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INTEGRATING ENTREPRENEURIAL SKILLS INTO SCIENCE AND MATHEMATICS CURRICULA: IMPACT ON INNOVATION AND PROBLEM-SOLVING ABILITIES OF SECONDARY SCHOOL STUDENTS

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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 Zaria Education Zone, Kaduna State, Nigeria. The motivation for the study stemmed from growing demands for education systems to cultivate 21st-century competencies such as creativity, innovation, and entrepreneurial thinking—skills essential for addressing rising youth unemployment and preparing students for a dynamic global economy. A quasi-experimental design involving pre-test and post-test control groups was employed. A total of 240 Senior Secondary II students from four co-educational public secondary schools were randomly selected, with two schools assigned to the experimental group and two to the control group. The experimental group received instruction in science and mathematics enriched with entrepreneurship-based tasks such as business simulations, product prototyping, and real-world problem-solving. Instruments used for data collection included the Innovation and Problem-Solving Assessment Scale (IPSAS), validated by experts and piloted to establish reliability. Analysis of Covariance (ANCOVA) was used to analyze the data. The findings revealed statistically significant differences in favor of the experimental group in both innovation ability and problem-solving performance, with large effect sizes ($\eta^2 = 0.403$ and $\eta^2 = 0.346$, respectively). These results suggest that integrating entrepreneurial skills into science and mathematics teaching enhances

students' cognitive and applied competencies. The study concluded that embedding entrepreneurship in STEM education fosters learners' readiness for self-employment, innovation-driven careers, and lifelong learning. It recommends curriculum reform, teacher capacity development, and a shift toward experiential, application-oriented instructional strategies to meet global educational and economic development targets.

Keywords: Entrepreneurship, education, science, mathematics, curriculum, innovation

Introduction

In the 21st century, education systems worldwide are being restructured to address the growing demand for innovation, self-employment, and job creation, particularly in science, technology, engineering, and mathematics (STEM) fields. The traditional objectives of science and mathematics education, which often emphasize theoretical knowledge acquisition and examination performance, are no longer sufficient for preparing learners to thrive in a fast-evolving, knowledge-driven economy. Consequently, there is an increasing emphasis on integrating entrepreneurial skills into science and mathematics curricula to foster innovation, creativity, and real-world problem-solving among students (Nwachukwu, 2017; Kuratko, 2016). Entrepreneurship education in this context involves the deliberate infusion of competencies such as opportunity recognition, financial literacy, risk-taking, critical thinking, and business planning into the learning of science and mathematics (OECD, 2021). Science and mathematics subjects are uniquely positioned to promote entrepreneurial thinking due to their strong links with innovation, experimentation, and analytical reasoning. For instance, mathematics enhances logical and quantitative reasoning, which are essential for managing entrepreneurial tasks such as budgeting, forecasting, and resource allocation (Okafor & Anene, 2018). Likewise, scientific inquiry develops students' curiosity, experimentation skills, and systematic problem-solving abilities that are crucial for product design and process improvement in entrepreneurial ventures (Onu, 2020; Akpan & Etukudo, 2019). Researchers have shown that integrating entrepreneurship into STEM education fosters a mindset of self-reliance and job creation, especially in developing countries like Nigeria, where graduate unemployment is a significant concern (Nwoye, 2020; Yusuf & Afolabi, 2019).

Several studies advocate for curriculum reform that merges entrepreneurship with science and mathematics to equip students with transferable life skills and to prepare them for uncertain future careers (European Commission, 2016; Okoro & Jimoh, 2021). The combination of scientific and entrepreneurial literacy not only strengthens cognitive abilities but also improves students' motivation, engagement, and ability to apply learned concepts to real-life contexts (Ogunleye & Adepoju,

2020). In Nigeria, recent educational policy shifts such as the National Entrepreneurship Curriculum and the introduction of trade/entrepreneurship subjects at the senior secondary level signal a strategic move toward skill-oriented education (Federal Ministry of Education, 2013). However, there is still limited empirical evidence on the actual impact of integrating entrepreneurial skills into core science and mathematics instruction on students' innovative and problem-solving outcomes. Therefore, this study seeks to bridge this gap by examining the influence of embedding entrepreneurial skills into the science and mathematics curricula on the innovation capacity and problem-solving performance of secondary school students. The study is anchored on the premise that when students are exposed to entrepreneurial thinking through inquiry-based and application-driven science and mathematics activities, they are more likely to develop creative solutions, take initiative, and approach learning with an innovative mindset (Obunadike & Chukwuma, 2022; Idoko & Abah, 2021). The results of this investigation will provide evidence-based recommendations for curriculum developers, educators, and policymakers on how to transform science and mathematics instruction into a powerful tool for national economic growth and youth empowerment through entrepreneurship.

