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Concept Mapping Strategy and Senior School Students' Acquisition of Entrepreneurial Skills in Constructing Standard-Variable Resistors in Ilorin, Kwara State

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Abstract
This study investigated the effect of concept mapping as a learning strategy for acquiring entrepreneurial skills in constructing standard-variable resistors in Ilorin, Kwara State. The research adopted a quasi-experimental design with 124 participants. Data were collected with the instruments Physics Creative Ability Test (PCAT) and the Physics Entrepreneurial Skills Acquisition Test (PESAT). The reliability test of the instruments was carried out using a test-retest method and analysed using Pearson's product-moment correlation, the reliability indices of PCAT and PESAT are 0.89 and 0.94 respectively. The data collected were analysed using descriptive and inferential statistics. The findings revealed a significant positive effect of concept mapping on students' entrepreneurial skills acquisition. Interestingly, students with low creative ability showed the greatest improvement compared to their high and moderate counterparts. Additionally, a gender difference emerged, with male students demonstrating a greater advantage in concept mapping compared to females. These results suggest that concept mapping can be a valuable tool for fostering entrepreneurial skills, particularly for students with lower initial creative abilities. Further research is needed to explore the underlying mechanisms behind these findings and to determine if concept mapping can mitigate gender disparities in this domain.

Keywords: Concept Mapping, Learning Strategy, Creativity, Entrepreneurial Skill, Standard-Variable Resistor

Introduction

The continuous march of progress in science and technology continues to transform our world at an ever-accelerating rate. This advancement supports almost every aspect of modern life, including communication, transportation, medicine, and manufacturing. As a result, science is a vital source of information and innovation, providing us with the tools we need to navigate and contribute to this ever-changing world. Science is a field of study that has helped humans learn more about the cosmos (Oyelekan et al., 2018). Science is a global discipline that encompasses the branches of knowledge that explore the structure and behaviour of the physical and natural world via observation and experimentation. (Bjorklund, 2023; López-Ocón&Thurner, 2023). Physics is a foundational discipline in science. Physics informs our grasp of the fundamental laws that govern the universe, from the smallest subatomic particles to the vast expanses of the planet. By providing students with a solid understanding of physics, we enable them to not only understand the world around them but also to harness its potential for creative solutions and breakthroughs. According to Oladajo et al. (2011), physics is an important subject in the secondary school curriculum because it allows students to apply principles, gain knowledge and skills to construct appropriate scientific expedients from available resources and prepare students for scientific and technological careers. Physics seeks different solutions to the energy challenges confronting both developed and developing countries. It helps engineers and scientists in the fields of biology, computer science, and engineering find innovative ways to harness existing and use new energy sources (Shivaraj, 2015).

Physics education plays a particularly crucial role in fostering not just scientific literacy but also a suite of transferable skills essential for success in the 21st century. Entrepreneurship involves identifying and capitalising on opportunities. By cultivating an entrepreneurial mindset, students are empowered to translate scientific knowledge

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into practical applications, fostering innovation and driving economic growth. While standard-variable resistors are a cornerstone in electrical circuits, their acquisition can be hindered by high costs and potential limitations in availability. This can pose a challenge for students seeking to experiment and develop their practical skills. To address this hurdle and foster a spirit of solution-oriented self-reliance, this study explores the construction of standard-variable resistors using readily available materials within the local context. This approach empowers students to not only gain practical physics knowledge but also cultivate resourcefulness and problem-solving skills.

Physics education must receive adequate attention, particularly concepts in physics that have been identified by researchers that can promote the entrepreneurial skills of students. Okafor (2018) reported that there are physics concepts that promote entrepreneurial skills, i.e., there are entrepreneurial skills embedded in concepts of physics. However, Ofoha (2011) stated that senior school graduates are not acquiring the necessary entrepreneurial skills for them to be self-employed. Therefore, there is a need to address why students are not acquiring the skills for them to be self-employed after school; hence, this study seeks to investigate the effects of metacognitive tools on senior school students' entrepreneurial skills acquisition on the construction of standard-variable resistor in Ilorin, Kwara State. In many electrical measurements, standard-variable resistors are required. Standard variable resistors are typically imported and expensive. As a result, most schools cannot afford to purchase adequate supplies. As a result, the ability to improvise utilising locally accessible materials is critical, opening up opportunities for self-employment. There are three types of resistors: standard, standard-variable, and variable. Standard resistors are wire or carbon-based components. Standard resistors are single-value resistors. To make standard resistors of various strengths, lengths of resistance materials, such as constantan wires, are cut and wound into electrical insulators with terminals for connection. Ohm's law states that the resistance of a wire or conductor is proportional to its length (l), resistivity (ρ), and cross-sectional area (A).

