



## Factors Influencing Implementation of STEM Education in Kano State Science and Technical Schools, Nigeria: Implication on Student's 21st Century Skill

<sup>1</sup>Salim Bala Sidi, <sup>2</sup>Abubakar Uba Gurjiya, <sup>3</sup>Faith Sadoh

<sup>1</sup>Mathematics Department, Aminu Kano College of Islamic and Legal Studies

<sup>2</sup>Geography Department Sa'adatu Rimi College of Education, Kumbotso,

<sup>3</sup>STE Department, Bayero University,  
Kano State

### ABSTRACT

The study was designed to investigate factors affecting the proper implementation of the STEM education program in Kano State science and technical secondary schools. Five (5) hypotheses were developed to guide the study based on the outlined factors. A survey research design was adopted for the study. The population of the study consists of STEM teachers and students, which are 1,527 and 15,900, respectively. The sample size was 390 STEM teachers and students, collectively. Two questionnaires were used for data collection: STEM teachers' questionnaire covering factors affecting implementation of the STEM program and STEM students' questionnaire on 21st century skills. The 21st century skills questionnaire was adapted from the work of Kelley et al. (2019). A structural equation model (SEM) was developed to show the relationship between the factors and their influence on the students' 21st century skills. The paper concludes that the factors affecting the proper implementation of the STEM education program were influenced by administrative interest and government policy, which hindered the attainment of the 21st century skills of STEM students.

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### INTRODUCTION

STEM education is an educational model that integrates science, technology, engineering, and mathematics for the purpose of achieving the goal of twenty-first century (21st century) challenges. White (2014) and Kola (2022) explain that STEM education was developed to train students who can investigate and engineer solutions to problems and construct evidence-based explanations of real-world phenomena, specifically for 21st century.

Additionally, STEM education goes beyond the classroom so much that it gives people skills that make them more employable and ready to meet the current labor demand (i.e. 21st century) (Sadoh & Sidi, 2021). In STEM, S stands for science, which includes biology, chemistry, physics and geoscience; it gives learners an in-

depth understanding of the world and helps learners to become better at research and critical thinking, the T stands for technology; it prepares young learners for the workforce of technological environment, the E stands for engineering; this develop students' problem-solving and utilize it in a new project, and the M stands for mathematics; it enables young learners to analyze information, eliminate errors, and make conscious decisions when designing solutions. (Thibaut et al., 2018). In light of the above, one can conclude and deduce that STEM education is an integrated body that brings educational disciplines into one umbrella of study that would engage students' minds in creation and innovation, which are major goals of 21st century skills, thereby producing a workforce that would meet the challenges of the twenty-first century.

Corresponding author: Salim Bala Sidi

✉ [sidisalimsidi@gmail.com](mailto:sidisalimsidi@gmail.com)

Mathematics Department, Aminu Kano College of Islamic and Legal Studies, Kano

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According to Coastal (2019), STEM education fosters a skill set that emphasizes critical thinking and problem-solving abilities and encourages innovation among those who possess the aforementioned skills. Coastal further penned that technological innovation in the modern age is only obtainable through the expertise of specialists with knowledge of relevant STEM education. As such, STEM education has become the road map for attaining 21st century skills.

When it comes to 21st century skills, innovation skills such as critical thinking and problem solving; communication; collaboration; creativity and innovation are the ones that come up most frequently (American Association of Colleges of Teacher Education [AACTE], 2010). They are becoming more widely recognized as characteristics that distinguish students who are prepared for a more complex life and work environment in the twenty-first century from those who are not. 21st century skills have a broad set of knowledge, skills, and work habits considered critical to success in today's world by educationalists, schools, contemporary careers, and workplaces (Erdem, 2019). These skills are needed to face the challenges of developing countries like Nigeria. Because every aspect of life has changed in the 21st century, notably the economic system. The 21st century marks changes from the industrial to the knowledge eras in terms of production and economics (Erdem, 2019). And most of the problems of these countries are one way or the other related to economic development and management. In general, 21st century skills can be employed throughout a student's life in all academic subject areas, especially in science, technology, engineering, and mathematics (STEM) subjects for greater effectiveness (White, 2014).

