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Assessing the Factors Affecting Senior Secondary School Students' Academic Achievement in Selected Science, Technology, Engineering, and Mathematics Subjects in North-East, Nigeria

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ABSTRACT

Workforce related to science, technology, engineering, and mathematics (STEM) fields has become increasingly important. STEM subjects form the basis of many career opportunities in science, technology, and management-related disciplines. Some of these jobs might be obvious, like research scientist, doctor, engineer, accountant, software developer, etc. States in the north-east region of Nigeria has been classified as educationally less developed states (ELDS), An overview of data on educational performances and admission spaces in federal tertiary institutions in Nigeria, shows that the six states in the north-east geopolitical region have consistently produced fewer number of candidates' study STEM related carrier in higher institutions of learning in Nigeria compared to number of spaces available to them by design. This study, therefore, identified the risk factors that affect the senior secondary students' academic achievement in selected science, technology, engineering, and mathematics subjects in the north-east geopolitical region in Nigeria. Data were collected from stakeholders in the six states of the north-east region using Saaty's nine-point scale structured questionnaire with the assistance of properly trained Interviewers. A multi-criteria decision-making method, the Analytic Hierarchy Process (AHP) was used. Using excels solver version 2.4, the risk factors were assessed and prioritized in the following order: School Base Factor (SB) considered to be 1st priority, Parental Factor (PF) 2nd priority, Teaching Facilities (TF) 3rd priority, Student Learning Skill (SL) 4th priority, Adequate & Qualified Teacher (AQ) 5th priority, Motivation (MF) 6th priority, Awareness (AW) 7th priority and Peer Group Factor (PG) 8th priority. It is recommended that the three most important factors, namely: school-based factor, parental factor, and teaching facilities, should be given due attention for students in the north-east to succeed in STEM-related subjects and disciplines.

1. Introduction

During the 21st century, the workforce related to science, technology, engineering, and mathematics (STEM) fields has become increasingly important (Ashford, 2016; Khalil & Osman, 2017; Wilhelm, 2014). Many countries have integrated STEM education into their school curricula, providing a meaningful learning environment (Siregar, Rosli, Maat & Capraro, 2020). According to McCaslin (2015), STEM education is a critical tool for improving students' knowledge and understanding in related fields, and the integration of STEM project-based learning embraces constructivism and cognitive principles in the learning process. A good understanding of STEM can cultivate students' thinking skills, which can help students form the ability to analyze, evaluate, and make conclusions and arguments correctly and logically about problems to be solved (Chia & Maat, 2018; Dwyer, Hogan, & Stewart, 2014). Hence, STEM subjects form the basis of many career opportunities in science, technology, and management-related disciplines. Some jobs might be obvious, like research scientist, doctor, engineer, accountant, software developer, etc.

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It is worth noting that the development of any nation has been linked to its scientific and technological development. Adikwu (2012) opined that any nation that wants to experience economic growth must have a strong commitment toward science. This implies that science plays a significant role in the economic, technological, and environmental development of any nation because science has permeated all facets of human life. Hence, in many climes there have been a paradigm shift from the disciplinary approach to teaching and learning Science, Technology, Engineering, and Mathematics (STEM), by integrating the four disciplines into interdisciplinary and multidisciplinary one called STEM education to show the interconnectedness among the various disciplines and how the skills acquired could be used in the real world (Onanuga & Saka, 2018). STEM is important because it pervades every part of our lives. Science is everywhere in the world around us. Technology is continuously expanding into every aspect of our lives. Engineering is the basic design of roads and bridges, but it also tackles the challenges of changing global weather and environmentally friendly changes to our home. Mathematics is in every occupation and in every activity we do in our lives (Sharma, 2021; Kavak, 2023).

The constitution of the Federal Republic of Nigeria FGN (1999), section 18(1) and (2), imposes constitutional obligations on both Federal and State governments in Nigeria to ensure the promotion of science and technology in educational curricula, among other provisions. According to Oloyede (2020), “most of the challenges confronting Nigeria today arose from lack or poor access to education by its citizens.”, the northeast geo-political zone of Nigeria; which comprise of Adamawa, Borno, Bauchi, Gombe, Taraba and Yobe States, has its fair share of the challenges.

According to a newspaper report, the zone accounts for nearly 60 percent of the 13 million out-of-school children in Nigeria (Vanguard, March 5, 2020). It was observed that, as of 2024, the zone can boast of 20 universities: Adamawa 3, Borno 4, Bauchi 3, Gombe 5, Yobe 2, and Taraba 3 Universities. Among them are 8 federal universities, 7 state universities, and 5 private universities. And a few other colleges of education and polytechnics. Above is the trend or situation for admission into all programmes. What is the situation with science, technology, engineering, and mathematics (STEM) related to admission and the programmes?

States in the Northeast region have been classified as less educationally developed states (ELDS), yet the zone has not been able to utilise the Joint Admission and Matriculation Board (JAMB) allotted 25% vacancies for admissions available to them. During the 21st century, the workforce related to science, technology, engineering, and mathematics (STEM) fields has become increasingly important (Ashford, 2016; Khalil & Osman, 2017; Wilhelm, 2014). Many countries have integrated STEM education into the school curricula, providing a meaningful learning environment (Siregar, Rosli, Maat & Capraro, 2020). According to McCaslin (2015), STEM education is a critical tool for improving students’ knowledge and understanding in related fields, and the integration of STEM project-based learning embraces constructivism and cognitive principles in the learning process. A good understanding of STEM can cultivate students' thinking skills, which can help students form the ability to analyze, evaluate, and make conclusions and arguments correctly and logically about problems to be solved (Chia & Maat, 2018; Dwyer, Hogan, & Stewart, 2014). Hence, STEM subjects form the basis of many career opportunities in science, technology, and management-related disciplines. Some of these jobs might be obvious, like research scientist, doctor, engineer, accountant, software developer, etc.

