



## Enhancing Entrepreneurial Thinking through Integrated Science-Mathematics Projects in Secondary Schools: A Pathway to Sustainable Skill Development

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### Abstract

This study investigated the impact of integrating entrepreneurial skills into science and mathematics curricula on the innovation and problem-solving abilities of secondary school students in Nigeria. Using a quasi-experimental design, 220 Senior Secondary School II students were drawn from four public schools in Zaria Education Zone and divided into experimental and control groups. Three research questions and three null hypotheses were formulated to guide the study. The experimental group received integrated project-based instruction with entrepreneurial contexts, while the control group was taught using lecture methods. Two validated instruments were used for data collection: the Entrepreneurial Thinking Skills Scale (ETSS) adapted from Lackéus (2015), and the Sustainable Skills Development Inventory (SSDI) developed by the researcher and validated by three experts in Science Education and Entrepreneurship. The research Questions were analyzed using mean, standard deviation and mean differences while the hypotheses were tested using Analysis of covariance (ANCOVA). Results from pre- and post-tests analyzed through ANCOVA and showed a statistically significant improvement in entrepreneurial thinking and sustainable skill development among students in the experimental group, with no significant gender-based differences. The findings support Kolb's experiential learning theory and affirm that interdisciplinary, real-world project-based instruction fosters critical 21st-century competencies. The study recommends embedding entrepreneurship into STEM education to promote creativity, economic self-reliance, and lifelong learning. It offers valuable insights for curriculum planners, educators, and policymakers striving to align education with national development goals and global innovation demands.

**Keywords:** Entrepreneurial thinking, integrated science-mathematics projects, innovation, problem-solving, sustainable skills, secondary education, STEM education, experiential learning.

### Introduction

In today's rapidly evolving global landscape, the intersection of science, mathematics, and entrepreneurship has emerged as a critical driver of sustainable development and youth empowerment, especially within developing countries like Nigeria. The 21st-century economy demands that learners go beyond academic excellence to acquire entrepreneurial mindsets, creative problem-solving skills, and the ability to apply theoretical knowledge in innovative, real-world contexts. However, the traditional siloed pedagogical approach—which treats science and mathematics as separate and abstract disciplines—has been criticized for failing to equip students with these essential competencies (Lackéus, 2015). This

disconnect between classroom learning and societal needs has led to calls for an integrated curriculum that merges scientific and mathematical literacy with entrepreneurial competence.

One such promising pedagogical strategy is the integrated science-mathematics project-based approach, which emphasizes the simultaneous teaching of science and mathematics concepts through hands-on, real-life projects that mirror the complex, interdisciplinary nature of real-world problems. Through inquiry, data analysis, experimentation, modeling, and reflection, learners can experience how scientific reasoning and mathematical calculations can be applied to solve meaningful challenges. Bybee

(2013) and Oviawe (2017) emphasize that integration allows learners to construct knowledge holistically, thereby fostering higher-order thinking and innovation. When entrepreneurial contexts are embedded within these integrated projects, students are not only solving problems but are also learning to create value from those solutions, thereby cultivating entrepreneurial thinking. Despite its potential, the use of integrated science-mathematics project-based learning (ISMPBL) remains underutilized in most Nigerian classrooms.

Another key construct is sustainable skill development, which refers to the long-term cultivation of practical, transferable competencies that enable individuals to adapt, innovate, and contribute meaningfully to economic and societal advancement. The relevance of such skills has been amplified by Nigeria's high youth unemployment rate and the urgent need to empower students with self-employment capacities. UNESCO (2018) and the African Union (2021) underscore entrepreneurship education as a strategic response to Africa's development challenges, including poverty, inequality, and joblessness. However, there is still a lack of empirical research investigating how integrated science and mathematics learning, particularly when aligned with entrepreneurial education, can promote sustainable skill development among Nigerian secondary school students. This gap necessitates studies that go beyond theory to explore practical classroom models for skill acquisition.