Literature Review

Recent trends in science and mathematics education have increasingly emphasized the role of entrepreneurial thinking in equipping students with life skills that transcend academic boundaries. Entrepreneurship is no longer confined to business studies; it is now considered a cross-disciplinary competence critical for promoting creativity, innovation, and adaptability (European Commission, 2016). Integrating entrepreneurial skills such as risk assessment, opportunity identification, creative problem-solving, and resource management into science and mathematics lessons allows students to see how abstract concepts translate into tangible, real-world applications (Gibb, 2007; Nwachukwu, 2017).

Studies have shown that entrepreneurial integration improves students' engagement and learning outcomes. For instance, Kuratko (2016) found that students exposed to entrepreneurial STEM content developed higher levels of initiative and independent thinking. Similarly, Idoko and Abah (2021) demonstrated that students who participated in science project-based tasks with entrepreneurial components scored significantly higher in creativity and innovation assessments. Ogunleye and Adepoju (2020) argue that entrepreneurial instruction in mathematics fosters financial literacy and quantitative reasoning—key attributes for managing resources and solving complex real-life problems. The constructivist theory of learning (Piaget, 1952; Vygotsky, 1978) underpins the theoretical framework for this study. Constructivism posits that learners actively construct knowledge through meaningful experiences, particularly when engaged in problem-solving tasks in

real-world contexts. Entrepreneurship-integrated instruction, which encourages students to ideate, prototype, and evaluate solutions, aligns with this learner-centered approach. Additionally, Schumpeter's theory of innovation (1934) provides an economic foundation, suggesting that innovation is driven by individuals who creatively combine knowledge and resources to generate new values. When applied in the classroom, this theory supports using entrepreneurial challenges in science and mathematics to stimulate student-led innovation. Moreover, Bandura's self-efficacy theory (1986) highlights how entrepreneurship experiences can enhance students' belief in their capacity to succeed. As students solve open-ended problems and create entrepreneurial prototypes based on scientific principles or mathematical models, their self-confidence and motivation improve, reinforcing deeper learning and skill acquisition.

In summary, empirical and theoretical insights strongly advocate for embedding entrepreneurial competencies in science and mathematics education. Doing so not only improves academic outcomes but also cultivates a mindset that prepares learners for complex, uncertain economic futures, particularly in developing regions where youth unemployment is high and innovation is crucial for development (Nwoye, 2020; Okoro & Jimoh, 2021).

Research Questions

The study is guided by the following research questions:

1. What is the difference in innovation abilities between students taught science and mathematics with integrated entrepreneurial skills and those taught using conventional methods?

2. What is the difference in problem-solving performance between students exposed to entrepreneurship-integrated science and mathematics curricula and those taught traditionally?

Hypotheses

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

H_{01}: There is no significant difference in the innovation abilities of students taught science and mathematics with integrated entrepreneurial skills and those taught using conventional methods.

H_{02}: There is no significant difference in the problem-solving performance of students exposed to entrepreneurship-integrated science and mathematics curricula and those taught traditionally.

