not connect to science (S) or engineering (E) and might or might not involve in-depth uses of technology (T). Also, art might be integrated into a mathematics lesson that does not involve either science or engineering. Mathematics always goes beyond serving as a tool for science, engineering, and technology to develop content unique to mathematics and apply content in relevant applications outside of STEM fields.

There are many advantages in support of the teaching and learning of mathematics through connecting and integrating science, technology, and engineering with mathematics, both in mathematics classes and in STEM activities. For example, engineering design offers an approach that nurtures and supports students' development of their problem-solving skills, which is a top priority for mathematics teachers. The design process both reinforces and extends how students think about problems and offers instruments that can help students creatively expand their thinking about solving problems of all types, these types of problems and issues are the ones that students are likely to encounter in both their personal and professional lives.

However, for some years ago, educational research has discussed STEM primarily from the perspective of science, while mathematics generally has played a superficial role in classroom activities (English, 2016). Hence, more attention should be paid to mathematics, the last letter in the term STEM, because mathematics works as a means of communication or language of all disciplines mentioned in the term. Also, the applications from science, technology, and engineering are usually based on (more or less complex) mathematical models. Identifying and sharing the essential mathematical characteristics enables users to interpret existing results and, if necessary, apply them to contexts that differ from those in which they were originally developed.

II. STATEMENT OF THE PROBLEM

Presently, there are three approaches of teaching in STEM education. These approaches are capable of meeting STEM content, supporting proper execution of STEM teaching and learning, and making STEM learning useful to face industrial revolution (Kelley and Knowles, 2016; Akiha et al., 2018; Erdmann, Miller & Stains, 2020). The STEM education teaching approaches are as follows:

a. The silo approach

Carr, Bennett & Strobel (2012) defines silo teaching approach as STEM educations approach in which STEM subjects are taught separately or are not integrated. The approach allows students to understand each subject's content separately (Erdogan & Stuessy, 2015). The silo approach emphasizes how STEM education should be in the design of school curricula (Jensen, Neeley, Hatch & Piorczynski, 2017). Harahap, Harahap & Harahap (2019) outlines the weaknesses associated with the silo approach as follows:

- it has a tendency of minimizing the benefits of STEM education due to the possibility of students' lack of interest in one of the areas
- without practice, students may fail to understand the natural integration between STEM education in the real world, hindering academic growth because, in this silo method, teachers only prioritize mastery of each STEM field content
- it only focus on mastering the content of a specific subject, which, leave students unaware of the relationships among each STEM field in applications to day-to- day activities.

b. The embedded approach

Embedded approach teaches each STEM discipline by focusing more on one or two of others (Bahrum, Wahid & Ibrahim, 2017). The embedded method is an educational approach in which knowledge is obtained through an emphasis on real-world situations and problem-solving techniques in cultural, social, and functional contexts (Dischino et al., 2011). This approach concentrates in one area of science or primary material by relating it to other embedded materials, but the other materials are not assessed or evaluated (Margot & Kettler, 2019). The disadvantage of this approach is that it can result in splitting students' learning into several pieces (Bahrum, Wahid & Ibrahim, 2017). If the case of a student is unable to associate embedded content with the main content, the student may risk only learning part of the lesson rather than benefiting from the whole (Karimah, Nasbey & Sasanti, 2022).

c. The integrated approach

Sanders (2008) defined integrated approach as a method that focuses on integrating different STEM fields and making them one subject. The approach is made of various cross-curricular contents such as critical thinking skills, problem-solving, and scientific information that can lead to a solution to a difficulty through the combination of materials taught in the classroom (Tanjung & Aminah- Nababan, 2019). Rossalia, Sutomo & Negoro (2019) stated that an integrated approach to STEM learning can be applied in schools and society by combining two, three, or all aspects of STEM. If just two aspects of STEM have been integrated in teaching, the method can be called integrated approach (Burke et al., 2020, Wang, Sun, Lee &Wagner, 2017). For instance, if mathematics is integrated with physics in learning, then such learning can already be considered STEM integrated approach (Akiha et al., 2018). Making students to see the interrelationships among all STEM subjects from a young age and allowing students to apply those linkages for solving challenges in the real world will require students to work more actively (Carlson et al., 2016). Hence, supporters of STEM education are increasingly enthusiastic about successfully supporting and continuing to develop the nature of interrelationships among all STEM subjects.