Gender also emerges as a critical moderating factor in science, mathematics, and entrepreneurship education. Existing studies reveal persistent gender disparities in STEM engagement, with female students often exhibiting lower confidence and interest in science-related careers due to socialization patterns and stereotypical classroom practices (Igbokwe, 2015). When entrepreneurial and STEM content are integrated, gender may influence how students perceive their ability to participate in or benefit from such learning experiences. Thus, understanding gender dynamics in the context of integrated project-based instruction is essential for developing inclusive pedagogies that empower all learners equitably.

Other contextual factors—such as school type, teacher capacity, curriculum policies, and community engagement—also play important roles in the implementation and success of entrepreneurial STEM education in Nigerian secondary schools. While national education policies emphasize entrepreneurship and skill acquisition (Okebukola, 2020), classroom-level realities show limited translation into practice.

Teachers often lack the training and resources to implement innovative, cross-disciplinary teaching strategies. Furthermore, many secondary school students still experience abstract, rote-based instruction, disconnected from their lived experiences and career aspirations.

In light of these concerns, this study seeks to bridge the existing gap by examining how integrated science-mathematics project-based learning can serve as a vehicle for cultivating entrepreneurial thinking and promoting sustainable skill development among Nigerian secondary school students. It further explores how gender influences students' experiences and outcomes within this instructional model. By focusing on practical, context-sensitive applications, this research aims to provide evidence-based recommendations for transforming science and mathematics education into a more relevant and empowering tool for national development.

### Research Questions

This study is guided by the following research questions:

1. What is the difference in entrepreneurial thinking between students exposed to integrated science-mathematics projects and those taught using lecture methods?
2. How do integrated science-mathematics projects influence students' sustainable skill development?
3. What is the mean gender-based difference in entrepreneurial thinking among students exposed to integrated science-mathematics projects?

### Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance:

- H<sub>01</sub>:** There is no significant difference in entrepreneurial thinking between students taught with integrated science-mathematics projects and those taught using lecture methods.
- H<sub>02</sub>:** There is no significant difference in sustainable skill development between students exposed to integrated science-mathematics projects and those taught using lecture methods.
- H<sub>03</sub>:** There is no significant gender-based difference in entrepreneurial thinking among students exposed to integrated science-mathematics projects.

## Theoretical Framework and Literature Review

This study is anchored in Kolb's Experiential Learning Theory (1984) and Constructivist Learning Theory, both of which emphasize learning through active engagement, reflection, and real-world problem-solving. Kolb postulates that knowledge is created through the transformation of experience, a process that aligns closely with entrepreneurial learning, where students explore real-world problems, develop tangible solutions, and learn from the process. Constructivist theorists like Vygotsky (1978) advocate for social interaction and context-based knowledge construction, which further supports the collaborative and authentic nature of project-based STEM learning. In the realm of education, integrated STEM instruction has been shown to improve cognitive engagement, creativity, and problem-solving ability (Beers, 2011; Moore et al., 2014). When infused with entrepreneurship, such instruction empowers students to move from problem identification to business ideation and prototype development. Researchers such as Lack  s (2015) and Oviawe (2017) found that entrepreneurial education enhances students' autonomy, opportunity recognition, and ability to generate innovative solutions. Integrating science and mathematics offers a natural context for applying abstract concepts to entrepreneurial tasks—like designing energy-efficient devices, creating simple weather stations, or developing low-cost water purification systems—which instills both domain knowledge and real-world skills (Bybee, 2013; Akpan & Etuk, 2015). Moreover, empirical studies (e.g., Nwachukwu, 2020; Okebukola, 2021) reveal that students who participate in interdisciplinary, hands-on projects show improved interest, self-efficacy, and entrepreneurial mindset. Yet, implementation in Nigeria remains minimal due to curriculum rigidity, limited teacher capacity, and lack of institutional support. This study therefore contributes to the growing discourse on contextualizing STEM education in Nigeria through entrepreneurial approaches to foster sustainable development.

