EFFECT OF CONCEPT MAPPING LEARNING STRATEGY ON SENIOR SECONDARY STUDENTS' CREATIVE ABILITY LEVELS AND ENTREPRENEURIAL SKILLS ACQUISITION IN CONSTRUCTING STANDARD-VARIABLE RESISTOR IN KWARA CENTRAL, NIGERIA

YAHAYA Quadri, AKANBI Abdulrasaq Oladimeji, YAHAYA Wasiu Olayinka, SHEHU Abdulrasaq, & YUSUF Mumeen Olowo

badaraeen@gmail.com

akanbi.ao@unilorin.edu.ng

yahaya.wo@unilorin.edu.ng

abdulrasaq181@gmail.com

yusufolowomumeen@gmail.com

[1] Department of Physical Science Education, Kwara State University of Education, Ilorin, Nigeria

Department of Science Education, University of Ilorin, Nigeria

Abstract

This study investigated the effectiveness of the concept mapping learning strategy in enhancing senior secondary students' entrepreneurial skills in constructing a standard-variable resistor. Using a pre-test, post-test quasi-experimental design, a total of 135 students were assigned to two groups: one exposed to concept mapping and the other taught using the conventional teaching method. In addition to examining the overall impact of the instructional strategy, the study explored how students' creative ability levels, high, moderate, and low, affected their acquisition of entrepreneurial skills. Data were collected using two validated instruments: the Physics Students' Entrepreneurial Skills Acquisition Test (PSESAT) and the Physics Students' Creative Ability Test (PSCAT). Data analysis was conducted using descriptive statistics and Analysis of Covariance (ANCOVA) to control for initial differences in pre-test scores. Results indicated that exposure to the concept mapping strategy led to improved entrepreneurial skills across all students, and there was no significant difference in skill acquisition among students with varying levels of creative ability. These findings suggest that concept mapping can provide an inclusive learning approach that supports students regardless of their creativity levels. Based on these results, the study recommended the integration of concept mapping into physics instruction to promote equal learning opportunities and enhance students' practical and entrepreneurial competencies in technical tasks such as constructing standard-variable resistors.

Keywords: Metacognitive Tools, Creative Ability, Standard-Variable, Resistor, Entrepreneurial Skills, Acquisition.

Introduction

Many secondary school graduates, regardless of their academic performance, lack essential entrepreneurial skills needed to succeed in business or the workforce. This skill

gap limits personal growth, employment opportunities and social mobility, hindering economic progress and exacerbating issues like unemployment and underemployment. In the third quarter of 2023, Nigeria's unemployment rate rose to 5.0%, 0.8% increase from the previous year (Aina & Olufemi, 2024). Skills such as opportunity recognition, creative thinking, and risk management are increasingly important, yet education often fails to meet these demands.

Entrepreneurial skills are key to addressing unemployment, helping individuals secure employment or pursue self-employment. Science education, particularly physics, is vital for skill development by fostering problem-solving, experimentation, and practical applications. Physics teaches fundamental principles, supporting industries like agriculture, medicine, engineering, and communication. It helps students innovate and contribute to solving global challenges like energy crises (Shivaraj, 2015; Malik et al., 2023). Physics advancements benefit industrial growth and technological development (CEBR, 2019).

Physics education has strong potential to promote entrepreneurial skills such as creativity, problem-solving, innovation, and self-reliance. Given the growing need for secondary school leavers who can apply scientific knowledge to real-world challenges, physics instructors should emphasise concepts that can lead to productive and income-generating skills. Okafor (2018) noted that certain physics concepts are capable of fostering entrepreneurship when effectively taught. However, in many classrooms, physics is still presented in a largely theoretical and examination-driven manner, which limits students' ability to translate knowledge into practical and entrepreneurial skills.

Despite the relevance of physics to entrepreneurship, many students leave school without adequate self-sufficiency and innovation skills. Ingwe et al. (2023) reported that students require improved instructional approaches to meaningfully acquire these skills. This reveals a gap between the entrepreneurial potential of physics concepts and the teaching strategies commonly used in schools. This research examined how the metacognitive tool (concept mapping) affects senior secondary students' entrepreneurial skill acquisition in constructing a standard-variable resistor in Kwara Central.

In electrical measurements, standard-variable resistors are essential but costly. Schools often cannot afford them, highlighting the need to improvise with locally available materials, offering self-employment opportunities. Standard resistors are made from materials like constantan wire, a copper-nickel alloy with high resistivity, ideal for precision resistors. Resistance depends on the wire's length, material, and cross-sectional area.

$R = \rho l/A.$ ---------- (1)

Where R = resistance (Ω),

ρ = resistivity (Ωm),

L = length (m), and

A = cross-sectional area (m^2) (Anyakoha, 2016).

