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# Teachers' Knowledge and their Perceived Competency in Integrated STEM Concepts: Implications on National and Global Trends

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**Abstract**: This study was carried out to investigate science teachers' perceived competency and their knowledge in the implementation of Integrated STEM in Gusau Local Government of Zamfara State, Nigeria. Descriptive and causal non-experimental design was adopted for the study. Three research questions were raised and answered using descriptive statistic, while Analysis of Variance (ANOVA) and t-test were used in testing the formulated hypotheses at $P<0.05$ probability level. The data was collected using two research instruments; Perceived Competency Questionnaire (PCQ) and Performance Test on Integrated STEM (PTIS) which were validated by experts and have reliability coefficient of 0.78 and 0.81 respectively. Both were administered to 37 science teachers who were purposively sampled from two Science and one Technical school in Gusau. The findings revealed that, the perception held by science teachers about their competence in implementing Integrated STEM curriculum at secondary school level was relatively high. However, difference was found between their perceived competency and their performance in Integrated STEM unit, and this varies according to their subject specializations. It was recommended that, government should look into the possibility of introducing Integrated STEM curriculum in Nigerian schools and also train science teachers in that regard so as to align them with global trends in STEM education.

**Keywords:** Science teachers, Perception, Competency, Integrated STEM

## Introduction

The global trends in science teaching in recent time have been geared towards advancing the integration of science discipline as a result of national and international economic, social, and political demands. This has led to what is now branded as Science, Technology, Engineering and Mathematics (STEM) education. The essence of STEM education is to prepare the 21$^{st}$ century workforce with STEM education and its related activities so that students can take what they learn in the classroom/laboratory and apply it to their future jobs in the real world (Ejiwale, 2013). Also, Okpala (2012) asserted that, STEM education is needed to produce global citizens. The contribution of STEM to social, industrial and economic life of the world in general and Nigeria in particular have been felt on all phases of human life (Ikeobi, 2010 cited in Ugo and Akpoghol, 2016). Hence, any nation which fails to adequately consider STEM education has planned to be left behind in all spheres of development (Ugo and Akpoghol, 2016). STEM integration has been an area of interest since it was first addressed in education in the United States in the early 1990s (Quang et. al., 2015). Nations are now investing huge amount of capital in designing an enhanced curriculum that recognizes interdisciplinary approach to science teaching and giving more emphasis on teachers' competency in the delivery of such curriculum in the production of workforce in STEM careers.

One of the problems identified as a barrier to STEM education was the perception that, STEM education consists only of the two bookends – science and mathematics (Lantz, 2009). By definition, STEM education is a "meta-discipline" and this means the "creation of a discipline based on the integration of other disciplinary knowledge into a new 'whole' rather than in bits and pieces (Okpala, 2012 and Ejiwale, 2013). Morrison (2008) and Tsupros, Kohler and Hallinen, (2009) contends that, STEM education is an interdisciplinary approach to learning by integrating the four disciplines (Science, Technology, Engineering and Mathematics) into one cohesive teaching and learning paradigm. The aim of this integration is to remove the traditional obstruction between the four disciplines (Morrison, 2008). The National Research Council (NRC, 2001) defined each components of STEM as thus;

- **Science** is the study of the natural world, including the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines.
- **Technology** comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves.
- **Engineering** is a body of knowledge about the design and creation of products and a process for solving problems. Engineering utilizes concepts in science and mathematics and technological tools.
- **Mathematics** is the study of patterns and relationships among quantities, numbers, and shapes. Mathematics includes theoretical mathematics and applied mathematics (NRC, 2001).

Existing literature reports shows no clear consensus among researchers and curriculum developers as to the approach of teaching STEM concepts in secondary schools. However, there are three most reported approaches/models that are being practice. They are ***Silo****;* instruction within each individual STEM subject, ***Embedded***; technology education content is emphasized, and ***Integrated***; the walls between each of the STEM content areas and teaching them as one subject are remove (Roberts and Cantu, 2012). Proponents of STEM education suggested that integration is the best approach for STEM instruction (Roberts and Cantu, 2012; Lantz, 2009; NRC, 2012).