According to Chinyere and Yamma (2021), the integration of technology in education has revolutionized teaching and learning processes, making them more interactive and accessible. The highlight the broad impacts of technological advancements in Nigerian society, particularly in sectors like education, finance, and communication. Ibrahim and Syed (2022) emphasized the transformative impact of STEM advancements in the secondary school teaching process. The study underscores how STEM education has redefined teaching methodologies, aligning them more effectively with modern educational needs. The study also emphasized the transformative role of STEM in enhancing the quality of education and preparing students for contemporary challenges. The study by Chisom *et al.* (2023) revealed a dynamic interplay of progress and challenges in Nigerian STEM education. These include the need for policy reforms focusing on teacher training, curriculum development, and the integration of technology, the study emphasized the need for gender equity in STEM fields and aligning education with industry needs.

Umoh (2016) stressed that STEM education is pivotal to the technological development and progress of any nation, while Salau (2017) opined that students need a strong foundation in these subjects to function properly in the 21st century. Further, on the importance of STEM, Amoo, Adekola, and Oladosun (2019) opined that integrating STEM education with humanities and social science disciplines could make the programme holistic, interdisciplinary, and multidisciplinary towards effective and rapid delivery of economic development. The United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2016) stated that STEM fields are crucial for sustainable development because they help in finding solutions to threats posed by global challenges such as climate change, global health epidemics, and increased income inequality. This implies that effective STEM education is capable of inculcating in learners the skills that will enable them to function effectively in modern-day society, which has been described as knowledge-driven by many nations. STEM subjects include Biology, Chemistry, Physics, Design and Technology, Mathematics, Computer science and Information and Communication technology (ICT), Economics and Geography.

The objective of this study is to assess and prioritize critical factors affecting students' academic achievement in STEM subjects in senior secondary school examinations in the northeastern states using a multi-criteria decision method. This study will be of benefit to the government, people, and stakeholders in the Northeast region. It will create awareness on the critical factors affecting performances in STEM subjects in the region and assist the government and non-governmental organizations to push resources to assist in the development of STEM training and professionals in the region.

2. METHODOLOGY

The study employs a multistage purposive sampling design. In the first stage, one local government area was selected from each of the states in northeastern Nigeria. In the second stage, urban and rural communities were where considered within each selected local government area. From each of these communities, two urban and two rural public secondary schools and one private secondary school were selected. In each of these schools, five key stakeholders including; a parent, community leader/elder stateman, security personal, principal/teacher and student were selected and interviewed using Saaty (2008) nine-point scale structured questionnaire. The instrument was administered with the assistance of trained interviewers. Thus, a total of ten (10) responses were collected from two public secondary schools in urban centers, ten (10) responses from two public secondary schools in rural area, and five responses from private secondary school. This gives total of twenty-five (25) responses per local government. Research ethics were also considered during the data collection processes.

2.1 Method of Data Analysis

The Analytic Hierarchy Process (AHP) is one of the methods for multi-criteria decision making. The method disaggregated a complex decision problem into different hierarchical levels. It aims at quantifying relative priorities for a given set of alternatives on a ratio scale, based on the judgment of the decision-maker, and stresses the importance of the intuitive judgments of a decision-maker as well as the consistency of the comparison of alternatives in the decision-making process. The weights for each criterion and alternative are judged in pairwise comparisons, and priorities are calculated by the Eigenvector method (Schmidt *et al*., 2015). The strength of the AHP approach is that it organizes tangible and intangible factors systematically, and provides a structured yet relatively simple solution to decision-making problems.

The AHP also allows group decision-making, where group members can use their experience, values, and knowledge to break down a problem into a hierarchy and solve it by the AHP steps. Brainstorming and sharing ideas and insights (inherent in the use of Expert Choice in a group setting) often leads to a more complete representation and understanding of the issues.

AHP is applied in different aspects of life, including health care systems. In 2009, IQWiG commissioned a systematic literature review to obtain information on how and where AHP was used in healthcare decision making. Eighty-five articles were identified, of which fifty-five reported on specific applications of AHP in different decision-making contexts. Of these, 44 percent focused on management decisions in healthcare organizations, 25 percent on the development of clinical guidelines, 13 percent, respectively, on shared decision making and the development of national healthcare policy, and 5 percent on the development of healthcare innovations. The review supported the notion that AHP was a well-structured decision-making tool, which was easy to handle for different groups of individuals participating in the pairwise-comparison procedures (Danner *et al.*, 2011). Alimohammadzadeh *et al.* (2016) proposed a method for ranking of radiology departments in selected hospitals of Tehran city using an analytical hierarchical process (AHP) and quality evaluation of their service. Liu and Giovanni (2019), used AHP and the Likert scale to evaluate a new health technology to assay thyroglobulin in patients with differentiated thyroid cancer to improve its service from an organizational point of view, by planning new and appropriate training activities, ensuring proper use of resources and satisfying the needs of different users. Results show the need for particular clinical efficiency, effectiveness, and return on sales (ROS) related to the technology; technological safety, human resources, and other parameters do not need to be improved because of the high satisfaction results of the users. AHP was also used to prioritize alternative strategies for malaria control in Bauchi State, Nigeria, the result shows that the use of insecticide-treated nets was ranked the best strategy for malaria control (Simon *et al.,* 2019). Hsu and Ding (2021) applied the fuzzy analytic AHP method to investigate key indicators of health promotion policies for an aging society in Taiwan.

