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Effect of Stem Education on Mathematics Performance among Secondary School Students in Tai Local Government Area, Rivers State

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ABSTRACT

This study investigated effect of inclusive-STEM education on Mathematics performance among junior secondary school students in Tai Local Government Area of Rivers State. A quasi-experimental design was adopted. Three research questions and three hypotheses guided the study. Two groups were used for the study. Group A was experimental group while group B was control group. The population of the study was 3,000 junior secondary school students. The sample size was 230 students in their intact classes from three schools. Pre-test and post-test that is made up of number base system, simple equation, construction and Angles were used in generating data. A structured instrument tagged "Mathematics Performance Test" was used for data collection. The instrument was validated by three experts in Mathematics Department and Measurement and Evaluation. The reliability of the instrument was established through test retest in which the initial and the retest scores were correlated using Pearson's Product Moment Correlation Statistics, which yielded a reliability coefficient of 0.82. The data obtained was analyzed using mean and standard deviation for the research questions while, ANCOVA was used for test of null hypotheses at 0.05 level of significant. The study revealed that students in STEM education performed better than students in Non-STEM education, hence STEM education improves student's creativity, empowers critical thinking skills and cognitive skills. Base on the findings the following recommendations were made: STEM education should be incorporated in the teaching and learning in secondary schools as it enhances academic performance of students. New technologies and innovations should be encouraged in secondary schools so as to meet up today's educational demands. STEM education should also start early enough, thus; from the cradle.

Keywords: STEM Education, Mathematics, Academic performance

In the 21st century, it has become significant for every country to raise individuals who are scientifically literate, who can keep up with the changing information and technology, who will respond to the needs of the education and business world with a high-level of cognitive skills. Along with the rapid development of information and communication technologies, 21st century skills have become different from 20th century skills. Therefore, the change in expectations of individuals in 21st century has required taking necessary measures in parallel with this change in educational goals. In the necessity of increasing the quality standards of education, students are required to have the skills to solve their daily problems and contribute to the needs of society (Kennedy & Odell, 2020).

Therefore, factor that enables the economic development and progress in a country is innovation in technology, hence it is imperative to train the next generation as science and technology literate and to make engineering common base for creativity and development of such a nation (Crawford, 2019). STEM education becomes an important vehicle for training students for economic advancement and growth. STEM which stand for (Science, Technology, Engineering and Mathematics) education becomes one of the ways of transforming theoretical knowledge into technology for skills and problem solving (Zan et al., 2016).

STEM education is essential as it contributes to thecritical thinking, creativity, cooperation, motivation, meta-cognitive skills, advancement and development of science and technology as well as its sustainability. This has also become a major emphasis in global initiatives seeking to enhance economic prosperity via a highly-educated workforce (Blanton et al., 2019).

STEM education is considered as a precious way to make the education system keep up with the developments and to meet the expectations. Countries are making reforms to their education policies in order to raise individuals who can prepare themselves for this rapid development and changing process. Some of these skills are taking responsibility, being innovative, having communication skills, taking risks, having a critical point of view, science and technology literacy, creativity, etc. (Gut 2016).

Furthermore, the age we are in expects individuals to be able to produce and solve problems. STEM education has emerged on the education scene as it brings these competencies and approaches towards problem solving (Van Langen & Dekkers, 2015). It is aimed at bringing these skills to the individual by focusing on literacy skills such as creative thinking, critical thinking, problem-solving, and collaborative work. Equipping individuals with such skills

that contributes to human development and promotes innovation, helping nations to grow and compete in the global knowledge economy (Jordan et al., 2019)

Nevertheless, STEM is an acronym commonly used to describe education or professional practice in the areas of science, technology, engineering, and mathematics. An authentic STEM education is expected to build students' conceptual knowledge of the inter-related nature of science and mathematics, in order to allow students to develop their understanding of engineering and technology (Hernandez et al., 2019). In schools today, STEM education is heavily focused on science and mathematics, and generally ignores the critical role of engineering and technology in preparing students to participate in an increasingly digital world (English, 2015).

STEM Task Force Report (2014) recognized that interdisciplinary approaches to STEM integration, whereby the knowledge and skills learned in two or more STEM disciplines are applied to real-world problems or used to deepen understanding, represent the ideal approaches in classroom for effective problem solving. Grootenboer and Hemmings (2017) also contributed that STEM is an educational approach based on the idea of educating students in science, technology, engineering, and mathematics with an interdisciplinary approach. STEM provides interdisciplinary interaction by emphasizing activity-based learning. Its aim is to raise individuals with high self-confidence and strong communication skills, think creatively, solve problems and understand mechanisms for difficulty problems.