Nevertheless, the current situation of STEM education in Nigeria is deteriorated by insufficient funding, ineffective government policy, inadequate qualified STEM teachers, infrastructural deficiencies, ineffective educational values, etc. (Abbas, 2018; Badmus, & Omosewo, 2020; Martins-Omlole, 2018; Kola, 2022).

**1. Insufficient funding:** Financial resources are one of the most important requirements for

STEM education, especially for the attainment of 21st century skills. However, it is obvious that STEM education is a capital-intensive program. For many decades, the Nigerian government has failed to allocate even half of the global recommended allocation for education. Inadequate budgetary allocation to education is a big problem for the achievement of 21st century skills in Nigerian STEM schools. Insufficient funds for procurement of important structures, facilities, equipment, and resources for STEM teaching and learning is a major constraint to address for 21st century skills acquisition.

**2. Administrative interest and ineffective government policy:** Misplacement of priority in the corridors of power in Nigeria is common. No matter how important a program is, when it loses governmental interest it automatically fails. Certain programs fail or remain unsuccessful due to ineffective policies, but others are good in all aspects and exist fruitlessly as a result of weak implementation of policies. In the absence of administrative interest and the presence of ineffective policy and its implementation, STEM education and 21st century skills may not be productive.

**3. Inadequate qualified STEM teachers:** The shortage of qualified STEM teachers and other personnel is a serious issue for 21st century skills in STEM education. Though obtaining a complete list of qualified STEM teachers in Nigeria is difficult, as of 2014, the country had 1.5 million qualified teachers registered with TRCN, ranging from primary to tertiary institutions. Another issue is a lack of training, retraining, and seminars for STEM teachers on modern pedagogical skills and techniques to improve achievement of 21st century skills objectives.

**4. Infrastructural deficiencies:** Insignificant infrastructure and facilities hinder the conduciveness of teaching and learning activities. Classrooms, laboratories, weather stations, studios, libraries,



workshops, seminar rooms, ICT facilities, conveniences, water supply, and other facilities are insufficient in Nigerian schools. Many STEM teaching and learning materials require adequate furniture and a moderate temperature to function properly, so air conditioners in ICT and other classes, stable and reliable electricity, and internet access are required. Many secondary schools in Nigeria have no other sources of electricity, for instance, solar or wind turbine power generation or standby generators.

5. Ineffective STEM educational values: In Nigeria, STEM education has greater value on paper than in actual application of the education to solve the country's problems. Nigeria places a larger weight on theoretical knowledge than practical skills, advancement, personality, and innovation since the grading system is overemphasized. There needs to be a system that supports those who have the ability to advance society. Because innovation and growth begin with accepting mistakes and failure while taking a chance to achieve a larger benefit. There is a wrong public mindset that some occupations and professions are superior to others and that everyone must live as though they are competing with one another.
6. Backward in the trend of STEM education: In the past, STEM education in Nigeria has assisted the country in a number of areas, including construction, telecommunications, agriculture, and health. However, there are still obstacles preventing the growth of STEM education in Nigeria. These issues include lack of innovation and employability, low research output, substandard instructors, etc. If nothing is done about it, STEM education in Nigeria may not have a bright future. A country that is overly reliant on certificates with little or no investment in innovative skills development could face serious challenges in this century. As a result, STEM education in Nigeria should emphasize equipping graduates with 21st century skills to become more productive.

With these, effective implementation of STEM education will not be possible, and the goals of STEM education and 21st century skills will not be achieved. Based on this information, the researchers used structural analysis to find the influence of the listed factors affecting the STEM education program and the 21st century skills of Kano state science and technical students.

### STATEMENT OF THE PROBLEM

STEM education was developed purposely for the attainment of the 21st century skills that will cater the technological and economic challenges of the era. Nigeria, and particularly Kano state, has joined the global race for STEM education programs. Unfortunately, for many years since the implementation, the 21st century skills of the students (citizens) as well as the technological and economic development of the state and the country at large (Nigeria), sounded like the program does not exist. Hence, the study focused on finding the influence of the listed factors affecting the implementation of the STEM program on the students' 21st century skills using structural equation model.