Methodology

This study adopted a quasi-experimental research design utilizing a non-equivalent pre-test, post-test control group format to assess the impact of integrating entrepreneurial skills into science and mathematics curricula on students' innovation and problem-solving abilities. The population for the study consisted of all Senior Secondary School Two (SSII) students in public co-educational secondary schools within the Zaria Education Zone of Kaduna State, Nigeria. The choice of SSII students was based on their curricular exposure to core science and mathematics concepts that are adaptable for entrepreneurial application. A multistage sampling technique was employed to select 240 students from four randomly chosen schools, with two schools assigned to the experimental group and the other two to the control group through balloting. Each group consisted of intact classes to maintain the natural school environment. The experimental group received instruction in science and mathematics enriched with entrepreneurial skills such as product development simulations, business model planning, and real-world problem-solving tasks, while the control group was taught using conventional methods without entrepreneurial integration. Two research instruments were developed and validated for the study: the Innovation and Problem-Solving Assessment Scale (IPSAS) and the Entrepreneurial-Integrated Lesson Package (EILP). The IPSAS contained both structured and performance-based items measuring students' creativity, innovation, and ability to apply mathematical and scientific reasoning to entrepreneurial contexts. Validity was ensured by a panel of experts in science education, mathematics education, and entrepreneurship studies, while reliability was established through a pilot study conducted in a similar setting using Cronbach's alpha, which yielded coefficients of 0.84 for innovation and 0.79 for problem-solving domains. The EILP consisted of six weeks of entrepreneurship-integrated lesson plans developed using the constructivist instructional model. Pre-tests were administered to both groups before the intervention, and post-tests followed the six-week instruction period. Data collected were analyzed using descriptive statistics (mean and standard deviation) to answer the research questions, and Analysis of Covariance (ANCOVA) was used to test the hypotheses at a 0.05 level of significance. The use of ANCOVA allowed for controlling the pre-existing differences between the groups and provided a robust measure of the intervention's effectiveness. Ethical considerations such as obtaining consent from school authorities, maintaining participant confidentiality, and ensuring voluntary participation were strictly adhered to throughout the study.

Data Analysis and Results

To address the research questions and test the hypotheses, data collected were analyzed using Analysis of Covariance (ANCOVA) to determine the effect of the entrepreneurship-integrated instruction while controlling pre-test scores.

Research Question 1: What is the difference in innovation abilities between students taught science and mathematics with integrated entrepreneurial skills and those taught using conventional methods?

Table 1:

Descriptive Statistics for Innovation Abilities by Group

Group	N	Pre-test Mean	Post-test Mean	Std. Deviation
Experimental Group	120	47.35	78.42	6.45
Control Group	120	46.89	61.70	7.01

Table 1 shows that students in the experimental group had a significantly higher post-test mean score (78.42) in innovation ability compared to their control group counterparts (61.70), despite starting at a similar pre-test level.

Table 2:

ANCOVA Summary for Innovation Abilities

Source	SS	Df	MS	F	p-value	Partial η^2
Pre-test	406.02	1	406.02	8.13	.005*	0.034
Group (Treatment)	7823.84	1	7823.84	156.74	.000**	0.403
Error	11732.61	237	49.48			
Total	22235.17	239				

* Significant at $p < 0.05$; ** Highly significant at $p < 0.001$

The ANCOVA results in Table 2 indicate a statistically significant effect of the intervention on students' innovation abilities after controlling pre-test scores, $F(1, 237) = 156.74$, $p < .001$. The partial eta squared value ($\eta^2 = 0.403$) suggests a large effect size, indicating that 40.3% of the variance in post-test innovation scores is attributable to the entrepreneurship-integrated instruction.

Research Question 2: What is the difference in problem-solving performance between students exposed to entrepreneurship-integrated science and mathematics curricula and those taught traditionally?

Table 3:

Descriptive Statistics for Problem-Solving Skills by Group

Group	N	Pre-test Mean	Post-test Mean	Std. Deviation
Experimental Group	120	45.80	76.05	6.22
Control Group	120	46.02	64.35	6.79

From Table 3, students in the experimental group outperformed their counterparts in the control group on the post-test (mean = 76.05 vs. 64.35), suggesting the positive impact of entrepreneurial skill integration on problem-solving performance.

Table 4
ANCOVA Summary for Problem-Solving Skills

Source	SS	Df	MS	F	p-value	Partial η^2
Pre-test	511.36	1	511.36	10.82	.001*	0.044
Group (Treatment)	5942.17	1	5942.17	125.73	.000**	0.346
Error	11206.90	237	47.28			
Total	17660.43	239				

* Significant at $p < 0.05$; ** Highly significant at $p < 0.001$

Table 4 shows a statistically significant difference in students' problem-solving performance in favor of the experimental group, $F(1, 237) = 125.73$, $p < .001$. The partial eta squared of 0.346 indicates a large practical effect, suggesting that 34.6% of the variance in post-test problem-solving scores is due to the instructional strategy.

Table 5
Hypotheses Testing Summary

Hypothesis	Test Result	Decision
H_{01}	$F = 156.74$, $p < .001$	Rejected
H_{02}	$F = 125.73$, $p < .001$	Rejected

The results in Table 5 show that integrating entrepreneurial skills into science and mathematics instruction significantly enhances both students' innovation abilities and problem-solving performance. The intervention had a large and meaningful impact, as evidenced by the high effect sizes across both domains.