AHP Nine-point scale for pairwise comparison for relative importance as defined and quantified by Saaty (2008) is presented in Table 1.

Table 1: AHP Nine-Point Scale for Pairwise Comparison for Relative Importance

S/N	**Verbal Judgments**	**Numerical Rating**
1	Extremely preferred	9
2	Very strongly to extremely preferred	8
3	Very strongly preferred	7
4	Strongly to very strongly preferred	6
5	Strongly preferred	5
6	Moderately to strongly preferred	4
7	Moderately preferred	3
8	Equally to moderately preferred	2
9	Equally preferred	1

The following steps will be considered to develop AHP:

i. Define the problem and determine its goal.

ii.. Structure the hierarchy from the top (the objectives from a decision-maker's viewpoint) through the intermediate levels (criteria on which subsequent levels depend) to the lowest level, which usually contains the list of alternatives. This is shown in Figure 1.

Level 1: Goal or Objective

Level2: Criteria

Level3: Alternative

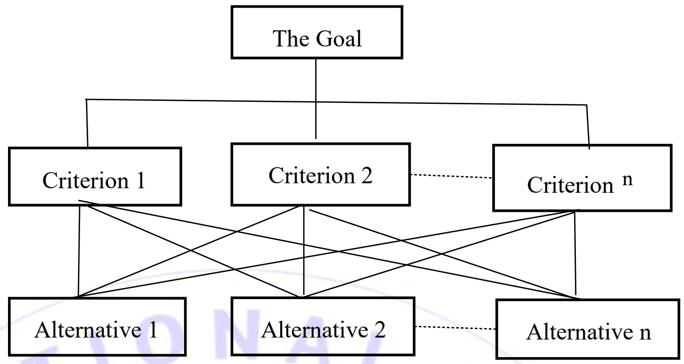

Figure 1. AHP Decision Hierarchy

iii. Construct a set of pairwise comparison matrices $(size \;\; n \times n)$ for each of the lower levels, with one matrix for each element in the level immediately above by using the relative scale measurement shown in Table 1. The pair-wise comparisons are done in terms of which element dominates the other.

$$A = \begin{pmatrix} w_{11} & w_{12} & w_{13} & \cdots & w_{1n} \\ w_{21} & w_{22} & w_{23} & \cdots & w_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ w_{n1} & w_{n2} & w_{n3} & \cdots & w_{nn} \end{pmatrix} \quad (1)$$

iv There are *n (n-1)*/judgments required to develop the set of matrices in step 3. Reciprocals are automatically assigned in each pairwise comparison.

$$W = \begin{pmatrix} 1 & \frac{w_1}{w_2} & \frac{w_1}{w_3} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & 1 & \frac{w_2}{w_3} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \frac{w_n}{w_3} & \cdots & 1 \end{pmatrix} \quad (2)$$

Note that $\forall i, j,: w_{ij} = \frac{1}{w_{jn}}$

v. Hierarchical synthesis is now used to weight the eigenvectors by the weights of the criteria, and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.

vi Having made all the pair-wise comparisons, the consistency is determined by using the eigenvalue,

$\lambda_{\max}$, to calculate the consistency index, CI, as follows: $CI = (\lambda_{\max} - n)/(n-1)$ where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value in Table 2.

The $CR = \frac{CI}{RI}$ is acceptable if it does not exceed 0.10. If it is more, the judgment matrix is RI

inconsistent, where RI is a random index. To obtain a consistent matrix, judgments should be reviewed and improved.

vii. Steps 3 - 6 are performed for all levels in the hierarchy.

Table 2: Average random Index

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.52	1.54	1.56	1.58	1.59

(Jeremy *et al*, 2017)

viii. Obtaining an overall relative score for each option or alternative. In a final step, the option scores are combined with the criterion weights to produce an overall score for each option. The extent to which the options satisfy the criteria is weighed according to the relative importance of the criteria. This is done by a simple weighted summation.

Aggregation Methods

The two widely used approaches to handle aggregation of individual judgement of pairwise comparison of the evaluating factor (criteria/alternatives) in AHP are the geometric mean and arithmetic mean. The responses of the experts' pairwise comparison judgement (score) are aggregated to arrive at the pairwise comparison matrix. Aggregation of individual judgments (AIJ) is usually performed using the geometric mean, while aggregation of the individual priorities (AIP) is usually performed using the arithmetic mean (Angiz *et al.,* 2012; Ossadnik *et al.*, 2016; Wu *et al*., 2008).

Forman and Peniwati (1998) maintained that in aggregating individual judgments, each individual is regarded as independent and considered both geometric and arithmetic means as appropriate procedures for ratio scales. But of these two methods, only the geometric mean satisfies the Pareto Principle (unanimity condition and homogeneity condition). Using the geometric mean in AHP for prioritizing decisions with diverse group members provides a range of benefits, including balancing perspectives, mitigating bias, promoting consensus, enhancing transparency, ensuring robustness to variability, and facilitating efficient and consistent decision-making. By leveraging the strengths of the geometric mean, groups can effectively navigate the complexities of decision-making in heterogeneous settings and arrive at informed and consensus-driven choices. In this study geometric mean was adopted to aggregate the pairwise comparison judgements of the criteria of all the experts to obtain the aggregate pairwise comparison matrix for the criteria. Aggregating Expert scores by geometric mean is given in question (3) below (Wu *et al*., 2008).

$$x_{ij}] = \begin{bmatrix} & C_1 & C_2 & \cdots & C_n \\ C_1 & 1 & \sqrt[m]{\prod_{e=1}^{m} x_{12}^{(e)}} & \cdots & \sqrt[m]{\prod_{e=1}^{m} x_{1n}^{(e)}} \\ C_2 & \frac{1}{\sqrt[m]{\prod_{e=1}^{m} x_{21}^{(e)}}} & 1 & \cdots & \sqrt[m]{\prod_{e=1}^{m} x_{2n}^{(e)}} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ C_n & \frac{1}{\sqrt[m]{\prod_{e=1}^{m} x_{n1}^{(e)}}} & \frac{1}{\sqrt[m]{\prod_{e=1}^{m} x_{n2}^{(e)}}} & \cdots & 1 \end{bmatrix} \quad (3)$$

Where:

x_{ij} = represents the verbal judgments of an expert/respondent; j= 1, 2, 3, … n

C = Represents the criteria;

i =1, 2, … n,   e = 1, 2, … m, represents the number of experts.

