
A FRAMEWORK FOR THE INTEGRATION OF STEAM IN ELECTRICAL TECHNOLOGY EDUCATION CURRICULUM IN NIGERIAN UNIVERSITIES

By

Aliyu Musa and Dahiru Sale Mohammed

Faculty of Education,

Northwest University Kano,

P.M.B. 3220, Kano, State, Nigeria

Email: dmsale72@gmail.com, doctoraliyumusa@yahoo.com

ABSTRACT

The contemporary Electrical Technology Education (ETE) curriculum of Nigerian technological universities has been cross-examined for not generating employable graduates. The curriculum gives less importance to effective integration of Science, Technology, Engineering, Art and Mathematics (STEAM) courses due to lack of framework that can guide its implementation. Hence, the purpose of this empirical paper was to develop a framework for the integration of STEAM skills in electrical technology education curriculum. The research was designed to determine the best STEAM skills and their respective elements. Mixed methods exploratory research design was employed for this study. 10 industry technical managers were interviewed. The interview data were analyzed by using coding process starting with open coding followed by axial coding to selective coding. The interview results were used to develop structured questionnaire. The questionnaire was validated by 4 experts and its reliability was established through pilot study. The sample of the survey was 646 including 528 ETE Graduates, 22 ETE Lecturers and 96 Industry Technical Managers. Stepwise linear regression was used to analyze the survey. The study developed the framework for the integration of STEAM skills including comprehension of STEAM, application of STEAM and evaluation of STEAM. The researcher recommended the implementation of the framework for the integration of STEAM skills in ETE curriculum.

Keywords: STEAM, employability skills, technical and vocational education, a Framework and curriculum

INTRODUCTION

The influence of knowledge of Science, Technology, Engineering, Art and Mathematics (STEAM) courses in electrical technology education curriculum to employability of the graduates excessive which stressed on the understanding of interdisciplinary work that join aesthetics thinking in art work with analytical thinking of sciences (Fitzsimmons, 2011) so as to expose students in imaginative artworks and STEM disciplines (Hetland, et al., 2007). There are needs of graduates from higher education institutions to possess employability skills

including STEAM skills in their university prior to commence of work in industry (Akinyemi, et al., 2012 and Dresanya, et al., 2014). Specifically, study indicates that graduates of electrical technology education programme need to be prepared in STEAM from higher educational institutions before starting work in industry (Ismail and Mohammed, 2015). Paradoxically, findings of studies have shown that ETE graduates at entrance level of employment are not equipped with needed STEAM skills and therefore are not ready to start, keep and prosper

in the employment (Crebert, 2004; Evers, et al., 1998; Lindberg, 2007 and Down, 2012).

From the end of the 20th century, the National Science Foundation (NSF) and other institutions in United States of America have encouraged for the addition of engineering components in the boundaries of technology, sciences and mathematics (Angier, 2010). Most of universities in United States of America market themselves to STEM, academies and charter to attract students into their institutions. The new United States framework for technology and science education contains engineering in a key position (NRC, 2011). Many federal government agencies in America like National Science Foundation and multinational companies like Exxon-Mobil, Boeing and IBM have funded creativities for the integration of engineering components into existing science, technology and mathematics curriculum. Arts and other teachers in STEM-focused universities have scrambled to make their disciplines relevant with little assistance from packaged curriculums that advertise STEAM learning.

The recognition and funding of STEM in the United States of America have called other disciplines like medicine and Art to be included under the umbrella of STEM to produce STEM(M) and STE(A)M where (M) and (A) stand for medicine and art respectively (Angier, 2010). However, Fitzsimmons (2011) confirmed that interdisciplinary work in the arts and sciences can lead to curricular modules which contained aesthetics and analytical methods of thinking for the improvement of the two disciplines.