Several reports and research findings have revealed that, when STEM concepts are integrated rather than in unconnected entities, the curriculum offers the best opportunities for students to be creative in solving real world complex problems (Roberts and Cantu, 2012; Lantz, 2009; NRC, 2012). This has been the current global trend in STEM instruction. Although, the Federal Government of Nigeria (FGN) in the National Policy on Education (2004) came up with some policies that were meant to develop and promote the teaching and learning of STEM at various levels (Opkala, 2012), the policies however lacks explicit integration of STEM subjects as an interdisciplinary curriculum framework. In the policy, the STEM remained recognized as an isolated discipline-specific *(Silo-approach).*

Consequently, the teachings of STEM in Nigerian secondary schools is continuously under represented by being taught separately, dominated by Science (S) (biology, chemistry and physics) and Mathematics (M) with some element of Technology (T) that is largely restricted to computer (some sort of embedded approach) while Engineering (E) is completely neglected. With the emergence of a new world order called globalization (Opkala, 2012) and its demands, Nigerian STEM teachers need to keep abreast of the global trends on how STEM discipline-specific being integrated in order to prepare students for a career in line with the 21st century demands. The 21st century challenges such as overpopulation, emerging health issues, declining energy and water sources, floods, earthquakes, climate change, collapse buildings, fire outbreaks, food supply crisis etc. are complex and therefore require interdisciplinary approach.

To effectively implement Integrated STEM education in secondary schools, teachers' content knowledge is very important for its success, likewise their perception about their pedagogical competency in delivering such curriculum. Because, integrating concepts across the four STEM disciplines is challenging when teachers lacks confidence and have little or no understanding of the related ideas in each disciplines due to lack of structure within the lesson. It's from this perspective that this study was conceived; to investigate the level of teachers' preparedness in implementing integrated STEM curriculum, by examining their perceived competency in relation to their knowledge in integrated STEM unit in Gusau, Zamfara State.

## Purpose of the Study

To find out the level of teachers' preparedness in implementing integrated STEM curriculum, by examining their perceived competency in relation to their knowledge of STEM.

### Study Area

Gusau is a Local Government and the capital of Zamfara State, Nigeria. Of all the public secondary schools owned by Zamfara state, 74 (38.74%) are located in Gusau Zone. There are 28 public secondary schools in Gusau zone; three out of these schools (two sciences and one technical) are under the management of Science and Technical Education Board. Gusau has the highest secondary school enrolment in the state. Also, there exist quite a number of privately owned secondary schools

### Objectives of the Study

The study was guided by the following objectives

i. To determine science teachers' perception about their competence in implementing integrated approach to STEM curriculum.
ii. To determine science teachers' performance in STEM curriculum when integrated as a discipline.
iii. To compare science teachers' perceived competency and their performance in integrated STEM curriculum.

### Research Questions

The study provided answers to the following questions

i. How do science teachers perceived their own competence in implementing an Integrated STEM curriculum at secondary school level in the study area?
ii. What is the performance of science teachers in teaching Integrated STEM curriculum on the basis of their area of specialization in the study area?
iii. Are there any differences between science teachers' perceived competency and their performance in STEM when integrated as a unit in the study area?

### Research Hypotheses

Two null hypotheses were formulated and tested at 0.05 level of significance

i. There is no significant difference in science teachers' performance on the basis of their knowledge of integrated STEM concepts.
ii. There is no significant difference in the mean scores of science teachers' perceived competency and their performance in integrated STEM curriculum.

### Scope of the Study

Only science teachers teaching in Science and Technical schools in Gusau Local Government Area were considered for the study. In content terms, the study only determined the perceived competency and performance of science teachers in Integrated STEM unit "Waste Management and Recycling" designed by the researchers.

### Significance of the Study

This study has the following significance:

i. It will establish science teachers' level of preparedness in teaching STEM in an integrated approach at secondary school level.
ii. It will enlighten the curriculum planners to look into the possibility of designing syllabus/programmes that will embrace STEM integration at secondary school level.
iii. The findings of this study will provide information to Government/policy makers on the training needed for effective implementation of Integrated STEM curriculum in order to align with global trends.

## Method

This study adopted a descriptive and causal non-experimental design (Sagadin, 1993). The design is suitable for describing and interpreting the prevailing opinions, knowledge, practices or trends that are developing. The population of the study encompassed all science teachers of the two Science and Technical schools in Gusau, Zamfara State. Using purposive sampling technique, 37 teachers were sampled and used for the study. Two research instruments were developed and validated. The instruments are Perceived Competency Questionnaire (PCQ) and Performance Test on Integrated STEM (PTIS), aimed at generating data on teachers' perceived competency and knowledge of Integrated STEM unit respectively. A trial test was conducted to determine the reliability of the instruments using test-retest method. The coefficient of 0.78 and 0.81 were obtained for PCQ and PTIS respectively these indicated the reliability of the instruments.