Standard-variable resistors are adjustable components used to estimate and compare resistance with high accuracy. Their primary function is to control current flow in a circuit. Learning to construct these resistors can help students become self-reliant by enabling them to produce them commercially. Resistance, including standard-variable resistors, is a concept in the physics curriculum that promotes entrepreneurial skills (Okafor, 2018).

Ingwe et al. (2023) emphasised that secondary school graduates need better instruction in entrepreneurial skills to achieve self-sufficiency. The lack of these skills contributes to the high unemployment rate among school leavers, raising concerns about the education system's failure to prepare them for entrepreneurship. Entrepreneurial skills include the knowledge, attitudes, and abilities needed to develop innovative projects or services that meet societal needs (Jardim, 2021). Secondary school physics teaches skills like designing electrical testers, solar collectors, and microscopes, which can help students pursue entrepreneurial ventures and achieve financial stability (Okafor, 2018).

This research focuses on the entrepreneurial skills required for construction and hands-on activities, including measurement, manipulative skills, and finger dexterity. Entrepreneurship demands soft skills, managerial skills, and entrepreneurial abilities. Accurate measurement, finger dexterity, and manipulative skills are key to completing tasks efficiently. Effective instruction is necessary to develop these skills and unlock

students' entrepreneurial potential, with metacognitive strategies playing an important role. Metacognition involves understanding one's own cognitive processes (Flavell, 1979) and helps students self-regulate their learning (Baker, 2015). Metacognitive tools, like concept mapping, could support entrepreneurial skill development, particularly in constructing standard-variable resistors. This research evaluates the impact of this tool on students' entrepreneurial skills acquisition in Kwara Central, considering their creative ability levels as moderating factors.

This research is grounded in Kolb's Experiential Learning Theory (1984), which suggests that learning occurs through transforming experiences into knowledge. Zapeda (2013) explains that learning happens when individuals engage with their environment, and Knowles et al. (2011) argue that adults learn best when new information is presented in relatable contexts. This highlights the importance of incorporating problem-solving and real-world applications in education, beyond traditional classroom content. Experiential learning is seen as a dynamic, social process where cognitive and social behaviours transform experiences into knowledge, classifying it as a constructivist theory (Zapeda, 2013). Kolb's learning cycle offers an effective method for teaching entrepreneurial skills, emphasising relevant, hands-on learning experiences. The cycle includes four stages: experience, reflection, reasoning, and investigation, which together foster learning through active engagement in entrepreneurial activities.

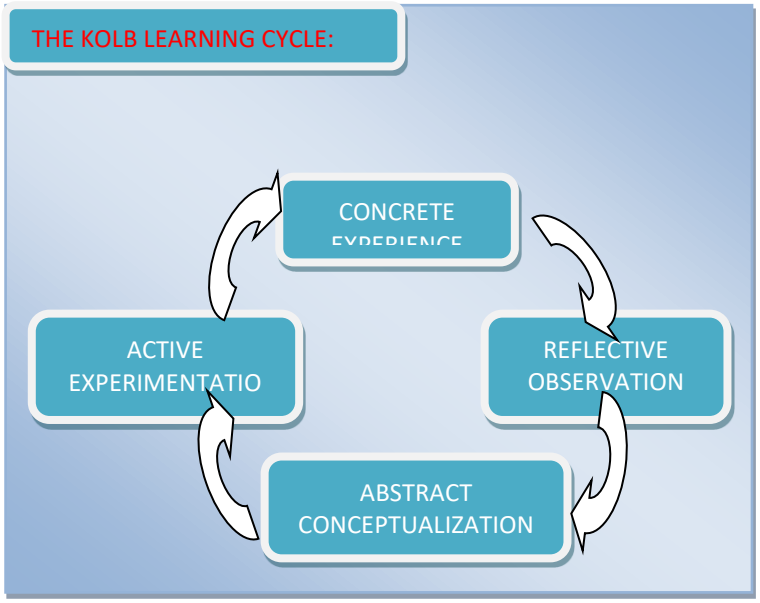

Figure 1: Kolb's Model of Experiential Learning

Source: (Kolb, 1984)

Kolb's (1984) learning cycle consists of two stages: grasping and transforming experience. The vertical axis in Figure 1 represents the experience-grasping mode, starting with concrete experience. Learning occurs through apprehension (direct experience) or comprehension (abstract conceptualisation). Knowles et al. (2011) suggest that learning is most effective when connected to real-world contexts, such as entrepreneurial simulations, presentations, and demonstrations, encouraging hands-on engagement. Project-based learning and concept mapping are effective strategies during the active conceptualisation phase.