The interdisciplinary context that joined art with STEM aimed at introducing students to mixture works of artist during design thinking, creative process and the value of aesthetic inquiry. Students can examine how artists mix art, science, technology, and math in imaginative artworks that shape boundaries between art, design, and STEM disciplines can develop thinking personalities that are respected both within and outside

the arts or sciences (Hetland, et al., 2007). The following are steps in art design cycle which starts with determining the problem and challenges that want to be answered, finding and evaluate the strengths and weaknesses of different ideas and choice of materials, choose appropriate design, carryout the artistic design, and then test and assess their functionality (Bequette and Bequette, 2012).

Some STEAM researchers considered the arts as the door to STEM education (Piro, 2010) while others reject contributory defense for the arts education to be way to improve undergraduate performance in other disciplines (Eisner, 2002; Hetland, et al., 2007). The two disciplines can assist one another where scientific value can easily be measured for instance aeroplane engineering and information technology while art benefits have cultural value that are not easily be measured for instance, aesthetic deep feeling, originality and creativity and higher spatial thinking skills (Bruce, 2010).

Objective of the Study

- . This study seeks to:
 1. Explore the perceptions of Industry Technical Managers (ITM) on STEAM skills for ETE curriculum
 2. Determine the best elements of STEAM skills for ETE curriculum
 3. Develop a framework for the integration of STEAM skills in ETE curriculum
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Research Question

1. What are the perceptions of ITM on STEAM skills for ETE curriculum?
2. What are the best elements of STEAM skills for ETE curriculum?
3. What is a framework for the integration of STEAM skills in ETE curriculum?

METHODOLOGY

Mixed methods exploratory research design was employed for this study. Ten industry technical managers were interviewed. The interview data were analyzed by using coding process starting with open coding followed by axial coding to selective coding. The interview results were used to develop structured questionnaire. The questionnaire was validated by 4 experts and its reliability was established through pilot study as 9.2. The sample of the survey was 646 including 528 ETE Graduates, 22 ETE Lecturers and 96 Industry Technical Managers. Stepwise linear regression analysis was used to analyze the survey. The survey results were used to determine the best elements of STEAM skills which were used to develop the framework.

Research Locations

The study was conducted at five states in Nigeria where five Federal Universities of Technology

are located which include Bauchi in Bauchi State, Minna in Niger State and Yola in Adamawa State, Owerri in Imo State and Akure in Ogun state.

RESULTS AND DISCUSSION

a) Interview Findings

The interview with industry managers perceived six major elements of STEAM which encompassed comprehension, applications, analysis and evaluation of Science, Technology, Engineering Arts and Mathematics (STEAM) skills in electrical technology systems.

This study found the comprehension skills are abilities to understand and acquire knowledge of Science, Technology, Engineering and Mathematics in electrical engineering technology. Four industry technical managers stated:

“STEAM skills are abilities to acquire skills in deep feeling of nature, mathematics and sciences for electrical technology” (Manager one).

“STEAM skills are that knowledge ... of Science, Technology, Engineering and Mathematics in electrical engineering technology and understandings of basic and advance electrical technology” (Manager four).

“STEAM skills are abilities, understandings ... of physical sciences and mathematics for basic and advance understanding of understanding and design of finished products... of the knowledge in electrical engineering technology for managing the electrical systems and machines” (Manager ten).

“STEAM skills are understandings of artistic machine design, mathematics, physics and chemistry to maintain electrical machines and other electrical systems” (Manager nine).

These data indicate that the managers described the STEAM skills in terms of comprehension skills which are understandings and acquiring of knowledge of STEM for the maintenance and management of electrical machines and other systems.

Industry technical managers' perceived comprehension STEAM skills related to STEAM skills. The main characteristics of comprehension STEAM skills found were understandings of STEAM like mathematics and sciences as well as understandings of basic and advance

STEAM and understandings of basic and advance physical sciences like physics, chemistry and applied mathematics for electrical engineering technology, understanding electrical technology and engineering

sciences like the principle of electricity from physics and chemistry. The STEAM skills from the industry perceptions were summarized and presented in Table 1 as follows:

Table 1: Elements of Comprehension of STEAM Skills

No.	Elements
1	Ability to understand STEAM
2	Ability to acquire STEAM
3	Ability to understand basic physical sciences like chemistry and physics.
4	Ability to understand advance physical sciences.