Presently, STEM education in Nigeria seems unpopular. Nbawuike (2018) lamented that STEM education was not taught in normal situation, he stressed further that instead of STEM education what we have in the country is S.T.E.M. educations which means each subject was taught in isolation to others. He found that there was no existing curriculum in STEM from primary to tertiary levels of education in Nigeria. With all of this information this paper looks if the situation of teaching STEM subjects in isolation has changed especially in Mathematics of STEM, and also if there is proper STEM training for Mathematics teachers in secondary schools.

III. RESEARCH HYPOTHESIS

This study would test the following hypotheses at significant level of 0.05:

H_{01}: There is no significant difference between the rates at which teachers teach mathematics of STEM using solo teaching approach and embedded teaching approach.

H_{02}: There is no significant difference between the rates at which teachers teach mathematics of STEM using solo teaching approach and integrated teaching approach.

H_{03}: There is no significant difference between the rates at which teachers teach mathematics of STEM using integrated teaching approach and embedded teaching approach.

H_{04}: There is no significant difference between the number of STEM and non-STEM education based training giving to mathematics teachers.

IV. METHODOLOGY

(i) Design, Population, Subjects and Instrument:

A survey research design of an ex-post factor type was used for this study. It was conducted in Lagos State Educational District III (which comprises Epe, Etiosa, Ibeju-Lekki, and Lagos Island Local Government Educational Areas). The population of the study was all mathematics teachers in the district, both public and private secondary schools. Eighty public secondary schools and forty private secondary schools were randomly sampled from the district. A mathematics teacher was used in each sampled school. So, total of one hundred and twenty mathematics teachers were used as subjects for the study. The main instrument of this study is STEM Teaching Methodology in Mathematics Questionnaire. The questionnaire is made of three sections: A, B and C. Section A is on informed concept, the respondent has to indicate his/her interest in participating in the study and not to reveal his/her identity. Section B is on background information of the respondent. Section C is on STEM teaching methods, training and curriculum with respect to teaching mathematics at secondary schools.

(ii) Procedure

The instrument was sent to the participants by online; the respondents filled it and returned it through the same source. The instrument was validated by some experts in educational management and mathematics education departments of a public university in Nigeria. Also to ensure that the instrument is reliable, a pilot study was conducted with 25 senior secondary schools mathematics teachers selected from public schools apart from the sampled schools in the population. A test-retest correlation coefficient of 0.8774 was obtained, which indicates that the instrument is reliable. Questionnaires filled were analyzed; the data obtained were used to test the null hypotheses.

V. RESULTS

Data from the Section C of the questionnaire were collected to test the three null hypotheses. Respondent rated the usages of each of the teaching approaches on the scale of 0 to 10, such that total rating for the three approaches should not greater than 10. T – test statistics was used for the analysis of the data; the results are in the table 1 - 3 below.

Teaching Approach	N	Mean S. S	S. E	T. cal.	P. value	Remark
Solo	120	7.31	177.59	1.49	29.27294	Significant*
Embedded	120	2.69	177.59			

* Significant at P < 0.05

Table 1: T-test analysis on solo and embedded mathematics teaching methods of STEM Education.

The table 1above shows that the P value is 0.00001 which is less than 0.05, which implies that the result is significant. Hence, the first null hypothesis is rejected, and alternative hypothesis accepted. So, there is significant difference between the rate of using solo teaching approach and embedded teaching approach by mathematics teachers in STEM education. Solo approach has the mean of 7.31 which is better than the embedded that has mean of 2.69.

Teaching Approach	N	Mean	S. S	S. E	T. cal.	P. value	Remark
Solo	120	7.31	177.59	0.75	65.53468	.00001	Significant*
Embedded	120	0.00	0.00				

* Significant at P < 0.05

Table 2: T-test analysis on solo and integrated mathematics teaching methods of STEM Education.

The table 2 above shows that the P value is 0.00001 which is less than 0.05, this implies that the result is significant. Hence, the second null hypothesis is rejected, and alternative hypothesis accepted. So, there is significant difference between the rate of using solo teaching approach and integrated teaching approach by mathematics teachers in STEM education. Solo approach has the mean of 7.31 while integrated approach has 0.00; none of the respondents used the integrated approach to teach Mathematics in STEM.

