DETERMINANTS FOR EFFECTIVE INSTRUCTIONAL MATERIALS AND FACILITIES FOR TEACHING STEM SUBJECTS IN BAUCHI STATE SECONDARY SCHOOLS, NIGERIA

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Abstract

The main purpose of the study was to determine the Effective Instructional Materials and Facilities for Teaching Integrated Science, Technology, Engineering and Mathematics (ISTEM) Subjects in Bauchi State Secondary Schools. The study was guided by two objectives and two research questions. The study adopted Cross-Sectional Survey as the research design. Which was carried out in Bauchi State. The population of the study was 102,302, which comprised 100,785 students, 1,327 teachers and 190 principals of public senior secondary schools that are offering STEM subjects in Bauchi state. Cluster sampling technique was used to draw the sample for this study. Structured questionnaire was used in data collection for the study. Three experts validated the instrument; Cronbach Alpha coefficient formula was used in determining the internal consistency of the instrument, which gave a coefficient value of 0.85, which indicated that it is reliable. The data collected was analyzed using mean and standard deviation with the help of Statistical Package for Social Science (SPSS) software, version 21. The result reveals that, there is a need for special instructional materials for teaching ISTEM, also there is the need for special instructional facilities for delivering ISTEM in the secondary schools in Bauchi State. It is recommended that teachers should be trained through workshops and seminars on ISTEM's appropriate instructional methodologies and usage of appropriate instructional facilities and materials for efficient lesson delivery. Government should provide ISTEM instructional facilities and materials for delivering and caution teachers for better handling.

Keywords: Instructional Materials, Instructional Facilities, Instructional methodology.

Introduction

Our lives dwell on the importance of outcomes of Science, Technology, Engineering and Mathematics (STEM) education when looking through the corner of global progress. Howard-Brown and Martinez (2012) stated that the term STEM was coined at the National Science Foundation (NSF, USA) as a way to incorporate a new "meta-discipline" that combined science, technology, engineering, and mathematics subject areas. This new discipline was meant to transform traditional classrooms from teacher-centered instruction into inquiry-based, problem solving, discovery zones where children engage with content to find solutions to problems. Moreover, when integrating the four STEM disciplines i.e. Science, Technology, Engineering, and Mathematics into one cohesive teaching and learning paradigm, the traditional barriers in-between them will be removed. STEM is referred to as interdisciplinary approach to learning as stated by Tsupros, Kohler, and Hallinen (2009), where rigorous academic concepts are coupled with real-world lessons with a view to ensuring that students apply science, technology, engineering, and mathematics in contexts that make connections among school, community, work and the global enterprise maximally harnessed to enable the curriculum development and STEM literacy and with it the ability to compete in the new economy.

A curriculum that is STEM based has real-life situations to help the students learn. Programs like Engineering for Kids in the US and other developed countries integrate multiple classes to provide opportunities to see how concepts relate to life in order to hopefully spark a passion for a future career in a STEM field. STEM activities provide hands-on and minds-on lessons for the student. Making mathematics and science both fun and interesting helps the students to do much more than just learn.

With the introduction of STEM education in the United states in 2003, the series of STEM concept's misunderstanding arouse from different perspectives which gave birth to Integrative STEM Education (I-STEM) as purported by (Sanders, 2009). The misconceptions, which are because of the acronym's ambiguities. The T and E in STEM were proudly claimed by the Technology educators overlooking that STEM without education is a reference to the fields in which scientists, engineers, and mathematicians toil. Science, mathematics, and technology teachers are STEM educators working in STEM education. Integrating STEM subjects can be engaging for students, and can promote problem-solving and critical thinking skills as well as helping to build real world connections.

The worn out of the term STEM education gave rise to the "Integrative Science, Technology, Engineering and Mathematics (ISTEM) education. I-STEM according to (Sanders, 2012) is considered as: Technological or engineering design-based learning approaches that intentionally integrate the concepts and practices of science and or mathematics education with the concepts and practices of technology and engineering education. Also, According Yakman (2008), Integrative STEM education may be enhanced through further integration with other school subjects, such as language arts, social studies, art, etc. when the art is included, the acronym then becomes STEAM or I-STEAM as the case may be.

However, STEM has long been an area of some confusion for some educators. While they can see many of the conceptual links between the various domains of knowledge, they often struggle to meaningfully integrate and simultaneously teach the content and methodologies of each of these areas in a unified and effective way for their students (Council, 2012; Thomasian, 2011). According to (Sanders, 2009) less attention has been paid to the infrastructure and pedagogy of conventional STEM education. Ugo and Akpoghol (2016), further stated, "It is worrisome to note that in Nigeria, STEM has not been embraced as expected. It is a thing to worry about if a nation is lagging behind in this area as it concerns teaching and learning of these subjects".