Concept mapping, based on Ausubel's learning theory, helps students deepen their understanding of topics (Novak, 1990). It encourages meaningful learning by reflecting prior knowledge (Novak & Canas, 2006). Studies (Ahmad, 2017; Ali, 2015) show that concept mapping enhances creativity and skill acquisition in students. It is also used in metacognitive teaching, promoting higher-order cognitive development (Soesilawaty et al., 2019; Khine et al., 2019). It has been shown to enhance students' cognitive achievements and problem-solving skills (Joshi et al., 2022; Soesilawaty et al., 2019). Creativity, driven by memory, enables students to overcome obstacles and generate ideas that benefit society (Ritter & Mostert, 2016). It forms the basis for innovation and social progress (Seydou et

al., 2016). Creativity, involving problem-finding and problem-solving, requires various skills (Mukhles, 2020; Schubert, 2021). Research has shown that concept mapping improves achievement in subjects like ecology and chemistry (Akintola & Odewumi, 2023; Francis & Baba, 2022). Studies also reveal that students with higher creativity benefit more from cooperative learning strategies, while those with lower creativity benefit from demonstration-based learning (Avwiri, 2020).

Research Objectives

The main objective of the research was to investigate the effect of concept mapping learning strategy on senior secondary students' creative ability levels and entrepreneurial skills acquisition in constructing a standard variable resistor in Kwara Central, Nigeria. Specifically, the research examined the effect of:

1. Concept mapping learning strategy on students' entrepreneurial skills acquisition in constructing a standard-variable resistor, considering students' high, moderate, and low creative ability;

Research Questions

The following research question was raised and answered.

1. What is the effect of the concept mapping learning strategy on students' entrepreneurial skills acquisition in constructing a standard-variable resistor, considering students' high, moderate, and low creative ability?

Research Hypotheses

The following null hypothesis was formulated and tested at the 0.05 level of significance:

H_{01}: There is no significant effect among students of high, moderate, and low creative ability in the entrepreneurial skills acquisition using the concept mapping learning strategy in constructing a standard-variable resistor.

Methodology

This study used a quantitative, pre-test, post-test, quasi-experimental design with a non-equivalent, non-randomised 2x3 factorial setup. The first set of factors included two teaching methods: concept mapping and traditional teaching strategies. The second set involved three creativity levels (high, moderate, and low). This design was appropriate for

investigating the effects of interventions without randomisation. The population for this study was eight thousand, eight hundred, and fifty (8,850) science students in senior secondary schools in Ilorin, Kwara State (Kwara State Ministry of Education and Human Capital Development, [KSMEHCD], 2023).

A purposive sampling technique was used to select 2 public co-educational schools from the eighty (80) senior secondary schools in Ilorin. One of the selected schools was randomly assigned experimental group, and the other one was the control group. The selected schools were purposively sampled because they were coeducational; that is, they contained both male and female students. The sample consisted of 135 students (55 males, 80 females) from Senior Secondary Three (SS3) physics classes in three randomly selected public co-educational schools in Ilorin, Kwara State, Nigeria.

Two main instruments were used: the Physics Students' Entrepreneurial Skills Acquisition Test (PSESAT), which assessed practical skills in constructing a standard-variable resistor, and the Physics Students' Creative Ability Test (PSCAT), which measured students' creativity levels. Both instruments were validated by experts, showing strong content validity (PSESAT: 0.88, PSCAT: 0.76) and reliability (PSESAT: 0.94, PSCAT: 0.89). The study was carried out over four weeks and began with the recruitment and training of three research assistants and participating students on instrument administration, concept mapping construction, and safe handling of tools for building a standard-variable resistor, alongside obtaining informed consent from all participants and parents where required. In the second week, pretests (PSCAT and PSESAT) were administered to both experimental and control groups to assess creative ability levels and prior entrepreneurial and construction knowledge. In the third week, different instructional strategies were implemented: concept mapping for the Experimental Group and the conventional method for the Control Group. In the fourth week, a posttest was administered to determine the effects of the treatments. Throughout the study, safety risks from tool use were minimised through prior training and provision of protective gloves, and all data collected were treated with strict confidentiality. Data analysis was performed using SPSS, with descriptive statistics and ANCOVA to test hypotheses at a 0.05 significance level.

Results

Research Question One

What is the effect of the concept mapping learning strategy on students' entrepreneurial skills acquisition in constructing a standard-variable resistor, considering students' high, moderate, and low creative ability?

Table 1 summarises the effect of using a concept mapping learning strategy on students' entrepreneurial skills acquisition in constructing a standard-variable resistor, categorised by students' high, moderate, and low creative ability. The highly creative students (N = 3.00) had a pretest mean score of 50.67 and a posttest mean score of 57.33. The mean gain score of highly creative students is 6.66 after using the concept mapping strategy. The moderately creative students had the largest number of students (N = 25.00).