This study found the application skills as abilities to translate knowledge of Science, Technology, Engineering and Mathematics into practical in electrical

engineering technology. Four industry technical managers revealed:

“STEAM skills are applications abilities in mathematics, physics and chemistry and other creativities to maintain electrical machines and other electrical systems” (Manager nine).

“STEAM skills are application of skills and knowledge of sciences including basic physical sciences like physics, chemistry and applied mathematics for electrical engineering technology” (Manager eight).

These findings indicated that the managers explained the STEAM skills in terms of applications skills which are interpreting of knowledge of STEAM for the maintenance and management of electrical machines and other systems. The main characteristics of application STEAM skills found were translating of STEAM

into practice for instance, translating of knowledge of mathematics, physics, chemistry and engineering to maintain electrical machines and other electrical systems. The applications of STEAM skills from the industry perceptions were summarized and presented in Table 2.

Table 2: Elements of Application of STEAM Skills

No.	Elements
1	Ability to understand STEAM.
2	Ability to translate STEAM into practice.
3	Ability to use basic physical sciences like chemistry and physics in electrical technology
4	Ability to use advance physical sciences in electrical technology.

This study found the analysis skills as abilities to study and examine knowledge of Science, Technology,

Engineering and Mathematics in electrical engineering technology. Four industry technical managers exposed:

“STEAM skills are analysis of knowledge of natural arts, sciences and engineering both theoretical and practical knowledge for electrical engineering technology systems” (Manager six).

“STEAM skills are analyses of basic skills of sciences, engineering and arts such skills include mathematics, physics and chemistry and fine arts” (Manager seven).

These data showed that the managers described the STEAM skills in terms of the analyses skills which are studying and examination of knowledge of STEM in the maintenance of electrical machines and other systems. Industrial technical managers' perceived application of STEAM skills related to STEAM skills. The :

main characteristics of analysis of STEAM skills found were the study and examination of STEAM for the maintenance of electrical machines and other electrical systems. The analysis of STEAM skills from the industry perceptions were presented in Table 3 as follows

Table 3: Elements of Analysis of STEAM Skills

No.	Elements
1	Ability to analyze STEAM like STEM in the theory of electrical technology systems
2	Ability to analyze STEAM like STEM in the practice. of electrical technology systems
3	Ability to analyze basic physical sciences like chemistry and physics in electrical technology systems
4	Ability to analyze advance physical sciences in electrical technology systems.

This study found the evaluation skills as abilities to assess the knowledge of Science, Technology,

Engineering and Mathematics in electrical engineering technology. Two industry technical managers mentioned:

“STEAM skills are abilities to assess skills of sciences and engineering in basic and arts for electrical technology systems” (Manager five).

STEAM skills are assessment of knowledge of sciences and physical machine design such as mathematics and physics as well as electrical engineering systems” (Manager three).

These findings exposed that the managers described the STEAM skills as evaluation skills which are assessment and appraisal of knowledge of STEM for the maintenance of electrical machines and other systems. Industry technical managers' perceived evaluation of STEAM skills related to STEAM skills. The main

characteristics of evaluation of STEAM skills found were appraisal of STEAM into practice for instance, appraising of knowledge of mathematics, physics, chemistry and engineering technology to maintain electrical machines and other electrical systems. The evaluation of STEAM

skills from the industry perceptions were presented in Table 4 as follows:

Table 4: Elements of Evaluation of STEAM Skills

No.	Elements
1	Industry Perceptions on the Analysis of STEAM Skills are
2	Abilities to assess skills in sciences and engineering in basic knowledge for electrical technology systems
3	Abilities to assess skills in sciences and engineering and contemporary knowledge for electrical technology systems
4	Ability to carry assessment of knowledge of sciences and STEAM such as mathematics and physics
5	Ability to perform assessment of electrical engineering systems.