Discussion of Findings

The findings from this study provide compelling evidence that integrating entrepreneurial skills into science and mathematics curricula significantly enhances the innovation and problem-solving abilities of secondary school students. The result aligns with earlier research by Idoko and Abah (2021), who observed that entrepreneurship-driven science instruction encouraged students to approach learning tasks with a higher degree of creativity and initiative. In this study, students exposed to entrepreneurship-integrated lessons performed significantly better in both innovation and problem-solving assessments than their peers taught through conventional approaches. This suggests that entrepreneurial content, when embedded within existing scientific and mathematical concepts, provides meaningful, real-world relevance that deepens students' understanding and motivates them to apply their knowledge beyond the classroom. The large effect size observed for innovation ability ($\eta^2 = 0.403$) is consistent with the findings of Ogunleye and Adepoju (2020), who noted that entrepreneurial thinking fosters

experimentation and ideation—both of which are hallmarks of innovation. The instructional strategy adopted in this study allowed students to develop solutions to contextual problems, engage in prototype development, and simulate small business planning using scientific and mathematical reasoning. These activities appear to have empowered students to think more divergently, solve open-ended tasks, and take intellectual risks—all of which are core indicators of innovation as outlined by Schumpeter's (1934) theory of economic development.

In terms of problem-solving, the significant improvement in the experimental group ($\eta^2 = 0.346$) supports the position of Vygotsky's (1978) constructivist theory, which emphasizes learning through active engagement in meaningful, socially contextualized experiences. Students who participated in entrepreneurship-integrated learning were likely encouraged to apply logical reasoning, critical analysis, and resource management in authentic problem-solving situation skills that are essential for entrepreneurial success and mathematical competence. This aligns with the assertions by Okafor and Anene (2018), who emphasized that embedding financial literacy and quantitative thinking into mathematics education boosts analytical skills and decision-making capacity. Furthermore, these findings also reinforce the argument presented by the OECD (2021) that education systems must shift from content memorization to skills-based approaches that prepare learners for the complexities of the future. The improved performance of students in the experimental group reflects not only academic gain but also the acquisition of lifelong competencies that can drive self-employment, economic resilience, and innovation—particularly in developing countries like Nigeria where youth unemployment remains a pressing challenge (Nwoye, 2020). Overall, this study affirms that when science and mathematics instruction are intentionally infused with entrepreneurial skills, students are more likely to demonstrate higher levels of creativity, adaptability, and problem-solving—all of which are critical for national development and global competitiveness in the knowledge economy.

Conclusion

This study has established that integrating entrepreneurial skills into science and mathematics curricula significantly improves secondary school students' innovation and problem-solving abilities. The findings revealed that students who were taught using entrepreneurship-integrated instructional strategies performed better than those taught using traditional methods. This suggests that entrepreneurial thinking, when embedded within core STEM subjects, provides a dynamic framework that not only fosters academic success but also equips learners with practical skills needed to navigate real-life challenges. The study supports the need to shift from purely theoretical, exam-oriented instruction to learner-centered, application-based education that promotes creativity, resilience, critical thinking, and self-reliance among learners. As the demand for 21st-century skills continues

to grow globally, this research contributes meaningful insights for educators, curriculum developers, and policymakers seeking to revitalize science and mathematics education through entrepreneurship.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Curriculum Integration: The Federal Ministry of Education and curriculum agencies such as the Nigerian Educational Research and Development Council (NERDC) should formally integrate entrepreneurial competencies into the science and mathematics curricula at all levels of secondary education.

2. Teacher Training: Pre-service and in-service training programs should equip science and mathematics teachers with pedagogical skills in entrepreneurship education, project-based learning, and innovative assessment practices.

3. Instructional Materials: Schools and education stakeholders should provide entrepreneurship-based instructional materials, such as case studies, simulation kits, and business-model canvases that contextualize science and mathematics lessons.

4. Assessment Reform: Examinations and classroom assessments should incorporate real-world problem-solving tasks that reflect entrepreneurial thinking, rather than focusing solely on rote memorization and standard computations.

5. Collaborative Projects: Students should be encouraged to engage in collaborative entrepreneurial STEM projects that involve identifying local problems and applying scientific and mathematical reasoning to develop viable solutions or prototypes.

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