Global initiatives to improve the quality of school mathematics have been a dominant focus in education, with many of these initiatives designed to elevate the competitive status of countries in the international arena, via improved levels of student achievement (Machin et al., 2017). Mathematical literacy could be seen as the capacity to identify, understand, and engage in mathematics; and the ability to make informed judgments about the role that mathematics plays in everyday life to act as a reflective citizen (Organisation for Economic Cooperation and Development, 2016). It is hard to imagine any aspect of daily life that is not touched by numerical ideas such as telephone numbers, currency, time, shopping, buying and selling, etc. The importance of mathematics in everyday life cannot be over-emphasized. It is the language and tool that is used in almost all fields of science. (Usman, 2010).

Prince (2019) supported that Indian laid the foundation of her technological development by giving her citizens quality science education with mathematics as its basis in the 1960s. Harbor-Peter (2010) also supported this fact when he said there can be no real technological development without mathematics.

Improving the quality of classroom mathematics instruction by changing teachers' pedagogical practices, to more active and collaborative practices develop students' problem-solving and mental abilities, is deemed necessary to help facilitate the shift to a more mathematically literate society (Murcia, 2016).The importance of developing STEM literacy is critical to ensure students leave school with the necessary knowledge, skills and attitudes to engage in an increasingly technological world. However, this requirement cannot be achieved unless students chose to remain in the STEM pipeline during their school education. (English & King, 2018). Importantly, for STEM pedagogical practices to be effective, it is critical that teaching approaches are altered from traditional, teacher-centred pedagogies to active, student-centred pedagogies to support student learning (Leuchter et al, 2017).

Besides, Vasquez et al.(2013) acknowledged that STEM education improves students' rational, creative, and inquisitive thinking skills and enables them to use their knowledge and skills more effectively. He added that it ought to start from the kindergarten, improves students' creative thinking skills, helping them to come out with new ideas and products, stimulates their curiosity, and increases their interest in science and technology. The student can direct his/her imagination in line with the knowledge he/she has acquired as well as obtain the ability to solve problems with his/her creative skills.

Marginson et al. (2019) also stated that students who were grown up with STEM education can easily overcome the difficulties they encounter in order to achieve their dreams. Hefty (2020) describe it as student-centered and collaborative learning beyond the contexts of traditional method of learning. STEM education is an approach that eliminates the boundaries between disciplines by enabling students to understand the world as a whole rather than parts. In general, it involves economic, high-level thinking that brings together disciplines, leads to effective and qualified learning, takes existing knowledge, and puts it into daily life. He found a significant difference in STEM and Non-STEM education.

On the same train, Rask (2020) contributed that its aim is to enable individuals to look at problems from a different perspective between fields by gaining skills and knowledge with a authoritarian approach to education. Zimmermam, (2013) reported that its curriculum should grow beyond the four walls of the classroom by incorporating informal learning and continuously expanding learning methods. It should be based on combining formal and informal activities, such as mobile device use or museum visits, and improves learners' interest in learning and increase in participation.

Adullah et al (2014) noted that STEM education increases academic success and mathematics performance of students; while Daughterty (2016) also collaborated that STEM education improves academic performance of students in secondary schools. On the other hand, Denson et al (2015) revealed that STEM education is structuring of knowledge, skills, and thoughts by teachers and learners with the cooperation of more than one STEM field.

Doerschuk et al. (2016) concluded that STEM education lead to improvements in students' scientific process skills and help to develop positive attitudes towards mathematics. It positively affected students' academic success and motivation for mathematics classes; hence it improves creativity and increases team collaboration of students. He also revealed difference in the pretest and posttest scores of students taught with STEM and Non-STEM education.