Structure of the AHP decision problem under consideration

The risk factors (alternatives) to be assessed and the criteria used in this study are shown in Table 3. Figure 2 shows the AHP decision structure of the considered problem. The overall goal is the assessment of the risk factors affecting senior secondary school students' academic achievement in selected STEM subjects (Level 1). Followed by sub-levels. criteria (Level 2) and risk factors/alternatives (Level 3). The structure of the aggregate pairwise comparison matrix for the criteria is shown in matrix B in equation (4), and the structure of the pairwise comparison matrix of the alternatives with respect to the five different criteria is shown in Matrix C_j (for j = 1, 2, 3, 4, 5) in equation (5).

Table 3: The Risk Factors Affecting Senior Secondary School Students' Academic Achievement in selected STEM subjects and Criteria for Assessment

S/N	Risk Factors (Alternatives)	S/N	Criteria for Assessment
i.	School-based factor - **SB**	i.	Economic – **EC**
ii.	Peer group factor - **PG**	ii.	Environment – **EV**
iii.	Parental factor - **PF**	iii.	Community Practice **– CP**
iv.	Awareness **– AW**	iv.	Value – **VL**
v.	Adequate & qualified teacher – **QA**	v.	Security **– SE**
vi.	Teaching facilities **– TF**		
vii.	Motivation - **MF**		
viii.	Student learning skill - **SL**		

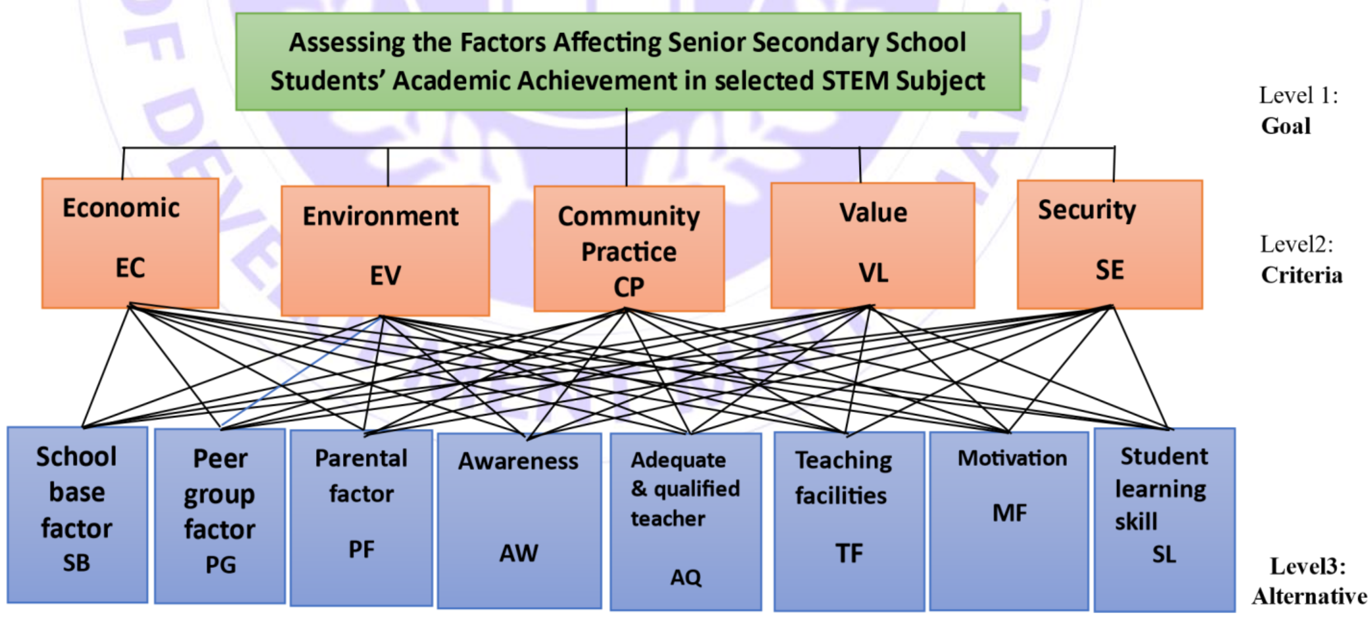

Figure 2: Hierarchical structure of the AHP Problem

$$B = \begin{pmatrix} & EC & EV & CP & VL & SE \\ EC & 1 & a_{12} & a_{13} & a_{14} & a_{15} \\ EV & - & 1 & a_{23} & a_{24} & a_{25} \\ CP & - & - & 1 & a_{34} & a_{35} \\ VL & - & - & - & 1 & a_{45} \\ SE & - & - & - & - & 1 \end{pmatrix} \quad (4)$$

$$C_j = \begin{pmatrix} & SB & PG & PF & AW & TF & MF & SL \\ SB & 1 & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} & a_{17} \\ PG & - & 1 & a_{23} & a_{24} & a_{25} & a_{26} & a_{27} \\ PF & - & - & 1 & a_{34} & a_{35} & a_{36} & a_{37} \\ AW & - & - & - & 1 & a_{45} & a_{46} & a_{47} \\ TF & - & - & - & - & 1 & a_{56} & a_{57} \\ MF & - & - & - & - & - & 1 & a_{67} \\ SL & - & - & - & - & - & - & 1 \end{pmatrix} \quad (5)$$