To construct items for PTIS, an Integrated STEM unit on "Waste Management and Recycling" was purposely developed for the study. Thereafter, 30 test items were constructed from it, comprising fifteen (15) items in science (i.e. 5 items in biology, chemistry and physics each) while Technology, Engineering and Mathematics have 5 items each. The unit posed a 21$^{st}$ century problem and solution concerning waste in our immediate environment using STEM interdisciplinary approach. PCQ on the other hand, contained 10 items on teachers' self perceived competency in implementing Integrated STEM curriculum. Both PTIS and PCQ were administered to the same participants at separate days, and were returned completed. Descriptive statistic was used to answer the research questions raised while the research hypotheses were tested using Analysis of variance (ANOVA) and t-test. The mean response was used to analyse the data generated from the questionnaire. In order to determine the degree of agreement/disagreement in each of the scaling statements in the items, nominal values of 3 to 1 were assigned to the different scaling statements where 3 was for yes, 2 for undecided, and 1 for No. Consequently, any response with a mean of 2.0 or more was regarded as "Yes" and any response that was below 2.0 was regarded as "No".

## Results and Discussion

The data collected from the study were analysed and presented in the tables below according to the research questions and hypotheses.

**Research Question One:** How do science teachers perceived their own competence in implementing Integrated STEM curriculum at secondary school level in the study area?

Table 1. Perception of science teachers on their competency in implementing an Integrated STEM curriculum

| | | Response categories | | | |
|---|---|---|---|---|---|
| **S/N** | **Items** | **Yes** | **Undecided** | **No** | **Mean** |
| 1 | I can teach other science subjects aside my area of specialization | 32 | 2 | 3 | 2.778 |
| 2 | I can teach mathematics and its applications in solving daily life problems | 23 | 11 | 3 | 2.528 |
| 3 | I can teach engineering concepts at secondary school level | 11 | 18 | 8 | 2.056 |
| 4 | I can teach technology at secondary school level | 32 | 5 | 0 | 2.861 |
| 5 | I can incorporate engineering concepts with other science subjects | 13 | 11 | 13 | 1.972 |
| 6 | I can design lessons/modules that can solves real life problem through the integration STEM concepts | 20 | 14 | 4 | 2.472 |
| 7 | I can select related supplementary resources for teaching Integrated STEM concepts | 32 | 3 | 2 | 2.806 |

| | | | | | |
|---|---|---|---|---|---|
| 8 | I can easily link all the STEM concepts in solving real life problem in a classroom setting | 30 | 5 | 2 | 2.750 |
| 9 | I can apply multiple teaching strategies for teaching Integrated STEM concepts | 18 | 11 | 8 | 2.250 |
| 10 | Lack of computer knowledge can limit my understanding of how STEM concepts can be interconnected | 9 | 19 | 9 | 2.250 |
| | ***Cumulative mean*** | | | | ***2.503*** |

*Standard/decision mean = 2.000*

Table 1 shows that, the competency level of the science teachers on their ability to teach STEM in an interdisciplinary approach was relatively high. This is because their cumulative mean competency level of 2.503 is higher than the standard/decision level of 2.000.

Specifically, majority of the respondents affirmed that they can conveniently teach technology at secondary school because of the qualifications they have. This item had the highest mean response of 2.861, where only 5 of the respondents were undecided while the remaining total of 32 respondents believed that "they can teach technology at secondary school level". Similarly, majority of them agreed that they can select related supplementary resources for teaching Integrated STEM as this item attracted their second highest mean competency level of 2.806 as details shows that while a total of 32 said "Yes", 3 were undecided and 2 that said "No".

**Research Question Two:** What is the performance of science teachers in teaching Integrated STEM unit on the basis of their area of specialization in the study area?

Table 2. Descriptive statistics on performance of science teachers in STEM concepts when integrated

| Science Teachers | N | Mean | Std. Deviation | Std. Error |
|---|---|---|---|---|
| Biology | 11 | 33.7500 | 9.79311 | 3.89656 |
| Physics | 7 | 37.2857 | 2.42997 | .91844 |
| Chemistry | 6 | 38.2353 | 2.33263 | .56575 |
| Mathematics | 8 | 45.1250 | 5.76783 | 2.03924 |
| Others | 5 | 73.8675 | 5.99783 | 2.09924 |
| Total | 37 | 43.0278 | 8.95859 | 1.49310 |

Table 2 shows that, the computed performance level of biology, physics, chemistry, mathematics and others science teachers are 33.75, 37.28, 38.23, 45.12 and 73.86 respectively. This shows that, differences exist among the science teachers in their performance in the Integrated STEM unit.

**Research Questions Three:** Are there any differences between science teachers' perceived competency and their performance in STEM when integrated as a unit in the study area?