### RESEARCH HYPOTHESES

- H<sub>1</sub>. Insufficient funding of STEM education program positively affects students' 21st century skills.
- H<sub>2</sub>. Administrative interest and ineffective government policy on STEM education program positively affect students' 21st century skills.
- H<sub>3</sub>. Inadequate qualified STEM teachers for STEM education program positively affects students' 21st century skills.
- H<sub>4</sub>. Infrastructural deficiencies in STEM education program positively affect students' 21st century skills.
- H<sub>5</sub>. Ineffective STEM educational values positively affect students' 21st century skills.

### METHODOLOGY

The research design adopted for the study was a survey. The design was appropriate for the study as it focused on the factors deteriorating the effective implementation of



STEM education for the successful attainment of 21st century skills. The population of study consists of all STEM teachers and students of Science and Technical Schools Kano, with a total number of one thousand five hundred and twenty-seven (1,527) teaching staff and fifteen thousand nine hundred students (15,900), respectively. Three hundred and ninety (390) teachers and students were randomly selected as suggested by (Hair et al., 2010).

The survey instrument was a structured questionnaire. Seven constructs were measured concerning the factors affecting STEM education programs in Nigeria and the 21st century skills of the STEM students. The questionnaire on the implementation of the STEM program was answered by STEM teachers, while the 21st century skills questionnaire was answered by the STEM students. Insufficient funding (InsFun) was measured by five items developed. Administrative interest and ineffective government policy (AdGPolicy) were measured by six items. Inadequate qualified STEM teachers (InAdQTech) were measured by six items. Infrastructural deficiencies (InfraDef) were measured by five items. Ineffective STEM education value (InEfSTEval) was measured by five items. All were developed by the researchers. Communication skills (CenSkill\_1), critical skills (CenSkill\_2), creative skills (CenSkill\_3), problem-solving skills (CenSkill\_4), and digital skills (CenSkill\_5) were measured, with each skill having six items. The 21st century skills questionnaire was adapted from the work of Kelley et al. (2019). All the items were used on a 5-point scale (ranging from 1 = Strongly Disagree to 5 = Strongly Agree) in this study. Cronbach's alpha was used to calculate the internal consistency for each of the six factors, yielding  $\alpha = 0.82$  for insufficient funding,  $\alpha = 0.84$  for administrative interest and government policy,  $\alpha = 0.80$  for

inadequate qualified STEM teachers,  $\alpha = 0.80$  for infrastructural deficiencies,  $\alpha = 0.82$  for ineffective STEM education value, and  $\alpha = 0.80$  for 21st century skills. Questions regarding demographic information (school type, teaching experience, teaching subject, etc.) were also included on the survey. The questionnaire (for both students and teachers) was administered through Google Form for those that have access to the internet and a hardcopy for those that have no access to the internet. The response from the hardcopy was entered into the downloaded Google sheet.

## DATA ANALYSIS

At the end of the data collection process, the responses from the Google form were downloaded, and those from the hardcopy were entered into the sheet for data analysis. Structural equation modeling (SEM) through path analysis was used to explore the influence of the listed factors deteriorating STEM education programs on STEM students' 21st century skills using the AMOS 23 version. SEM involves testing the measurement model and then testing the structural model. To test the measurement model, analysis began with an explanatory factor analysis (EFA), followed by a confirmatory factor analysis (CFA) using prior research for how items loaded on each factor. In the EFA analysis, both convergent and discriminant validity were observed. All the low-loaded ( $<.50$ ) and cross-loaded items were removed.

## RESULT

### Explanatory Factor Analysis (EFA)

EFA using principal component analysis (PCA) was performed in order to explore the main variables to create the model from reflective items that measure the latent variables (Lee, et al. 2022; Taherdoost, et al. nd), and to confirmed the validity of the variables as shown in Table 1.



**Table 1:** Extraction Communalities and Pattern Matrix

	Communalities	Factors Loading				
		Extraction	1	2	3	4
IF2	.701				.834	
IF3	.699				.836	
AGP5	.625					.772
AGP6	.630					.782
IQT3	.523	.730				
IQT4	.707	.796				
IQT5	.778	.845				
ID1	.774	.871				
ID2	.707	.847				
ID3	.652	.807				
ID4	.549	.744				
ISEV1	.591			.741		
ISEV2	.625			.778		
ISEV3	.690			.824		
CentSkill_1	.737		.857			
CentSkill_2	.711		.887			
CentSkill_3	.756		.865			
CentSkill_4	.557		.603			
CentSkill_5	.644		.786			

Extraction Method: Principal Component Analysis.  
 Rotation Method: Promax with Kaiser Normalization<sup>a</sup>

a. Rotation converged in 5 iterations.