Teaching Approach	N	Mean	S. S	S. E	T. cal.	P. value	Remark
Embedded	120	2.69	177.59	0.745	24.1403	.00001	Significant*
Integrated	120	0.	0.00				

* Significant at P < 0.05

Table 3: T-test analysis on embedded and integrated mathematics teaching approaches of STEM Education.

The table 3above shows that the P value is 0.00001 which is less than 0.05, hence that the result is significant. Therefore, the third null hypothesis is rejected, and alternative hypothesis accepted. So, there is significant difference between the rate of using embedded teaching approach and integrated teaching approach by mathematics teachers in STEM education. Embedded approach has the mean of 2.69 which is better than the integrated that has mean of 0.00; none of the respondents used the integrated approach to teach Mathematics in STEM.

The forth null hypothesis was tested with the information which respondents gave about their in-house training, seminar, workshop and conference. Respondents stated the number of training that is of STEM education and the ones that were not of STEM education that they had for the last five years. The result is in the table 4 below.

Teaching Approach	N	Mean	S. S	S. E	T. cal.	P. value	Remark
STEM Education	120	1.79	119.79	0.981	0.13065	.896162	Not Significant**
Non-STEM Education	120	1.81	112.59				

**Not Significant at P < 0.05

Table 4: T-test analysis on training that were STEM education and non- STEM education.

Table 4 shows that the P value is 0.896162 which is greater than 0.05, this implies that the result is not significant. Hence, the fourth null hypothesis is accepted. So, there is no significant difference between the number of STEM and non-STEM education based training giving to mathematics The numbers of STEM education based and non-STEM education based trainings, workshops, seminar, and conferences for mathematics teacher are almost the same.

VI. DISCUSSION

The first hypothesis was rejected; the alternative hypothesis that there is significant difference between the rates at which teachers teach mathematics of STEM using solo teaching approach and embedded teaching approach was accepted. This is in line with Maass, Geiger, Ariza & Goos (2019), & Margot and Kettler (2019) that STEM education is in embryo stage which needs to be tamed for some times, and STEM education research is still in a rudimentary state which is lacking a scientific evidence based that can inform the development of theory, policy and practice . The analysis of the second and third null hypotheses found that the integrated teaching approach of STEM does not exist in mathematics class. This finding support Nbawuike (2018) and Bahrun, Wahid & Ibrahim (2019) that STEM education was not taught in normal situation in underdeveloped countries. The fourth null hypothesis that was accepted indicates that STEM training was encouraged among the mathematics teachers; this is in line with Kelley & Knowles (2016), Erdmann, Miller & Stains (2020) and Margot & Kettler (2019) that STEM education has spread all over the world, making no country to lack behind.

VII. SUMMARY OF THE FINDINGS

1. Majority of mathematics teachers were still using the conventional method (which is solo teaching approach) in STEM education.
2. Few of mathematics teachers were using embedded teaching approach in STEM education.
3. No mathematics teacher so far in the study used integrated approach in mathematics.
4. Trainings, conferences, workshops, and seminars that were STEM education based and those that were non-STEM education attended by mathematics teachers were almost the same.

VIII. RECOMMENDATION

1. Policy makers and government should look into STEM curriculum in Nigerian schools especially

in its integrative form, both in primary, and secondary schools, such that mathematics teachers can teach STEM in all three approaches.

2. STEM education in Nigerian primary and secondary schools does not yet incorporate engineering. Only science, basic technology and mathematics are taught there. So, policy makers and government should try to incorporate engineering at primary and secondary schools level.
3. There are no teachers qualified as 'STEM teachers' in Nigeria for now and no University is training STEM teachers. Our universities should look into creating STEM education department/unit and start training prospectus teachers for STEM education.
4. The government and educational authorities should look into STEM instructional materials as part of curricula reforms that addresses the current economic crises in the country. This curriculum needs to integrate innovation and entrepreneurship education into the STEM program and its mission should be to raise young generation of people with STEM skills that will be the future innovators and entrepreneurs of tomorrow.
5. For an effective STEM education, there is need for increased funding. Nigeria government should see to it that sufficient fund required training teachers to use the right strategies that get more students interested in STEM and the provision of instructional gadgets, computer systems and textbooks are provided. The Government should also seek partnership with private sectors as the government cannot do it all alone.

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