In Nigeria, STEM education faces hindrances of the conceptual awareness, adoption and implantation, that is why Ugo and Akpoghol (2016) attributed the problem to the inability of teachers to use necessary approaches in teaching STEM subjects, they also posited that, the teaching and learning of STEM subjects is too teacher-centered where the teacher dominates the explanation of concepts, thereby making students passive. The studies also observed that the chalkboard becomes the center for students' instructions as teachers mainly give directions or topics for them to copy, Innovative teaching strategies are rarely done by teachers where students' ideas in planning their choice of experiments are always ignored, or they are less encouraged to perform experiments on their own.

Students lose interest in science and mathematics at an early age, and thus make an early exit from the so-called "STEM pipeline." Conventional approaches to science and mathematics education have, in fact, prepared some students to be as capable in science and mathematics as any in the world. Nevertheless, at the same time, there is widespread concern regarding the large percentage of students who opt out of "rigorous" science and mathematics middle and high school courses, and for the many students who graduate from high school with relatively low science and/or mathematics ability. Also, contrary to the above-mentioned challenges, ISTEM achievements have been recorded by students in other countries as claimed by other scholars, Okpala (2016).

The teaching and learning of Science, Technology, Engineering and Mathematics subjects in Nigeria is mainly through the traditional approach rather than the science process skill or engineering design process approaches. Based on the aforementioned, there is a need to explore the possibility for adopting the Integrated Science, Technology, Engineering and Mathematics (I-STEM) Instructional Methodology in Nigeria. This can be done through Need Analysis or Needs Assessment, being it a systematic approach to studying the state of knowledge, ability, interest, or attitude of a defined audience or group involving a particular issue of education McCawley (2009).

The instructional Methodologies for STEM subjects in Nigerian schools today is bedeviled with a lot of problems ranging from lack of appropriate delivery methods, large class size, deficient curriculum, poor teacher supply, poor teacher quality, overloaded syllabus, inadequate incentives, poor work environment among others. Moreover, Ugo and Akpoghol (2016) pointed out that students poor performance in STEM subjects in Nigeria is due to teachers' inability to use appropriate instructional materials in teaching STEM subjects which is supported by Okonkwo (2009)

that most ISTEM teachers teach their subjects without proper methodology and teaching aids which makes the lesson not easy to understand by the students.

Objectives of the Study

1. Determine the instructional materials required for delivering, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in the secondary schools in Bauchi State.

2. Assess the instructional facilities needed for delivering, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in the secondary schools in Bauchi State.

Research Questions

1. What are the instructional materials required for delivering, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in the secondary schools in Bauchi State?

2. What instructional facilities needed for delivering, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in the secondary schools in Bauchi State?

Methodology

The study employed a Cross-Sectional type of survey research design. The area of the study was Bauchi State the state consists of twenty (20) local governments with the total number of all secondary schools in all the local governments is 190. The total the population is 102,302, which is comprised of all students, teachers and principals of all public senior secondary school that are offering Integrated Science, Technology, Engineering and Mathematics and related subjects in Bauchi state. Cluster sampling technique was used to draw 384 samples for this study. The instrument used for the study was questionnaire, developed by the researcher based on the review of related literature. To ensure the validity of the instrument, three experts validated the questionnaire. The reliability of the instrument was established using Cronbach Alpha coefficient formula to determine the internal consistency of the instrument using SPSS version 21 software. An average reliability coefficient of 0.85 alpha value was obtained which indicates that the instrument was highly reliable since the value was above 0.70 and the closer the reliability value to 1, the greater the item consistency of the rating scale and vice-versa Enemali (2010).

Data collected from the retrieved questionnaires was analyzed using mean and standard deviation with the help of Statistical Package for Social Science (SPSS) software, version 21. The mean and the standard deviation were used in answering research questions 1, 2, 3, & 4. The response modes was assign numerical value as follows: Strongly Agree - 5 points, Agree - 4 points, Undecided - 3 points, Disagree - 2 points and Strongly Disagree- 1 point. For answering the research questions in this study, a decision rule was taken that, any item with a mean response of 3.50 and above was considered as agreed while those below 3.50 were regarded as not agreed-. This is because 3.50 is the beginning of lower limit average of the sum of the five response values and the lower true limit of agreed as shown in Table 1.

Table 1:

Options	**Numerical value**	**Lower limit**	**Upper limit**
Strongly Agree (SA)	5	4.50	5.00
Agree (A)	4	3.50	4.49
Undecided (UD)	3	2.50	3.49
Disagree (DA)	2	1.50	2.49
Strongly Disagree (SD)	1	0.50	1.49

RESULTS

Research Question 1: What are the instructional materials required for delivering, if adopted, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in secondary schools in Bauchi State?

Table 2 answered research question three, which aimed at determining the instructional materials required for delivering, if adopted, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in the secondary schools in Bauchi State, All the items of the research question were agreed by the respondents with the exception of items 22 and 29, but the total mean scores is in category of 3.50 - 4.49, (see Table 1) and grand mean of 4.17. This shows that delivering Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology if adopted, needs special instructional materials for teaching in the secondary schools in Bauchi State. Also, teaching aids, improvised objects orreal objects can be used to teach ISTEM provided by the government.

Table 2: Mean rating and standard deviation of the respondents on the instructional materials required for delivering, if adopted, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in the secondary schools in Bauchi State.