Academic performance has been an issue of concern to students, teachers, parents, school administrators, and the society at large. Attempts have been made by researchers to figure out the challenges surrounding students' performance in mathematics. Therefore, academic performance could be seen as the level of proficiency and knowledge demonstrated by an individual after learning has taken place. It has to do with the use of mental effort and skill acquisition. It deals with the level of success made by the students in their academic pursuits and performance recorded in the school (Elliot et al., 2019). It also deals with the students' success in meeting a goal while in school. It could be high or low performance. It is high when a student is able to excel

in his academic activities and perform extra-ordinarily well, scoring high marks. It is conversely low when a child performs poorly in academic activities and consistently scores very low marks in examination. Anunaobi and Inko-tariah (2020) asserted that student's academic performance is the main focus in the overall educational performance. It is a veritable tool that can be used to determine and predict the standard of any educational system in Nigeria in terms of it efficiency and effectiveness. It portrays the quality of education offered in Nigeria. Therefore, STEM education is very important as improve academic performance of secondary school students in mathematics.

Statement of the problem

Despite the fact that STEM education contributes to thecritical thinking, creativity, cooperation, motivation, meta-cognitive skills, advancement and development of science and technology in the society today, it is still faced with some challenges. However, some parents do not encourage their wards to start up STEM education early enough, which made most students not being aware of such program, while some lack interest because of the approach used towards the STEM education in the country. Lack of infrastructural facilities and required technology in this area has also been a major problem setting such program backward. Again, STEM education has not been fully integrated in our school curriculum despite its necessities in equipping individuals with such skills that contributes to human development; promote innovation, helping nations to grow in the global knowledge economy. Therefore, it is imperative to examine effect of STEM education on junior secondary school student's academic performance in our schools today.

Purpose of the Study

1. To investigate the difference in pretest- post mean performance of students taught with STEM education and non-STEM education in junior secondary school in Tai Local Government Area.
2. To determine the difference in the mean performance of students taught with STEM and Non-STEM Education in junior secondary school in Tai Local Government Area
3. To examine the difference in the mean performance of male and female students taught with STEM and Non- STEM Education in junior secondary school in Tai Local Government Area.

Research Questions

1. What is pretest- post mean performance of students taught with STEM education and non-STEM in junior secondary school in Tai Local Government Area?
2. What is the mean performance of students taught with STEM and Non-STEM Education in junior secondary school in Tai Local Government Area?
3. What is the mean performance of male and female students taught with STEM and Non- STEM Education in junior secondary school in Tai Local Government Area?

Research Hypotheses

1. There is no significant difference in pretest- posttest mean performance of students taught with STEM and Non-STEM education in junior secondary school in Tai Local Government Area.
2. There is no significant difference in the mean performance of students taught with STEM and Non-STEM education in junior secondary school in Tai Local Government Area.
3. There is no significant difference in the mean performance of male and female students taught with STEM and Non-STEM education in junior secondary school in Tai Local Government Area?

Method

In each school, two arms of a class were randomly selected as experimental and control groups; STEM Education and Non-STEM respectively. The study employed the quasi- experimental design, using students in their intact classes. The sample of this study consists of (230) JSS2 students. Three schools were drawn through simple random sampling technique by balloting in Tai Local Government Area of Rivers State for the study. Pre-test and post-test that is made up of number base system, simple equation, construction and Angles were used in generating data. The instruments for data collection consisted of structured questions tagged ''Mathematics Performance Test (MPT)" with 60 multiple choice questions for pre-test and post-test and four options (A, B, C, D) in which the students were requested to thick the correct option. In a period of 12 weeks that the study was concluded, in the experimental group, the researcher taught the students with STEM education. Pre-test scores were collected in the groups before commencement of teaching and post-test scores after teaching and treatment of experimental group. The instruments for data collection were validated by two experts, one in Mathematics and one in Measurement and Evaluation. The reliability of the instrument was established through test retest in which the initial and the

retest scores were correlated using Pearson's Product Moment Correlation Statistics, which yielded a reliability coefficient of 0.82. Mean and standard deviation were used to answer the research questions, while ANCOVA was used to test the null hypotheses at 0.05 level of significant.

Experimental procedure: The researcher used students in their intact class for experimental group and control group in the three schools. A pre-test was administered to the groups before the commencement of STEM education method. The scores obtained from the result were referred to as pre-test scores. The mathematics subject teachers assisted in order to make sure the arms are in order to carry out the experiment. In the experimental group (Arm A) the STEM education method was used as an intervention in the form of collaborative learning, critical thinking and creative learning skill.

In the control group (Arm B), Non-STEM education method was used. There was no form of intervention or treatment. The two groups were taught separately in their respective classes. The teaching exercise continued for twelve weeks. At conclusion of the experiment, all the students in the two groups weregiven a post-test, which yielded the post-test scores.