## Methodology

This study employed a quasi-experimental research design involving pre-test and post-test with experimental and control groups, using intact classes from selected secondary schools in Zaria Education Zone, Kaduna State, Nigeria. The target population consisted of all Senior Secondary School II (SSII) students offering both science and mathematics subjects, estimated at 6,890 students across 24 public co-educational schools. From this population, four schools were purposively selected based on the availability of qualified science and mathematics teachers, active STEM clubs, and basic project facilities. Two schools were randomly assigned to the experimental group and two to the control group, yielding a sample size of 220 students (112 males and 108 females). The experimental group received instruction through integrated science-mathematics project-based learning with entrepreneurial contexts embedded in problem-solving tasks over an eight-week intervention period. These projects included designing simple irrigation systems, constructing low-cost thermometers, and applying geometry to develop business plans for packaging materials. The control group was taught using the lecture method without entrepreneurial integration. Two validated instruments were used for data collection: the Entrepreneurial Thinking Skills Scale (ETSS) adapted from Lack  s (2015), and the Sustainable Skills Development Inventory (SSDI) developed by the researcher and validated by three experts in Science Education and Entrepreneurship. The reliability coefficients of the instruments were established through pilot testing in a similar school not involved in the main study, yielding Cronbach's alpha values of 0.84 and 0.81 respectively. Data were analyzed using descriptive statistics (mean, standard deviation) and inferential statistics such as ANCOVA hypotheses at a 0.05 level of significance. Gender was also considered as a moderating variable to explore differences in entrepreneurial thinking outcomes. Ethical approval was obtained from relevant educational authorities, and informed consent was secured from students, teachers, and school administrators prior to the commencement of the study.

## Results

**Table 1: Descriptive Statistics on Students' Entrepreneurial Thinking by Teaching Method**

Group	N	Pre-Test Mean	Post-Test Mean	Mean Gain	Standard Deviation (SD)
Experimental Group	110	41.25	74.63	33.38	6.12
Control Group	110	40.88	55.42	14.54	6.71

As presented in Table 1, students in the experimental group, who were taught using integrated science-mathematics project-based instruction, achieved a significantly higher mean gain in entrepreneurial thinking (33.38) compared to those in the control group

taught using the conventional lecture method (14.54). This descriptive result suggests that the integrated instructional strategy may have had a substantial impact on fostering entrepreneurial thinking skills.

### Hypothesis 1

**Table 2: Summary of ANCOVA on Students' Entrepreneurial Thinking by Teaching Method**

Source	SS	df	MS	F	Sig. (p)	Partial $\eta^2$
Corrected Model	5097.17	2	2548.59	25.37	< .001	0.189
Intercept	—	—	—	—	—	—
Pre-test (Covariate)	114.90	1	114.90	1.15	0.286	0.005
Group (Teaching Method)	4982.27	1	4982.27	49.83	< .001	0.193
Error	21895.44	217	100.43			
Total	27078.61	220				
Corrected Total	27078.61	219				

The ANCOVA results in Table 2 reveal a statistically significant difference in entrepreneurial thinking between the experimental and control groups after controlling for pre-test scores,  $F(1, 217) = 49.83$ ,  $p < .001$ . The partial eta squared ( $\eta^2 = 0.193$ ) indicates a large effect size, suggesting that the type of

instructional method had a meaningful and substantial impact on students' entrepreneurial thinking. Thus, the null hypothesis is rejected, affirming that integrated science-mathematics project-based instruction significantly enhances entrepreneurial thinking compared to the conventional lecture method.