Table 3. Difference between science teachers' perceived competency in implementing integrated STEM and their performance in Integrated STEM unit

| Variable | N | Mean | Std. Deviation | Mean Difference |
|---|---|---|---|---|
| Perceived Competency | 37 | 67.972 | 8.603 | |
| Performance | 37 | 43.027 | 3.958 | 24.945 |

Table 3 above shows that there is difference in the mean scores of science teachers' perceived competency and their actual performance in STEM when integrated as a unit. From the result, the mean competency score is 67.972 with Standard deviation of 8.603 as against their performance tests scores with a mean of 43.027 and Standard deviation of 3.958. This implies that science teachers' perceived competency is higher than their performance.

**Hypothesis One:** There is no significant difference among science teachers' in their performance on the basis of their knowledge of STEM concepts when integrated as a unit.

Table 4. Analysis of Variance (ANOVA) of science teachers' performance on the basis of their knowledge level in Integrated STEM unit

| Source of Variance | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 1882.860 | 3 | 627.620 | 21.686 | .000 |
| Within Groups | 926.112 | 32 | 28.941 | | |
| Total | 2808.972 | 35 | | | |

Table 4 reveals that, significant difference exist in the respondents' performance on the basis of their knowledge on STEM concepts when integrated. Reason being that, the calculated p-value of 0.000 is lower than the 0.05 alpha level of significance and the computed F-value of 21.686 is greater than the 2.60 F critical value. Therefore, the study rejects the null hypothesis and concludes that there is significant difference (P>0.05) among science teachers' in their performance on the basis of their knowledge of STEM concepts when integrated.

**Hypothesis Two:** There is no significant difference in the mean scores of science teachers' perceived competency and their performance in STEM when integrated as a unit.

Table 5. Paired sample t-test statistics on difference in the mean scores of science teachers' perceived competency and their performance in STEM concepts when integrated

| Variable | N | Mean | SD | df | t-value | t-crit | P-value |
|---|---|---|---|---|---|---|---|
| Perceived Competency | 37 | 67.972 | 8.603 | 36 | 12.36 | 1.96 | 0.00 |
| Performance | 37 | 43.027 | 3.958 | | | | |

*$P > 0.05$, t computed $< 1.96$ at df 36*

Table 5 results shows that, the t-value computed is 12.36 and the p-value of 0.00 was observed at the df of 36. Since the p-value of 0.00 is less than the alpha value of 0.05, there is a significant difference between science teachers' perceived competency and their actual performance in Integrated STEM unit. Therefore, the null hypothesis which stated that there is no significant difference in the mean scores of science teachers' perceived competency and their performance in STEM when integrated is hereby rejected.

From the finding in Table 1, the study reveals that science teachers have high confidence in their competence of being able to teach STEM concepts when integrated in order to solve real life global problem that is confronting their immediate environment. This finding could serve as an indication of science teachers' readiness in teaching STEM subjects in an integrated approach. This finding supported Bybee (2013) study, who investigated challenges and opportunities of STEM concept integration. The author found that, teachers revealed high perception of confidence in their competency in implementing Integrated STEM curriculum model. Table 2 shows that, differences exist among the science teachers' performance in Integrated STEM test, which was found to be significant as revealed in table 4. This reveals that, science teacher will tend to put more weight in their respective area of specialization while other STEM concepts outside their subject areas will not be properly taught. Similar result was found by Tsupros et al. (2009) in Pennsylvania. The finding is also affirmed the assertions of Morrison (2006) and Lantz (2009) that, science teachers do better in the area of their disciplines when implementing an Integrated STEM curriculum. Table 3 and 6 compared the perceived competency and performance of the respondents in Integrated STEM unit test, and all the findings in the two tables show a significant difference.

## Implications on National and Global Trends

The perception held by science teachers in the study area about their competency and knowledge on Integrated STEM is not supported by the findings of this study. Since, of all the approaches for STEM instruction in schools, integration model is more emphasized globally at present. Therefore, for science teachers in the study area to keep abreast of the global trends in STEM education, they need to be trained on the interrelatedness of STEM disciplines for them to be able to prepare future generation (students) to face 21$^{st}$ century challenges that are complex and requires interdisciplinary in approach. Understanding science teachers' perception and their knowledge about how the world works within the four disciplines to tackle real world problems will help in identifying the intervention needed to keep them on track of what is obtainable globally.

## Conclusion

From the findings of this study, it can be concluded that science teachers over rated their competency and knowledge on Integrated STEM since significant difference was found between their perception and actual performance in items designed from an Integrated STEM unit. Science teachers also scored better in items related to their specific STEM disciplines.

## Recommendations

The following recommendations are hereby put forward

1. Government should collaborate with science teachers' professional bodies such as STAN to look into the possibility of introducing an Integrated STEM curriculum in Nigerian schools in order to align with global trends.
2. Adequate training and re-training should be provided to science teachers on recent approaches of STEM instruction in a classroom setting that can address national and global challenges.

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