In summary, from the perceptions of industry technical managers, the STEAM skills has four major elements which comprised comprehension of STEAM skills, application of STEAM skills, analysis of STEAM skills and evaluation of STEAM skills. The elements of STEAM skills found from the perceptions of industry were presented in Figure 1 as follows:

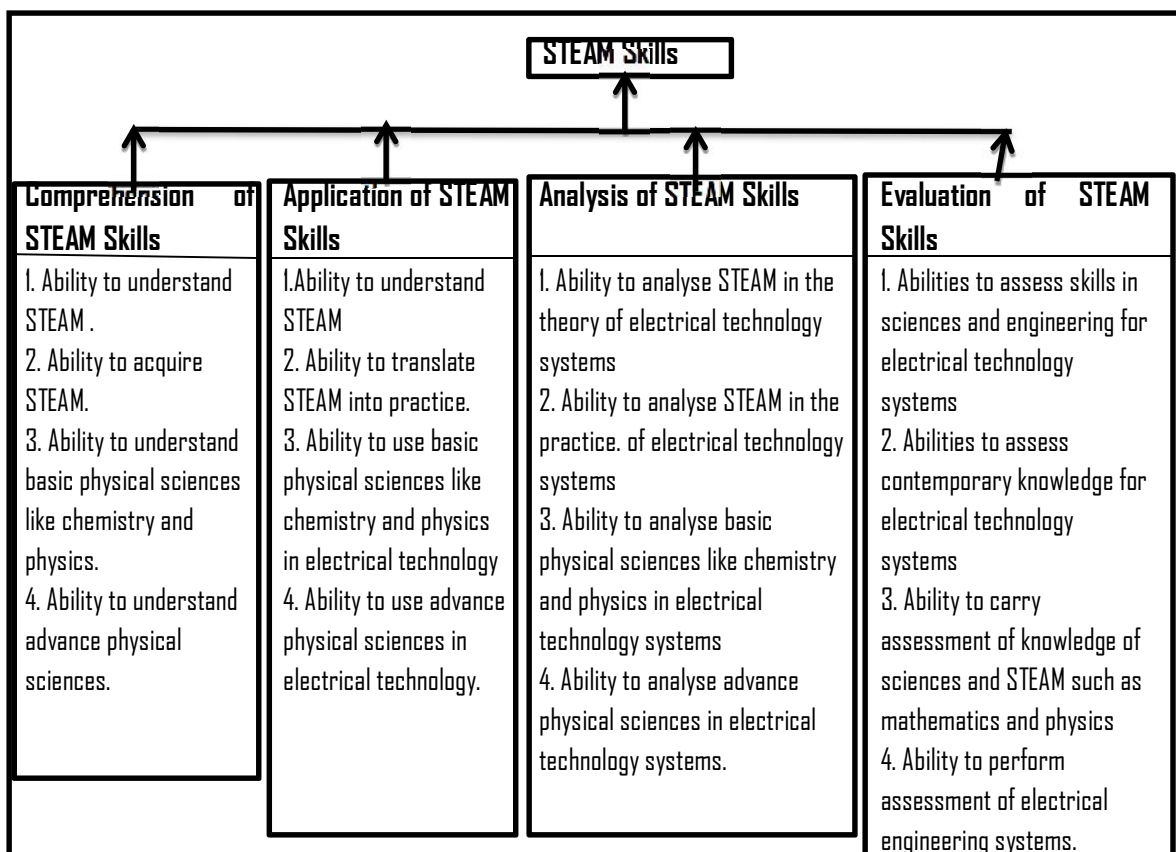


Figure 1: Elements of STEAM skills

b) The Survey Findings

The survey data were subjected to Stepwise Linear Regression (SLR) of SPSS version 22 computer software.

i) SLR Analysis

The SLR results determined the best themes and best elements of knowledge of contemporary issue skills for the integration into ETE curriculum.

Four Elements of STEAM skills which are comprehension of STEAM, application of STEAM, analysis of STEAM and evaluation of STEAM were identified from the opinions of industry.

The data collected from ETE graduates related to STEAM skills were subjected to Stepwise Linear Regression Method. Significant results emerged: $F(3, 88) = 4784.829, p < 0.05$. The results explain 99.4% of

the variance (Adjusted $R^2 = .994$). The best Elements of STEAM skills considered important and their respective standardized coefficient Beta values as follows: Comprehension STEAM = .403, Application STEAM = .365 and Evaluation STEAM = .238. The analysis considered three out of four Elements of STEAM skills for ETE curriculum integration as best by graduates as presented in Table 5.