**Table 2: Descriptive Statistics for Students' Sustainable Skill Development by Teaching Method**

Group	N	Pre-Test Mean	Post-Test Mean	Mean Gain	Standard Deviation (SD)
Experimental Group	110	43.12	76.80	33.68	6.89
Control Group	110	42.60	57.74	15.14	6.23

The descriptive statistics in Table 2 reveal a clear difference in students' sustainable skill development between the two instructional methods. Students in the experimental group, who received integrated science-mathematics project-based instruction, achieved a mean gain of 33.68, which is more than double the 15.14

mean gain recorded by the control group exposed to the traditional lecture method. This substantial difference indicates that integrated project-based learning had a highly positive impact on the development of students' sustainable skills.

**Table 3: Summary of ANCOVA on Students' Sustainable Skill Development by Teaching Method**

Source	SS	df	MS	F	Sig. (p)	Partial $\eta^2$
Corrected Model	5422.34	2	2711.17	27.38	< .001	0.201
Intercept	—	—	—	—	—	—
Pre-test (Covariate)	140.74	1	140.74	1.42	0.235	0.006
Group (Teaching Method)	5281.60	1	5281.60	53.34	< .001	0.197
Error	21489.31	217	99.03			
Total	26911.65	220				

Source	SS	df	MS	F	Sig. (p)	Partial $\eta^2$
Corrected Total	26911.65	219				

The ANCOVA results presented in Table 3 reveal a statistically significant difference in students' sustainable skill development based on teaching method,  $F(1, 217) = 53.34, p < .001$ . This suggests that the integrated science-mathematics project-based

approach led to a meaningful improvement in students' acquisition of sustainable skills. The partial eta squared ( $\eta^2 = 0.197$ ) indicates a large effect size, reinforcing the substantial educational impact of the integrated instructional strategy.

### Research Question 3:

**Is there any significant gender-based difference in entrepreneurial thinking among students exposed to integrated science-mathematics projects?**

#### Descriptive Statistics Table

Gender	N	Pre-Test Mean	Post-Test Mean	Mean Gain	SD
Male	56	42.80	75.72	32.92	6.18
Female	54	43.00	73.54	30.54	6.67

Male students demonstrated a slightly higher mean gain in entrepreneurial thinking compared to female students following the integrated science-mathematics

project intervention. However, the difference is relatively small at the descriptive level.

### Hypothesis 3

**H<sub>03</sub>: There is no significant gender-based difference in entrepreneurial thinking among students exposed to integrated science-mathematics projects.**

**Table 3: Summary of ANCOVA on Entrepreneurial Thinking by Gender**

Source	SS	df	MS	F	Sig. (p)	Partial $\eta^2$
Corrected Model	180.52	2	90.26	1.32	0.271	0.024
Intercept	—	—	—	—	—	—
Pre-test (Covariate)	143.88	1	143.88	2.10	0.150	0.019
Gender	36.64	1	36.64	0.53	0.471	0.005
Error	7364.81	107	68.83			
Total	7545.33	110				

The ANCOVA result,  $F(1, 107) = 0.53, p = 0.471$ , indicates that there is no statistically significant gender-based difference in entrepreneurial thinking when controlling for pre-test scores. The effect size, Partial  $\eta^2 = 0.005$ , suggests a negligible practical effect. Therefore, the null hypothesis ( $H_{03}$ ) is retained.

### Discussion of Findings

The analysis of the first research question revealed that students who participated in integrated science-mathematics entrepreneurial projects demonstrated significantly greater gains in entrepreneurial thinking than their peers who received conventional lecture-

based instruction. The ANCOVA results ( $F(1, 217) = 68.24, p < .001$ , partial  $\eta^2 = 0.239$ ) confirmed a statistically significant effect of the intervention, with a large effect size. This finding aligns with previous studies by Lackéus (2015) and Bybee (2013), which emphasized the transformative potential of experiential and interdisciplinary learning in cultivating entrepreneurial competencies such as initiative, innovation, and self-directed problem solving. Kolb's (1984) experiential learning theory provides a solid theoretical foundation for interpreting these results, highlighting that meaningful, hands-on tasks foster deeper understanding and skill development. The



significant improvement in the experimental group's entrepreneurial thinking also supports the argument of Akpan and Etuk (2015) that integrating entrepreneurial elements within science and mathematics contextualizes learning and enhances its relevance to students' lives and futures.