For a reliable solution all the variable were sufficiently correlated; KMO = .885 (>.80) it is meritorious, and Bartlett's Test Sphericity (Chi-sqr = 3165.895, df =171) which is significant (.000), and all the values of the extracted communalities were greater than .5. There are 39(22%) non-redundant residuals with absolute greater than .05.

### Confirmatory Factor Analysis (CFA)

Confirmatory Factor Analysis (CFA) was used to access all of the study's components, as shown by the model in Figure 1. It is the result of five knowledge construction activities for 365 STEM teachers and students. The factor loadings are shown by the arrows connecting the factors and variables (Shaheen et al. 2017).

Corresponding author: Salim Bala Sidi

✉ [sidisalimsidi@gmail.com](mailto:sidisalimsidi@gmail.com)

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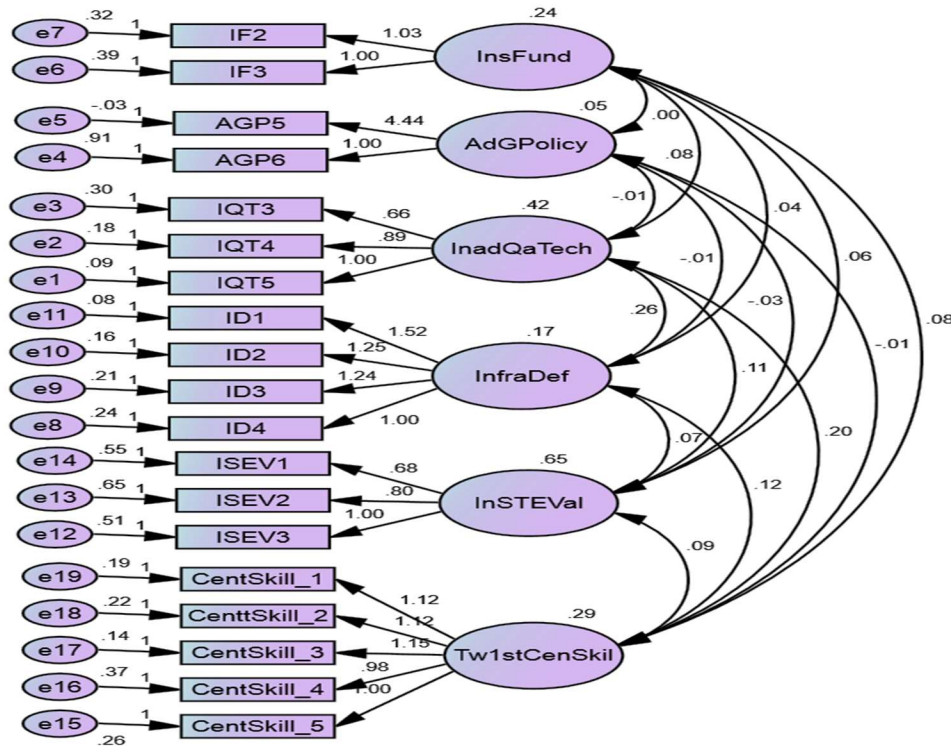


Figure 1: Confirmatory Factor Analysis (CFA)

Table 2 shows the Maximum Likelihood Estimation (MLE), which indicates that inadequate qualified teachers, administrative interest and

government policy, insufficient funding, infrastructural Deficiency, insufficient STEM Value, and the students' 21st century skills are influenced and supported, except for one item in the administrative interest and government policy.