Results

Research Question One: What is the pretest- posttest mean performance of students taught with STEM education method and Non-STEM in junior secondary school in Tai Local Government Area?

Table 1: Mean and Standard Deviation of Pre-test and Post-test Scores of Students Taught with STEM education method and Non-STEM education.

Group	No	Pre-test		Post-test		Mean Difference
		Mean	Std	Mean	Std	
STEM education	120	20.51	5.18	54.84	8.34	34.33
Non-STEM education	110	20.53	5.10	31.69	6.45	11.16
Total	230					

Table 1 reveals that the mean scores and standard deviation at pre-test stage of students taught with STEM education method was (20.51; 5.18), while Non-STEM education was (20,53 ; 5.10). This indicates that there was equal performance of both groups at pretest stage. Meanwhile, at post-test stage the mean scores and standard deviation for students taught using STEM education method was (54.84; 8.34), while Non-STEM education (control group) was (31.69; 6.45) respectively. This shows a mean gain of (34.33 and 11.16) in the STEM education method and non-STEM respectively. It also shows that experimental group performed better than the control group at the posttest stage because of the intervention in the form of inclusive STEM education teaching method.

Research Question Two: What is the mean performance of students taught with inclusive STEM education teaching method and Non-STEM Education in junior secondary school in Tai Local Government Area?

Table 2: Mean and Standard Deviation of Students Taught with inclusive STEM and Non-STEM Education in Tai L.G.A

Group	Number	Mean	Standard deviation
STEM education	120	54.84	8.34
Non- STEM education	110	31.69	6.45
Total	230		

Table 2 reveals that mean and standard deviation for students taught with STEM education (experimental group) was (54.84 and 8.34), while the mean and standard deviation for the Non-STEM (control group) was (31.69 and 6.45). This therefore shows that STEM group performed more than the non-STEM group in the experiment.

Research Question Three: What is the mean performance of male and female students taught with STEM and Non-STEM Education in junior secondary school in Tai Local Government Area?

Table 3: Mean and Standard Deviation of Students Taught with STEM Blended Learning and those Taught using Discussion Method Based on Gender.

Group	Number	STEM Education		Non-STEM		Mean gain
		Mean	Std	Mean	Std	
Male	125	56.50	8.34	40.15	6.71	16.35
Female	115	39.24	7.60	30.24	6.58	9.00
Total	**230**					

Table 3 reveals that mean and standard deviation for female and male students in STEM education (experimental group) was (39.24; 7.60) and (56.50; 8.34) respectively, while performance of female and male students taught with STEM education (control control) was (30.24; 6.58) and (40.15; 6.71) respectively. Again, the male students gained a mean difference of (16.35), while the female students had a mean difference of (9.00). This therefore indicates that male students performed better than the female students, with a higher performance in the STEM education (experimental group).

Hypothesis One: There is no significant difference in pretest-posttest mean performance of students taught with STEM education and Non-STEM in junior secondary school in Tai Local Government Area.

Table 4: ANCOVA Results of Pretest-Posttest Performance of Students Taught with STEM Education and Non-STEM Education.

Source	Sum of Squares	Df	Mean Square	F-value	P-value	Decision
Corrected Model	26959.025[a]	2	13479.513	274.952	.000	**Significant**
Intercept	18197.192	1	18197.192	371.182	.000	
Pretest	162.900	1	162.900	3.323	.070	
Group	26804.233	1	26804.233	176.146	.000	
Error	9657.930	227	49.025			
Total	410989.000	230				

Table 4 of the ANCOVA results reveal F-value of 176.146 and P-value of 0.000< 0.05 (which is less than) the chosen level of significant between 1 and 227 degree of freedom. Therefore, the null hypothesis **is rejected**; hence the p-value< 0.05 level of significant. This indicates that there is significant difference in the pretest and posttest performance of students taught with STEM education and Non-STEM in junior secondary school in Tai Local Government Area.

Hypothesis Two: There is no significant difference in the mean performance of students taught with STEM and Non-STEM Education in junior secondary school in Tai Local Government Area.