$j = 1, 2\ 3\ 4\ 5$

3. Results and Discussion

A total of 150 stakeholders responded (125 males and 25 females), of which 25 are from Adamawa, 28 from Borno, 23 from Bauchi, 23 from Gombe, 26 from Taraba, and 23 from Yobe, while 2 did not indicate their state of origin. The stakeholders in the six states of the Northeast geopolitical zone were fairly represented. More than 82% (126) of the respondents are 30 years and above, and 75% (115) of them attended a higher institution of learning.

Using geometric mean, the Aggregate pairwise comparison judgements from the 150 respondents (stakeholders) in the six states of the northeast geopolitical zone produce the pairwise comparison matrix of the five criteria, shown in Table 4. Table 5 shows the complete pairwise comparison matrix and synthesized matrix of the criteria. The judgements of the stakeholders were consistent as the value of consistency ratio CR = 0.05 < 0.1.

Table 4: Pairwise Comparison Matrix of the Five Criteria

	EC	EV	CP	VL	SC
EC	1	1.64842	1.52506	0.77696	0.91371
EV	-	1	1.423	0.79603	0.96451
CP	-	-	1	0.85723	0.96285
VL	-	-	-	1	1.3433
SC	-	-	-	-	1

Table 5: Pairwise Comparison Matrix of the Criteria and Synthesized Matrix with Priority Vector.

Complete Pairwise Comparison Matrix of Criteria.						**Synthesized Matrix of The Criteria**					
Criteria	**EC**	**EV**	**CP**	**VL**	**SC**	**EC**	**EV**	**CP**	**VL**	**SC**	**Priority Victor**
EC	1.00	1.65	1.53	0.78	0.91	0.22	0.29	0.25	0.19	0.18	**0.22**
EV	0.61	1.00	1.42	0.80	0.96	0.13	0.18	0.23	0.19	0.19	**0.18**
CP	0.66	0.70	1.00	0.86	0.96	0.14	0.12	0.16	0.21	0.19	**0.16**
VL	1.29	1.26	1.17	1.00	1.34	0.28	0.22	0.19	0.24	0.26	**0.24**
SC	1.09	1.04	0.96	0.74	1.00	0.24	0.18	0.16	0.18	0.19	**0.19**
Total	**4.64**	**5.64**	**6.08**	**4.17**	**5.18**						**1.00**

λ_{max} = 5.05, C.I = 0.013, RI = 1.12, $CR_{criteria}$ = 0.012 < 0.1, the judgment is consistent

Table 6 shows the geometric mean aggregate pairwise comparison matrix judgements of the eight alternatives with respect to the economic (EC) criterion by all the respondents in the six states of the North-east geopolitical zone. Table 7 shows the Synthesized matrix and the priority vector of the pairwise comparison matrix of the alternatives with respect to the Economic (EC) criteria. The judgement of the respondents was found to be consistence as shown by the value of the consistency ratio, CR_{EC} = 0.078 < 0.1.

Similarly, the pairwise comparison matrix judgments of the alternatives with respect to the remaining criteria (EN, CP, VL, and SC) by the stakeholders in all the six states were obtained in Tables 8, 10, 12, and 14, respectively. Their respective synthesized matrices and priority vectors were shown in Tables 9, 11, 13, and 15, respectively. Judgment of the respondents was also consistent, as shown by the consistency Ratios, CR_{EN} = 0.065 < 0.1, CR_{CP} = 0.080 < 0.1, CR_{VL} = 0.088 < 0.1, and CR_{SC} =0.084 < 0.1, respectively.

Table 16 shows the overall priority matrix for assessing the risk factors (alternatives) affecting senior secondary school students' academic achievement in selected STEM subjects. The overall priority vectors of the alternative with respect to the criteria, this shows that school base factor (SB) considered to be the first priority, follow by Parental factor (PF) second priority, Teaching facilities (TF) third priority, Student learning skill (SL) fourth priority, Adequate & qualified teacher (AQ) fifth priority, Motivation (MF) sixth priority, Awareness (AW) seventh priority and Peer group factor (PG) eighth priority.

Table 6: Pairwise Comparison Matrix of the Alternatives with Respect to Economic (EC) Criteria

With respect to EC	**SB**	**PG**	**PF**	**AW**	**AQ**	**TF**	**MF**	**SL**
SB	1.0000	1.0397	1.1022	1.1431	0.7999	1.5007	1.0251	0.9838
PG	-	1.0000	0.7253	0.7361	0.7952	1.1470	0.8187	0.6797
PF	-	-	1.0000	0.7778	1.0229	1.0813	0.8517	0.8912
AW	-	-	-	1.0000	0.6990	0.9705	1.0368	0.9165
AQ	-	-	-	-	1.0000	1.1229	0.9249	0.8291
TF	-	-	-	-	-	1.0000	1.2103	0.8110
MF	-	-	-	-	-	-	1.0000	0.9551
SL	-	-	-	-	-	-	-	1.0000

Table 7: Pair-Wise Comparison Matrix of the Alternatives with Respect to Economic (EC) Criterion and Synthesized Matrix with Priority Vector