**Table 2:** Maximum Likelihood Estimation (MLE) Result

			Estimate	S.E.	C.R.	P	Label
IQT5	<---	InadQaTech	1.000				
IQT4	<---	InadQaTech	.893	.042	21.042	***	Supported
IQT3	<---	InadQaTech	.662	.049	13.447	***	Supported
AGP6	<---	AdGPolicy	1.000				
AGP5	<---	AdGPolicy	4.436	5.045	.879	.379	Not Supported
IF3	<---	InsFund	1.000				
IF2	<---	InsFund	1.032	.296	3.481	***	Supported
ID4	<---	InfraDef	1.000				
ID3	<---	InfraDef	1.242	.102	12.125	***	Supported
ID2	<---	InfraDef	1.253	.098	12.803	***	Supported
ID1	<---	InfraDef	1.518	.107	14.170	***	Supported
ISEV3	<---	InSTEVal	1.000				

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✉ [sidisalimsidi@gmail.com](mailto:sidisalimsidi@gmail.com)

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			Estimate	S.E.	C.R.	P	Label
ISEV2	<---	InSTEVal	.800	.103	7.784	***	Supported
ISEV1	<---	InSTEVal	.682	.089	7.701	***	Supported
CentSkill_5	<---	Tw1stCenSkil	1.000				
CentSkill_4	<---	Tw1stCenSkil	.975	.082	11.835	***	Supported
CentSkill_3	<---	Tw1stCenSkil	1.147	.074	15.424	***	Supported
CentSkill_2	<---	Tw1stCenSkil	1.122	.078	14.332	***	Supported
CentSkill_1	<---	Tw1stCenSkil	1.117	.076	14.741	***	Supported

\*\*\*indicate highly significant at  $p < .001$

Table 3 gives the results for the goodness-of-fit index (GFI), normed fit index (NFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA) for the confirmatory analysis. All of the model fit indices fall within the acceptable range of limits (Kang &

Ahn, 2021). As a result,  $Cmin/df = 2.159 (<3.0)$ ,  $GFI = .917 (<.95)$ ,  $NFI = .908 (<.95)$ ,  $CFI = .948 (>.90)$ , and  $RMSEA = .056 (<.08)$ , GFI and NFI are acceptable as they are within the range. GFI and NFI are within the range of accepted values.

Table 3: Fitness of Confirmatory Factor Analysis (CFA) Model

Model	CMIN	DF	P	CMIN/DF	GFI	NFI	CFI	RMSEA	SRMR
Default Model	295.787	137	.000	2.159	.917	.908	.948	.056	.0454
Saturated Model	.0000	0			1.000	1.000	1.000		
Independent Model	3229.480	171	.000	18.886	.351	.000	.000	.222	

### Structural Equation Model (SEM)

The last step in the SEM analysis is the structural model. It connects and correlates all the factors to the constructs and also provides a structural link from the factor deteriorating the STEM education to the STEM students' 21st century skills, as Figure 2 showed. The fitness of the structural model indicates the influence of the factors on STEM students' 21st century skills, so hypotheses were accepted.

Corresponding author: Salim Bala Sidi

✉ [sidisalimsidi@gmail.com](mailto:sidisalimsidi@gmail.com)

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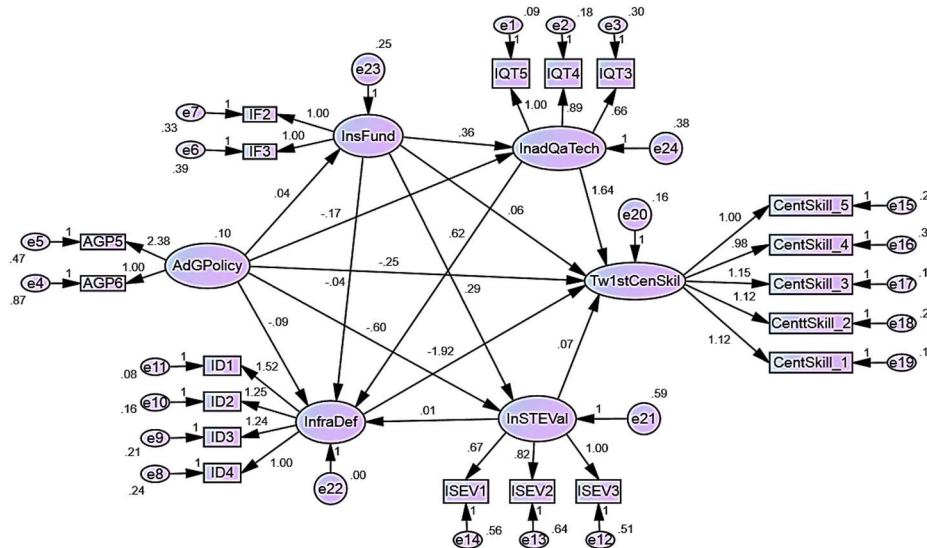