The students had a pretest mean score of 39.68 and a posttest mean score of 58.72. The mean gain score of moderately creative students is 19.04, while the low creative students (N = 14.00) had a pretest mean score of 47.14 and a posttest mean score of 56.00. The students with low creative ability had a mean gain score of 8.86. The students with moderately creative had the highest mean gain score (19.04), followed by the low creative students (8.86), and the highly creative students had the lowest mean gain score (6.66).

Table 1: *Entrepreneurial Skills Acquisition in Constructing a Standard Variable Resistor Using Concept Mapping Among Students with High, Moderate, and Low Creative Ability*

Creative Ability Levels	N	Pretest Mean	SD	Posttest Mean	SD	Mean Gain
High	3.00	50.67	9.24	57.33	6.10	6.66
Moderate	25.00	39.68	9.79	58.72	6.60	19.04
Low	14.00	47.14	11.76	56.00	5.40	8.86

Research Hypothesis One

There is no significant effect among students of high, moderate, and low creative ability in the entrepreneurial skills acquisition using the concept mapping learning strategy in constructing a standard-variable resistor.

Table 2 shows that $F_{(2, 84)} = 0.16$, indicating a low effect of the strategy on the students, and the calculated value is 0.85 ($p > 0.05$), which is higher than the table value. This implies there was no significant difference in entrepreneurial skills acquisition among students with different levels of creative ability. Therefore, the hypothesis earlier stated that there was no significant difference among students of high, moderate, and low creative ability levels in the entrepreneurial skills acquisition when taught with the concept mapping learning strategy in constructing a standard-variable resistor is hereby retained.

Table 2: *Analysis of Entrepreneurial Skills Acquisition in Constructing a Standard Variable Resistor Using Concept Mapping Among Students with High, Moderate, and Low Creative Ability*

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3507.89a	6.00	584.65	16.57	0.00
Intercept	56767.08	1.00	56767.08	1609.25	0.00
Strategy	942.37	2.00	471.19	13.36	0.00
CAL	11.54	2.00	5.77	0.16	0.85
Strategy * CAL	68.55	2.00	34.27	0.97	0.38
Error	2963.14	84.00	35.28		
Total	245104.00	91.00			
Corrected Total	6471.03	90.00			

P>0.05

Discussion

This research assessed the effect of concept mapping learning strategy on senior secondary students' creative ability levels and entrepreneurial skills acquisition in constructing a standard variable resistor in Kwara Central, Nigeria.

The research revealed there was no significant effect among students of high, moderate, and low creative ability levels in the entrepreneurial skills acquisition when exposed to the concept mapping learning strategy in constructing a standard-variable resistor. This outcome is similar to the research of Geoffrey et al. (2022), Akintola and Odewumi (2023), and Francis and Bada (2022), who reported that there was no significant effect on the students' skills acquisition and performance of the different teaching

strategies on students' creative ability levels. This is attributed to the consistent use of concept mapping and diverse instructional approaches.

The research is in variance with Avwiri (2020), which reported that there was a significant difference in students' creative ability levels using strategies on students' entrepreneurial skills acquisition, and this is likely due to the use of different teaching strategies or assessment criteria that might have differently influenced students' creative ability levels. This implies that the concept mapping learning strategy did not favour any particular creative ability level in terms of entrepreneurial skills acquisition in constructing a standard-variable resistor; it can be considered an equitable learning strategy. Teachers or instructors can utilise concept mapping to teach entrepreneurial skills, knowing that it is not a disadvantage to any students based on their creative ability level.

Conclusions and Recommendations

This research assessed the effect of concept mapping strategy on entrepreneurial skills acquisition among students of varying creative ability levels. The findings contributed valuable insights into effective instructional strategies, specifically in the context of constructing standard-variable resistors.

According to the study, learners with different levels of creativity achieved consistent learning outcomes while using the concept mapping instructional strategy. Concept mapping is generally effective and inclusive, independent of individual differences in creativity, as evidenced by the similar levels of entrepreneurial skills learning shown by students categorised as having high, moderate, or low creativity.

In line with the findings of this study, teachers are encouraged to adopt and deliberately integrate a variety of instructional methods and strategies in their classrooms to enhance entrepreneurial skills acquisition among students. Specifically, teachers should make consistent use of concept mapping as a teaching strategy, as it provides equal learning opportunities for students across different levels of creative ability. By using concept maps during lessons, teachers can support clear understanding of concepts, promote meaningful learning, and ensure that all learners benefit regardless of individual differences.

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