S/N	ITEMS	Mean	SD	Remarks
1.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) if adopted in Nigeria needs special instructional materials for teaching.	4.41	0.82	Agreed
2.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) if adopted in Nigeria do not need special instructional materials for teaching.	3.39	1.35	Disagreed
3.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) can be taught with only teaching aids drawn on cardboards or pictures.	3.65	1.30	Agreed
4.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) cannot be taught with teaching aids drawn on cardboards or pictures.	3.82	1.24	Agreed
5.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) can be taught with only improvised objects.	3.34	1.24	Agreed
6.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) cannot be taught with improvised objects.	4.29	1.23	Agreed
7.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) can only be taught with real objects.	4.72	1.15	Agreed
8.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) can be taught even without real objects.	4.82	1.22	Agreed
9.	Provision of instructional materials for teaching ISTEM in schools is the responsibility of the government.	4.87	1.06	Agreed
10.	The provision of instructional materials for teaching ISTEM in schools is on the teachers.	3.42	1.36	Disagreed
Grand Mean		**4.17**	**1.19**	**Agreed**

Field survey (2018)

Research Question 2: What instructional facilities needed for delivering the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in secondary schools in Bauchi State?

Table 3 answered research question four, which aim at determining the instructional facilities needed for delivering, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology inthesecondary schools in Bauchi State, All the items of the research question were agreed by the respondents with the exception of item 32, but the total mean scores is in category of 3.50 - 4.49, (see Table 2) and grand mean of 3.57.This shows that there is a need for special instructional facilities for delivering, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in senior secondary schools in Bauchi State, also Science laboratory, Technical and engineering workshops needs to be put in place before ISTEM

can be taught in Nigerian schools, provision of facilities for teaching ISTEM must be adequate and student wise in terms of usage for their effective learning.

Table 3: Mean rating and standard deviation of the respondents on the instructional facilities needed for delivering, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) instructional methodology in the secondary schools in Bauchi State.

S/N	ITEMS	Mean	SD	Remarks
11.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) if adopted in Nigeria needs special instructional facilities for teaching.	4.26	0.89	Agreed
12.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) if adopted in Nigeria do not need special instructional facilities for teaching.	2.97	1.34	Disagreed
13.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) can be taught with only referenced text books.	3.22	1.23	Agreed
14.	Integrated Science, Technology, Engineering and Mathematics (ISTEM) cannot be taught with only referenced textbooks.	3.55	1.15	Agreed
15.	Facilities like Science laboratory, Technical and engineering workshops must be put in place before ISTEM can be taught in Nigerian schools.	4.04	1.08	Agreed
16.	Even if facilities like Science laboratory, Technical and engineering workshops are not put in place, ISTEM can be taught in Nigerian schools.	3.31	1.32	Agreed
17.	The provision of facilities for teaching ISTEM must be adequate in terms of usage for effective learning by students.	4.00	0.96	Agreed
18.	The provision of facilities for teaching ISTEM must not be adequate in terms of usage for effective learning by students.	3.28	1.34	Agreed
19.	The ISTEM laboratory must comprise of all the STEM components integrated for better learning; which are: Science/mathematics laboratory, Technical and engineering workshops together in a single room/hall.	3.74	1.17	Agreed
20.	The ISTEM laboratory must not comprise of all the STEM components shops or labs integrated as the students can rotate from one shop to another within a short time frame.	3.41	1.24	Agreed
Grand Mean		**3.57**	**1.17**	**Agreed**

Field survey (2018)

FINDINGS OF THE STUDY

i. All the respondents indicated that there is a need for special instructional materials for teaching Integrated Science, Technology, Engineering and Mathematics (ISTEM) in the secondary schools in Bauchi State. Respondents also agreed that where scarcities exist of the real objects and teaching aids, improvised versions can be used to teach ISTEM.

ii. All the respondents indicated that there is the need for special instructional facilities for delivering, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) in the secondary schools in Bauchi State. Also that, Science laboratory, Technical and engineering workshops need to be adequately put in place before ISTEM can be effectively taught or learnt in Nigerian schools.

CONCLUSION

- There is a need for special instructional materials for teachingIntegrated Science, Technology, Engineering and Mathematics (ISTEM) in the secondary schools in Bauchi State.
- Where scarcities exist of the real objects and teaching aids, improvised versions can be used to teach ISTEM.
- There is the need for special instructional facilities for delivering, the Integrated Science, Technology, Engineering and Mathematics (ISTEM) in the secondary schools in Bauchi State.
- Science laboratory, Technical and engineering workshops need to be adequately put in place before ISTEM can be effectively taught or learnt in Nigerian schools.

RECOMMENDATIONS

- Integrated Science, Technology, Engineering and Mathematics (ISTEM) teachers should be trained on the usage of ISTEM's appropriate instructional facilities and materials for efficient lesson delivery.
- Government should provide ISTEM instructional facilities and materials for delivering and caution teachers and school heads on better handling and proper maintenance of the facilities and materials.

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