Figure 2: Structural Model Factors Affecting STEM

Program and Students 21<sup>st</sup> Century Skills. The structural model result in Figure 2 depicts the estimated stable model fit. The indicators of fit are: Cmin/df = 2.184 (Cmin = 301.444, df = 138); GFI =.916; NFI =.901; CFI =.947; RMSEA =.057 and SRMR =.0530. Figure 2 experimentally showed that administrative interest and government policy (AdGpolicy) greatly affected students' 21<sup>st</sup> century skills, infrastructural deficiency, insufficient funding, insufficient qualified STEM teachers, and insufficient STEM value. However, a substantial relationship was discovered between inadequately qualified STEM teachers and students' 21<sup>st</sup> century skills. The structure showed the influence of the listed factors affecting the STEM education program on the students' skills. It also showed that the data at hand was fit as provided by the indices of the structural model and generated corroborating value for the good model fit.

### DISCUSSION OF FINDING

The fitness of the structural model in Figure 2 shows how the empirical data fit the model. The structure showed that administrative

interest and government policy significantly affected the implementation of the STEM education program in Kano State. This administrative interest and government policy coursed insufficient funding, infrastructure deficiency, inadequately qualified STEM teachers, ineffective STEM education value, and finally deteriorated the aspiration of the students twenty-first (21<sup>st</sup>) century skills. On the other hand, insufficient funding influences infrastructural deficiency, ineffective STEM education value, inadequately qualified STEM teachers, and the students 21<sup>st</sup> century skills. Inadequately qualified STEM teachers also have an influence on infrastructural deficiencies and the students' 21<sup>st</sup> century skills. Ineffective STEM education values influenced infrastructural deficiency and the students' 21<sup>st</sup> century skills.

From the structural analysis, one can deduce that administrative interest and government policy, insufficient funding, inadequately qualified STEM teachers, and ineffective STEM education value led to infrastructural deficiency and hence poor outcomes for the students' 21<sup>st</sup> century skills. Infrastructure comprises many aspects of the program, right from the starting point: the curriculum, school structures, administrative structures, teaching staff, practical laboratories, cultural perspectives, the learning environment, a

Corresponding author: Salim Bala Sidi

✉ [sidisalimsidi@gmail.com](mailto:sidisalimsidi@gmail.com)

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lack of educational technology, and the students themselves.

This finding is in line with the finding of Chowdhury et al. (2020), which conclude that to enable the implementation of STEM education, standard laboratories, skilled teachers, and suitable text books are required; otherwise, the aspiration of the program would fail. Also, the study by Bardoe et al. (2023) showed that inadequate teaching and learning materials for STEM education, a shortage of certified STEM teachers, a shortage of STEM infrastructure, a lack of motivation for STEM learning opportunities, a low standard of STEM program and curriculum, a lack of technological inclusion in the STEM program, and a limited teaching and learning period for STEM subjects are all factors that affect the implementation of STEM education programs.

### CONCLUSION

The main goal of this paper is to determine factors and their influence on the implementation of STEM education programs toward achieving students' 21st century skills. The paper shows that implementation of STEM education is below, which in one way or another influences the STEM students' 21st century skills. All the outlined factors, that is, administrative interest and government policy, infrastructural deficiency, inadequately qualified STEM teachers, insufficient funding, and ineffective STEM education value, have a significant influence on the skills of STEM students in the 21st century. The structural model (Figure 2) proves that administrative interest and government policy have an influence on all the factors that hinder the attainment of the 21st century skills of STEM students.

### RECOMMENDATIONS

The government should consider the STEM education program as a tool for economic development by investing huge funds in order to harvest good results. For the attainment of 21st century skills, the government, stakeholders, and NGO's should give special attention to the STEM education infrastructure and value the program above all else, as it is the basics to confront the

current technological trend and economic challenges.

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Corresponding author: Salim Bala Sidi

✉ [sidisalimsidi@gmail.com](mailto:sidisalimsidi@gmail.com)

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Corresponding author: Salim Bala Sidi

✉ [sidisalimsidi@gmail.com](mailto:sidisalimsidi@gmail.com)

Mathematics Department, Aminu Kano College of Islamic and Legal Studies, Kano

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