Table 5: Best Elements of STEAM Skills According to Levels of Importance for ETE Curriculum Integration by Graduates

Elements of Skills	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 Comprehension of STEAM	.931	.012	.993	79.146	.000
2 Comprehension of STEAM Application of STEAM	.585	.049	.624	11.853	.000
	.359	.050	.376	7.150	.000
3 Comprehension of STEAM Application of STEAM Evaluation of STEAM	.378	.052	.403	7.286	.000
	.348	.042	.365	8.385	.000
	.228	.035	.238	6.475	.000

The data collected from ETE lecturers related to STEAM skills were subjected to Stepwise Linear Regression Method. Significant results emerged: $F(3, 16) = 1431.157, p < 0.05$. The results explain 99.6% of the variance (Adjusted $R^2 = .996$). The best Elements of STEAM skills and their respective standardized

coefficient beta values as follows: Comprehension STEAM = .974, Application STEAM = .709 and Evaluation STEAM = -.683. The analysis considered three out of four Elements of STEAM skills for ETE curriculum integration as best by ETE lecturers as presented in Table 6.

Table 6: Best Elements of STEAM Skills According to Levels of Importance for ETE Curriculum Integration by ETE Lecturers

Elements of Skills	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
1 Comprehension of STEAM	.988	.025	.994	38.884	.000
2 Comprehension of STEAM Application of STEAM	.679	.113	.683	5.996	.000
	.300	.108	.317	2.783	.013
3 Comprehension of STEAM Application of STEAM Evaluation of STEAM	.968	.103	.974	9.362	.000
	.672	.114	.709	5.889	.000
	-.656	.151	-.683	-4.340	.001

The data collected from Industry Technical Managers related to STEAM skills were subjected to Stepwise Linear Regression Method. Significant results emerged: $F(3, 88) = 4784.829$, $p < 0.05$. The results explain 99.4% of the variance (Adjusted $R^2 = .994$).

The best Elements of STEAM skills and their respective standardized coefficient Beta values as

follows: Comprehension STEAM skills = .403, Application STEAM skills = .365 and Evaluation STEAM skills = .238. The analysis considered three out of four Elements of STEAM skills for ETE curriculum integration as best by Industry Technical Managers as presented in Table 7.

Table 7: Best Elements of STEAM Skills According to Levels of Importance for ETE Curriculum Integration by Industry Technical Managers

Elements of Skills	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
1 Comprehension of STEAM	.931	.012	.993	79.146	.000
2 Comprehension of STEAM Application of STEAM	.585	.049	.624	11.853	.000
	.359	.050	.376	7.150	.000
3 Comprehension of STEAM Application of STEAM Evaluation of STEAM	.378	.052	.403	7.286	.000
	.348	.042	.365	8.385	.000
	.228	.035	.238	6.475	.000

From Table 5, Table 6 and Table 7, the three best Elements of Knowledge of Contemporary Issues Skills for ETE Curriculum Integration by Graduates, ETE

Lecturers and Industry Technical Managers were comprehension STEAM, application STEAM and evaluation STEAM.

DISCUSSION OF FINDINGS

STEAM refers to STEM and (A)rts. STEM refers to

"..... the application of technical, scientific, and mathematical knowledge with the use of natural laws and physical resources to create and implement materials, structures, machines, devices, systems and processes to accomplish a desired objective, safely and economically. Basically, engineering is a creative and interactive process that interfaces between scientific and mathematical knowledge with the society. Engineers design and create successful systems that lead to an improved quality of life... Therefore, engineering education must be carefully planned and executed so that the students ... attain the necessary skills and competencies ...to be successful professional engineers capable to face such challenges. ...Emphasis is placed on the fundamentals of engineering principles and design techniques which lead the student to identify and define engineering problems, develop engineering concepts and alter-nate solutions. The success of the engineering program is measured by the high competence of its graduates in their professional career, and the full satisfaction of their industry technical managers and society" (Khan, et al., 2014; pp:11)