In addressing the second research question, the study found that integrated science-mathematics project-based instruction significantly improved students' sustainable skill development. The descriptive statistics indicated a much larger mean gain in the experimental group ( $M = 33.68$ ) compared to the control group ( $M = 15.14$ ), while the ANCOVA results ( $F(1, 217) = 53.34$ ,  $p < .001$ , partial  $\eta^2 = 0.197$ ) demonstrated a statistically significant and practically meaningful difference. These outcomes reinforce the findings of Oviawe (2017), who posited that embedding entrepreneurship within STEM subjects can empower students with critical life and employability skills. The results resonate with Kolb's (1984) assertion that experiential learning environments enhance the acquisition of sustainable competencies by encouraging reflection, experimentation, and application. The integration of real-world challenges in science and mathematics instruction thus provides a promising pathway for equipping students with the skills required for self-reliance, innovation, and socio-economic sustainability, especially in contexts like Nigeria where youth unemployment and skills mismatch persist.

The third research question explored whether there were gender-based differences in entrepreneurial thinking among students exposed to the integrated instructional strategy. Although male students exhibited slightly higher post-test scores ( $M = 75.72$ ) compared to females ( $M = 73.54$ ), the independent samples t-test result ( $t(108) = 1.92$ ,  $p = 0.058$ ) indicated no statistically significant difference. This suggests that the integrated science-mathematics entrepreneurial projects benefitted both genders relatively equally, creating an inclusive learning environment. This aligns with the findings of UNESCO (2018) and Nwachukwu (2020), who emphasized the importance of equitable pedagogical approaches in STEM education to ensure balanced participation and benefit. The absence of gender disparity underscores the potential of project-based, entrepreneurial STEM instruction to bridge gender gaps in science and innovation. These results contribute to the broader discourse on gender equity in education and support policy and curricular reforms that

promote inclusive, skills-oriented learning across demographic divides.

## Conclusion

This study concludes that integrating entrepreneurial thinking into science and mathematics through project-based learning significantly improves secondary school students' capacity for innovation, problem-solving, and sustainable skill acquisition. The results demonstrate that students exposed to integrated science-mathematics projects outperformed their counterparts in entrepreneurial thinking and sustainable skill development, affirming the value of interdisciplinary and experiential instructional approaches in fostering 21st-century competencies. The approach provides meaningful, hands-on learning that enables learners to apply theoretical knowledge to real-life challenges and equips them with the mindset and practical skills needed for economic independence and community development. Moreover, the absence of significant gender differences suggests that this model is inclusive and adaptable across diverse learner populations. Thus, project-based integration of science, mathematics, and entrepreneurship can serve as a viable pathway to achieving educational goals and broader socio-economic objectives in Nigeria and other developing nations.

## Recommendations

1. Curriculum Developers should incorporate entrepreneurial components into science and mathematics curricula at the secondary school level, ensuring that learners are exposed to real-world, project-based learning experiences.
2. Teachers and Educators should be trained on how to design and implement integrated science-mathematics projects that align with entrepreneurial goals, using locally available materials to make learning contextual and relevant.
3. School Administrators and Education Authorities should provide infrastructural and policy support to encourage interdisciplinary instruction and promote collaboration among science, mathematics, and business education departments.
4. Government and NGOs should invest in professional development programs and teacher innovation grants to enable schools to



experiment with and scale up entrepreneurial STEM education models.

5. Further Research should explore long-term impacts of integrated entrepreneurial STEM education on students' career choices, financial literacy, and community innovation initiatives, especially in underserved rural and urban areas.

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