Table 5: ANCOVA Results of Students Taught with STEM Education Learning and Non-STEM Education in Tai L.G.A

Source	Sum of Squares	Df	Mean Square	F-value	P-value	Decision
Corrected Model	10036.304	2	5018.152	71.158	.000	
Intercept	34230.204	1	34230.204	485.388	.000	
Pretest	73.697	1	73.697	1.045	.307	**Significant**
Groups	10017.101	1	10017.101	142.044	.001	
Error	42101.214	227	70.521			
Total	1168687.000	230				

Table 5 of the ANCOVA results reveal that F-value of 142.044 and P-value of 0.001< 0.05 (which is less than) the chosen level of significant between 1 and 227 degree of freedom was gotten. Therefore, the null hypothesis **is rejected**; hence the p-value< 0.05 level of significant. This suggests that there

is significant difference in the mean performance of students taught with STEM and Non-STEM Education in junior secondary school in Tai Local Government Area.

Hypothesis Three: There is no significant difference in the mean performance of students taught with STEM and Non-STEM Education in junior secondary school in Tai Local Government Area.

Table 6: ANCOVA Results of Students Taught with STEM and Non-STEM Education Based on Gender.

Source	Sum of Squares	Df	Mean Square	F-value	P-value	Decision
Corrected Model	3939.186	2	1969.593	11.874	.000	
Intercept	17177.385	1	17177.385	103.555	.000	**Significant**
Pretest	199.490	1	199.490	1.203	.274	
Gender	3784.394	1	3784.394	122.814	.003	
Error	32677.769	227	165.877			
Total	410989.000	200				

Table 6 of the ANCOVA results reveal F-value of 122.814 and P-value of 0.003< 0.05 (which is less than) the chosen level of significant between 1 and 227 degree of freedom was gotten. Therefore, the null hypothesis **is rejected**; hence the p-value< 0.05 level of significant. This implies that there is significant difference in the performance of students taught with STEM and Non-STEM Education in junior secondary school in Tai Local Government Area.

Discussion of Findings

The study is in agreement with the studies of Vasquez et al. (2019) who found significant difference in the performance of students in the pretest -posttest of experiment and control group. They also supported that, it is a learning that emphasizes the central role of science, technology, Engineering and Mathematics. It empowers critical thinking skills and improves cognitive skills. Consequently, that is why there is a significant difference in the pretest-posttest performance of STEM and Non-STEM teaching and learning. Doerschuk et (2016) also supported that there is significant difference in the pretest- posttest of students in the STEM and Non-STEM groups. He added that STEM positively affected students' academic success and motivation for mathematics classes; hence it improves creativity and increases team collaboration of students.

They study is also in accordance with the studies of Hefty(2020) who found significant difference in STEM and Non-STEM education. They acknowledged that STEM education improves students' rational, creative and inquisitive thinking skills, and enables them to use their knowledge and skills more effectively, thereby enhancing their mathematics ability. This made the students in STEM group performed effectively than their counterparts in Non-STEM group at posttest stage. Abullah (2014) also found significant difference between students in the STEM group and Non-STEM group. He added that STEM education lead to improvements in students' scientific process skills, problem solving and help to develop positive attitudes towards mathematics.

The study is also in harmony with the studies of Anunaobi and Inko-Tariah (2020) who found significant difference in performance of male and female students in the experimental and control groups of their own studies. They noted that the girls develop better verbal skills than boys, while boys are better in mathematical skills. This according to them is because social forces directing a child's experiences and activities lead to the differences in the neurological sophistication of boys and girls. Sweeney (2013) also supported that female students are lower in mathematics and spatial ability but good at reading, and oral communications as male are superior to female on mathematics problem solving. Similarly, this is probably because male students showed more concentration and individual interest in learning which yielded greater effect in their mathematics performance of students.

Conclusion

STEM education has the vital importance to be applied in order to raise individuals having skills and problem solving ability. With the advancement of science and technology, it is expected to raise individuals with skills of creativity, critical reasoning, abstract thinking, cooperative team work and problem solving. STEM education paves the way for being creative, productive, thinking critically, and analytically in the field of science, technology, engineering, and mathematics. Therefore, this study concluded that there is significant difference in the performance of the students in STEM and Non-STEM groups in the experiment. Hence, it improves student's creativity, team collaboration, develops communication skills, empowers critical thinking skills and improves cognitive skills.

Recommendation

1. STEM education should be incorporated in the teaching and learning in secondary school as it enhances academic performance students.
2. Equal opportunity should be given to both male and female students to participate in STEM education.
3. STEM education should also start early enough, thus; from the cradle.

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