Pairwise Comparison of the Complate Matrix of the Alternatives with Respect to Economic Criterion									**Synthesized Matrix of the Pairwise Comparison**								
with respect to EC	**SB**	**PG**	**PF**	**AW**	**AQ**	**TF**	**MF**	**SL**	**SB**	**PG**	**PF**	**AW**	**AQ**	**TF**	**MF**	**SL**	**Priority Vector**
SB	1.00	1.04	1.10	1.14	0.80	1.50	1.03	0.98	0.13	0.11	0.13	0.15	0.11	0.17	0.13	0.14	0.13
PG	0.96	1.00	0.73	0.74	0.80	1.15	0.82	0.68	0.13	0.10	0.09	0.10	0.11	0.13	0.10	0.10	0.11
PF	0.91	1.38	1.00	0.78	1.02	1.08	0.85	0.89	0.12	0.14	0.12	0.10	0.14	0.12	0.11	0.13	0.12
AW	0.87	1.36	1.29	1.00	0.70	0.97	1.04	0.92	0.11	0.14	0.15	0.13	0.09	0.11	0.13	0.13	0.13
AQ	1.25	1.26	0.98	0.70	1.00	1.12	0.92	0.83	0.16	0.13	0.12	0.09	0.13	0.13	0.12	0.12	0.12
TF	0.67	0.87	0.92	1.03	0.89	1.00	1.21	0.81	0.09	0.09	0.11	0.14	0.12	0.11	0.15	0.11	0.12
MF	0.98	1.22	1.17	0.96	1.08	0.83	1.00	0.96	0.13	0.13	0.14	0.13	0.14	0.09	0.13	0.14	0.13
SL	1.02	1.47	1.12	1.09	1.21	1.23	1.05	1.00	0.13	0.15	0.13	0.15	0.16	0.14	0.13	0.14	0.14
TOTAL	**7.65**	**9.60**	**8.31**	**7.44**	**7.49**	**8.88**	**7.91**	**7.07**									**1.00**

λ_{max}= 8.77, CI = 0.11, RI = 1.41, CR_{EC} = 0.078 < 0.1, the judgment is consistent.

Table 8: Pairwise Comparison Matrix of the Alternatives with Respect to Environmental (EN) Criteria

With respect to EN	**SB**	**PG**	**PF**	**AW**	**AQ**	**TF**	**MF**	**SL**
SB	1.0000	1.8521	1.2374	2.1825	1.6889	1.4653	1.4702	2.1134
PG		1.0000	0.4515	0.5929	0.6344	0.6772	0.7767	0.9285
PF	-	-	1.0000	2.1107	1.1068	0.9633	1.1445	1.0363
AW	-	-	-	1.0000	1.0829	0.6806	0.7038	1.1448
AQ	-	-	-	-	1.0000	1.0889	0.8322	1.3672
TF	-	-	-	-	-	1.0000	1.5057	1.0973
MF	-	-	-	-	-	-	1.0000	2.0345
SL	-	-	-	-	-	-	-	1.0000

Table 9: Pair-Wise Comparison Matrix of the Alternatives with Respect to Environmental (EN) Criterion and Synthesized Matrix with Priority Vector

Pairwise Comparison of the Complate Matrix of the Alternatives with Respect to Enveromental Criterion									Synthesized Matrix of the Pairwise Comparison								
with respect to EN	SB	PG	PF	AW	AQ	TF	MF	SL	SB	PG	PF	AW	AQ	TF	MF	SL	Priority Vector
SB	1.00	1.85	1.24	2.18	1.69	1.47	1.47	2.11	0.19	0.15	0.18	0.20	0.20	0.20	0.19	0.20	0.19
PG	0.54	1.00	0.45	0.59	0.63	0.68	0.78	0.93	0.10	0.08	0.07	0.06	0.08	0.09	0.10	0.09	0.08
PF	0.81	2.21	1.00	2.11	1.11	0.96	1.14	1.04	0.15	0.18	0.14	0.20	0.13	0.13	0.14	0.10	0.15
AW	0.46	1.69	0.47	1.00	1.08	0.68	0.70	1.14	0.09	0.14	0.07	0.09	0.13	0.09	0.09	0.11	0.10
AQ	0.59	1.58	0.90	1.08	1.00	1.09	0.83	1.37	0.11	0.13	0.13	0.10	0.12	0.15	0.11	0.13	0.12
TF	0.68	1.48	1.04	1.47	0.92	1.00	1.51	1.10	0.13	0.12	0.15	0.14	0.11	0.13	0.19	0.10	0.13
MF	0.68	1.29	0.87	1.42	1.20	0.66	1.00	2.03	0.13	0.11	0.13	0.13	0.14	0.09	0.13	0.19	0.13
SL	0.47	1.08	0.96	0.87	0.73	0.91	0.49	1.00	0.09	0.09	0.14	0.08	0.09	0.12	0.06	0.09	0.10
TOTAL	**5.23**	**12.17**	**6.94**	**10.73**	**8.36**	**7.45**	**7.92**	**10.72**									**1.00**

$\lambda_{max} = 8.64$, CI = 0.091, RI = 1.41, $CR_{EN} = 0.065 < 0.1$, the judgment is consistent.