While arts refer to higher spatial thinking skills, creativity that has high cultural value and aesthetic deep feeling but not easily measured (Bruce, 2010). The interdisciplinary knowledge science and art can assist the two disciplines (Fizimmons, 2011). Industry technical managers stated STEAM skills are knowledge and applications of Science, Technology, Engineering, Arts and

Mathematics (STEAM) in electrical engineering technology for the understandings of basic and advance electrical technology. The SLR found three best elements of STEAM which include comprehension STEAM skills, application STEAM skills and evaluation STEAM skills. The Framework for the Integration of STEAM Skills in ETE Curriculum is presented in Figure 2.

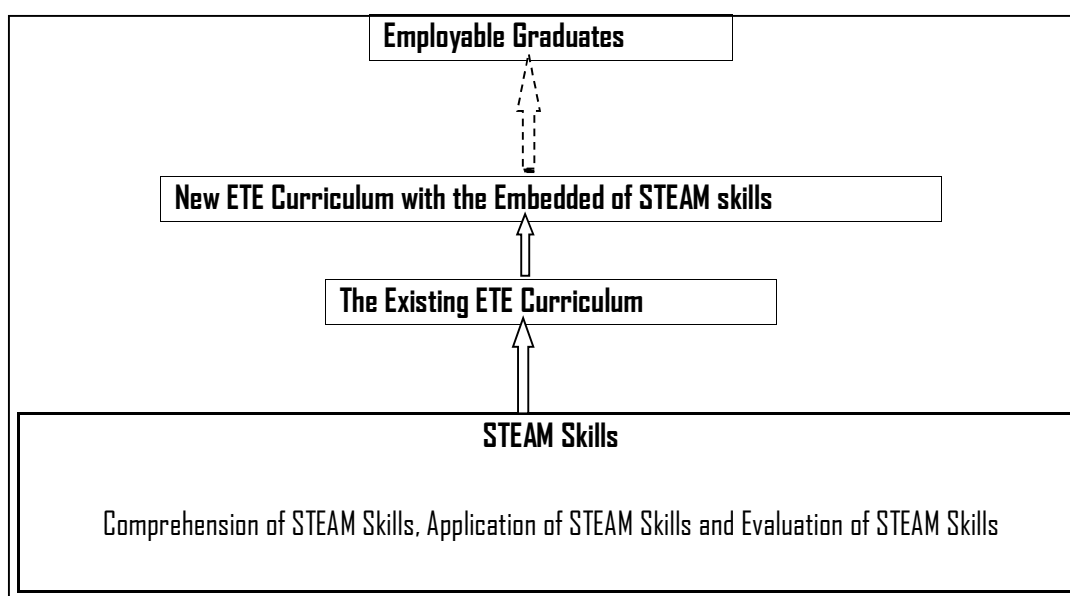


Figure 2: A Framework for the Integration of STEAM Skills in ETE Curriculum

CONCLUSION

The concept of employability skills which include STEAM skills is new in Nigeria and has not been integrated into higher education system of the country (Oresanya, et al., 2014). There are requests for STEAM skills to be integrated at undergraduate levels in Nigeria (Akinyemi, et al., 2012). There is need for TVET institutions in Nigeria to focus and equip their graduates with the STEAM skills (Idris and Rajuddin, 2012). For example, Ismail and Mohammed (2015) that conducted analytical review of Electrical Technology Education curriculum of Nigeria Federal Universities of Technology revealed that STEAM skills are not integrated. Hence, this study developed the framework for the integration of

STEAM skills in Nigeria including Comprehension, application and evaluation of STEAM Skills,

IMPLICATION AND RECOMMENDATIONS

The implication of this findings propose that integrating STEAM skills in ETE curriculum may likely have influence on work performance of TVET graduates during working life in industry. It is suggested that integration probability studies and putting into practice of the framework for the integration of STEAM skills in ETE curriculum be carried out in the universities in Nigeria.

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