Table 10: Pairwise Comparison Matrix of the Alternatives with Respect to Community Practice (CP) Criteria

With respect to CP	SB	PG	PF	AW	AQ	TF	MF	SL
SB	1.0000	1.7928	1.1564	0.9280	1.3475	1.1831	1.0606	1.2879
PG		1.0000	0.7346	0.7474	0.9076	0.7415	0.7720	0.6589
PF	-	-	1.0000	1.0493	1.2725	0.8546	1.0913	1.2983
AW	-	-	-	1.0000	1.0487	1.0871	1.0568	1.0180
AQ	-	-	-	-	1.0000	0.7952	0.9470	1.5185
TF	-	-	-	-	-	1.0000	0.9522	0.6779
MF	-	-	-	-	-	-	1.0000	1.1459
SL	-	-	-	-	-	-	-	1.0000

Table 11: Pair-Wise Comparison Matrix of the Alternatives with Respect to Community Practice (CP) Criterion and Synthesized Matrix with Priority Vector

Pairwise Comparison of the Complate Matrix of the Alternatives with Respect to Community Practice Criterion									Synthesized Matrix of the Pairwise Comparison								
with respect to CP	SB	PG	PF	AW	AQ	TF	MF	SL	SB	PG	PF	AW	AQ	TF	MF	SL	Priority Vector
SB	1.00	1.79	1.16	0.93	1.35	1.18	1.06	1.29	0.15	0.17	0.15	0.12	0.16	0.14	0.14	0.15	0.15
PG	0.56	1.00	0.73	0.75	0.91	0.74	0.77	0.66	0.08	0.09	0.10	0.10	0.11	0.09	0.10	0.08	0.09
PF	0.86	1.36	1.00	1.05	1.27	0.85	1.09	1.30	0.13	0.13	0.13	0.14	0.15	0.10	0.14	0.15	0.13
AW	1.08	1.34	0.95	1.00	1.05	1.09	1.06	1.02	0.16	0.12	0.13	0.13	0.12	0.13	0.14	0.12	0.13
AQ	0.74	1.10	0.79	1.05	1.00	0.80	0.95	1.52	0.11	0.10	0.10	0.14	0.12	0.10	0.12	0.18	0.12
TF	0.85	1.35	1.17	0.92	1.26	1.00	0.95	0.68	0.12	0.13	0.16	0.12	0.15	0.12	0.12	0.08	0.12
MF	0.94	1.30	0.92	0.95	1.06	1.05	1.00	1.15	0.14	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13
SL	0.78	1.52	0.77	0.98	0.66	1.48	0.87	1.00	0.11	0.14	0.10	0.13	0.08	0.18	0.11	0.12	0.12
TOTAL	**6.81**	**10.76**	**7.49**	**7.62**	**8.55**	**8.19**	**7.75**	**8.61**									**1.00**

λ_{max}= 8.79, CI = 0.113, RI = 1.41, CR_{CP} = 0.080 < 0.1, the judgment is consistent.

Table 12: Pairwise Comparison Matrix of the Alternatives with Respect to Value Criteria (VL) Criteria

With respect to VL	SB	PG	PF	AW	AQ	TF	MF	SL
SB	1.0000	1.1182	1.1842	1.0198	1.3391	1.2961	1.2196	0.9792
PG	-	1.0000	1.2474	1.0561	1.2429	1.1359	1.1163	1.3451
PF	-	-	1.0000	1.1554	1.1226	0.7186	1.3364	0.9287
AW	-	-	-	1.0000	1.2165	0.6544	0.6886	0.7675
AQ	-	-	-	-	1.0000	0.9548	0.9790	0.7097
TF	-	-	-	-	-	1.0000	0.9109	0.7133
MF	-	-	-	-	-	-	1.0000	0.7168
SL	-	-	-	-	-	-	-	1.0000

Table 13: Pair-Wise Comparison Matrix of the Alternatives with Respect to Value (VL) Criterion and Synthesized Matrix with Priority Vector

Pairwise Comparison of the Complate Matrix of the Alternatives with Respect to Value Criterion									Synthesized Matrix of the Pairwise Comparison								
With respect to VL	SB	PG	PF	AW	AQ	TF	MF	SL	SB	PG	PF	AW	AQ	TF	MF	SL	Priority Vector
SB	1.00	1.12	1.18	1.02	1.34	1.30	1.22	0.98	0.14	0.16	0.14	0.10	0.14	0.16	0.14	0.14	0.14
PG	0.89	1.00	1.25	1.06	1.24	1.14	1.12	1.35	0.13	0.14	0.15	0.11	0.13	0.14	0.13	0.19	0.14
PF	0.84	0.80	1.00	1.16	1.12	0.72	1.34	0.93	0.12	0.11	0.12	0.12	0.12	0.09	0.15	0.13	0.12
AW	0.98	0.95	0.87	1.00	1.22	0.65	0.69	0.77	0.14	0.13	0.10	0.10	0.13	0.08	0.08	0.11	0.11
AQ	0.75	0.80	0.89	1.22	1.00	0.95	0.98	0.71	0.11	0.11	0.11	0.13	0.11	0.12	0.11	0.10	0.11
TF	0.77	0.88	1.39	1.53	1.05	1.00	0.91	0.71	0.11	0.12	0.17	0.16	0.11	0.12	0.11	0.10	0.12
MF	0.82	0.90	0.75	1.45	1.02	1.10	1.00	0.72	0.12	0.12	0.09	0.15	0.11	0.13	0.12	0.10	0.12
SL	1.02	0.74	1.08	1.30	1.41	1.40	1.40	1.00	0.14	0.10	0.13	0.13	0.15	0.17	0.16	0.14	0.14
TOTAL	**7.08**	**7.19**	**8.40**	**9.73**	**9.40**	**8.26**	**8.65**	**7.16**									**1.00**

λ_{max}= 8.867, CI = 0.124, RI = 1.41, CR_{VL} = 0.088 < 0.1, the judgment is consistent.

Table 14: Pairwise Comparison Matrix of the Alternatives with Respect to Security Criteria (SC)

With respect to SC	SB	PG	PF	AW	AQ	TF	MF	SL
SB	1.0000	1.4920	1.0931	0.7334	1.7518	1.1177	1.2503	1.7747
PG	-	1.0000	0.9002	1.0627	1.4652	1.0382	1.4131	1.0287
PF	-	-	1.0000	0.8804	1.0579	1.3620	1.9371	1.3148
AW	-	-	-	1.0000	1.4625	0.7441	1.0836	0.9363
AQ	-	-	-	-	1.0000	1.2305	1.3996	1.2999
TF	-	-	-	-	-	1.0000	1.0451	1.5483
MF	-	-	-	-	-	-	1.0000	0.9929
SL	-	-	-	-	-	-	-	1.0000

Table 15: Pair-Wise Comparison Matrix of the Alternatives with Respect to Security (SC) Criterion and Synthesized Matrix with Priority Vector

Pairwise Comparison of the Complate Matrix of the Alternatives with Respect to Security Criterion									Synthesized Matrix of the Pairwise Comparison								
With respect to SC	SB	PG	PF	AW	AQ	TF	MF	SL	SB	PG	PF	AW	AQ	TF	MF	SL	Priority Vector
SB	1.00	1.49	1.09	0.73	1.75	1.12	1.25	1.77	0.15	0.19	0.15	0.09	0.19	0.14	0.12	0.18	0.15
PG	0.67	1.00	0.90	1.06	1.47	1.04	1.41	1.03	0.10	0.13	0.13	0.13	0.16	0.13	0.14	0.10	0.13
PF	0.91	1.11	1.00	0.88	1.06	1.36	1.94	1.31	0.13	0.14	0.14	0.10	0.12	0.17	0.19	0.13	0.14
AW	1.36	0.94	1.14	1.00	1.46	0.74	1.08	0.94	0.20	0.12	0.16	0.12	0.16	0.09	0.11	0.09	0.13
AQ	0.57	0.68	0.95	1.46	1.00	1.23	1.40	1.30	0.08	0.09	0.13	0.17	0.11	0.15	0.14	0.13	0.13
TF	0.89	0.96	0.73	1.34	0.81	1.00	1.05	1.55	0.13	0.12	0.10	0.16	0.09	0.12	0.10	0.16	0.12
MF	0.80	0.71	0.52	0.92	0.71	0.96	1.00	0.99	0.12	0.09	0.07	0.11	0.08	0.12	0.10	0.10	0.10
SL	0.56	0.97	0.76	1.07	0.77	0.65	1.01	1.00	0.08	0.12	0.11	0.13	0.09	0.08	0.10	0.10	0.10
TOTAL	**6.78**	**7.87**	**7.09**	**8.47**	**9.03**	**8.10**	**10.14**	**9.90**									**1.00**

$\lambda_{max} = 8.83$, CI = 0.119, RI = 1.41, $CR_{SC} = 0.084 < 0.1$, the judgment is consistent.

Table 16: Overall Priority Matrix for Assessing the Risk Factors/Alternatives

	EC (0.2241)	**EV (0.1837)**	**CP (0.1643)**	**VL (0.2381)**	**SC (0.1898)**	**Overall Priority**	**Priority Ranking**
SB	0.1337	0.1883	0.1473	0.1400	0.1516	0.0302	**1st**
PG	0.1064	0.0821	0.0930	0.1386	0.1265	0.0222	**8th**
PF	0.1224	0.1475	0.1337	0.1199	0.1413	0.0264	**2nd**
AW	0.1260	0.1005	0.1314	0.1089	0.1318	0.0238	**7th**
AQ	0.1250	0.1215	0.1208	0.1103	0.1261	0.0241	**5th**
TF	0.1158	0.1343	0.1247	0.1239	0.1237	0.0248	**3rd**
MF	0.1280	0.1303	0.1274	0.1170	0.0982	0.0240	**6th**
SL	0.1427	0.0955	0.1216	0.1413	0.1007	0.0244	**4th**

4. Conclusion and Recommendation

Five criteria: economic, environment, community practice, value, and security, were considered to assess the eight identified risk factors affecting senior secondary school students' academic achievement in selected science, technology, engineering, and mathematics subjects in the North-East geopolitical region in Nigeria. The stakeholders' judgments obtained across the six states of the North-East region were found to be consistent, as indicated by the value of the consistency ratios ($CI < 0.1$) for both pairwise comparisons of the criteria and pairwise comparisons of risk factors (alternatives) with respect to the five different criteria. Multicriteria decision method-AHP results, using excel solver version 2.4, the risk factors were assessed and prioritized.

The results reviewed that: school base factor (SB) considered to be first (1^{st}) priority, follow by Parental factor (PF) second (2^{nd}) priority, Teaching facilities (TF) third (3^{rd}) priority. Furthermore, the results shows that Student learning skill (SL) ranked fourth (4^{th}), Adequate & qualified teacher (AQ), fifth (5^{th}), Motivation (MF) sixth (6^{th}), Awareness (AW) seventh (7^{th}) and Peer group factor (PG) eighth (8^{th}) priority. The research recommends that the three most important factors, namely: school-based factor, parental factor, and teaching facilities, should be given due attention for students in the North-east to succeed in STEM-related subjects and disciplines.

The findings of this work are in line with the study by Barret *et al.* (2015) and Edgerton and McKechnie (2023), whose work indicates that students' physical school environment, along with attendance, socioeconomic status, and gender, are all significantly related to academic achievement. The findings also corroborate the work of Kanta (2024) and Amposah *et al.* (2018), who concluded that parents can foster a culture of learning and resilience, and that there is a significant positive relationship between parental involvement in education and students' academic performance. Furthermore, the findings also corroborate the finding of several studies, who discovered that readily available teaching facilities have great impact on the students' academic performances (Elegonye, 2020; Ikegbusi *et al.*, 2022; Darman, 2023).

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