Standard-variable resistors are resistors that hold resistances of adjustable values to estimate and compare resistance. Its accuracy is high. The main aim of a standard-variable resistor is to control the specific value of the current that circulates or flows in the circuit. The skills in the construction of standard-variable resistors by students will assist them after leaving school as they could be constructing the resistors in commercial quantities, and with this, they will be self-reliant. More so, resistance has been reported as a concept in the physics curriculum that promotes entrepreneurial skills, of which the standard-variable resistor is a sub-concept (Okafor, 2018). For students to gain cognitive ability in particular physics concepts, they must also develop psychomotor ability through entrepreneurial skills, which turns concept cognition into the creation of things that may be helpful to society. Furthermore, Onwioduokit (2014) claimed that incorporating hands-on activities with the concept is an excellent method of teaching physics. Making potentiometers and other sensitive devices for physics education would necessitate hands-on activity. Learning skills are crucial in the twenty-first century. Learners need these skills to deal with the rapid changes in creativity that accompany developments in science and technology (Chu et al., 2017). Memory controls creativity through planning and ideas, as well as product quality (Baum & Newbill, 2010; Ritter & Mostert, 2016). Creativity requires using psychomotor skills and the brain to create things that are unlike those that already exist, as well as creating something out of nothing. It is founded on two principles: 'issue discovery' and 'problem solutions', and it requires a wide range of knowledge and skills. According to Miller and Dumford (2015), Perry and Karpova (2017), and Srikoon et al. (2018), creativity is divided into four components: fluid thinking (fluency), flexible thinking (flexibility), original thinking (originality), and detailed thinking (elaboration).

Arokoyu and Nna (2012) evaluated the effect of the demonstrative approach to teaching and students' creative level on the learning of science process skills for self-reliance among senior secondary school (SS2) students in chemistry. The study's findings revealed that students with high creative abilities contributed the most to the difference in the effects of creative abilities on students' acquisition of measurement skills compared to low and averagely creative students. However, Igboegwu and Egbutu (2011) looked into the impact of cooperative learning strategies and demonstration methods on the acquisition of science process skills by chemistry students with varying degrees of scientific literacy. The study found that students with average and low creative ability benefited the most from the training in manipulating skills. The need for entrepreneurial skills cannot be overemphasized, as there is a need for students to develop these skills. Therefore, in doing this, creativity can hardly be separated from entrepreneurial skills. To enhance students' creative and entrepreneurial talents, it is vital to consider the educational methods used by teachers. As a result, the current study analyses the effects of metacognitive tools on senior school

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students' development of entrepreneurial abilities in the manufacture of standard-variable resistors in Ilorin, Kwara State, using a concept-mapping as a learning strategy.

Concept mapping is a teaching and learning approach that was derived from Ausubel's learning theory and is used to assist students explains and generating individual understanding of certain ideas. (Novak, 1990; Novak & Cañas, 2008). Ahmad (2017) investigated the impact of using a concept map on the development of creative thinking in students. It revealed that conducting a concept map strategy in the development of creative thinking in students will enhance their skills. Also, Ali (2015) investigated the effects of concept mapping and inquiry strategy on achievement and creativity among College of Education physics students in the North East, Nigeria. The study found no significant difference between the two groups of students in their creativity ability, indicating that both concept mapping and inquiry strategy improve the creative ability of students and equally develop skill acquisition in students. Gender disparity and equity have been a topic of discussion in recent times. Most developing and developed countries throughout the world now support gender equality. Gender is the social notion of being male or female. It is a set of qualities that identify males and females, notably men and women, and which, depending on the situation, can range from sex to social role to gender identity. The evidence in the literature accessible to the researcher indicates that no conclusion has been made about the influence of creative ability level on students' entrepreneurial skill acquisition. Some believe that male students outperform girls in terms of acquiring entrepreneurial abilities; others disagree.

Despite calls for self-reliance and job creation in Nigeria, the examination-oriented educational system remains in place, with students being tested and inspected weekly and yearly to determine their level of knowledge or for certification purposes (Avwiri, 2017). The quest for self-reliance was not required to address the issue of unemployment. These could be the effect of the teaching approaches used (Avwiri, 2020). However, might these students' creative abilities be enhanced, and could there be a learning technique that aids in the acquisition of entrepreneurial skills so that they can be self-sustaining? Maryrose and Obiajulu (2017) investigated the acquisition of innovative and entrepreneurial skills in fundamental science education for job creation in Nigeria. The study discovered that the teaching strategies required for the acquisition of innovative and entrepreneurial skills in fundamental scientific education include the utilisation of diverse modes of inquiry. In line with the foregoing, the purpose of this study is to evaluate the impacts of a metacognitive tool on senior school students' entrepreneurial skill acquisition during the design of a standard-variable resistor in Ilorin, Kwara State, using concept mapping as a learning approach. Given the requirement to acknowledge the differences in sex status among the sampled students, the researcher will additionally consider the students' gender in the current study.

Aim and Objectives of the Study

The main purpose of this study is to investigate the effect of metacognitive tools on senior school students' entrepreneurial skills acquisition in the construction of standard-variable resistors in Ilorin, Kwara State. Specifically, the study investigated;

1. The effect of concept mapping learning strategy on students' acquisition of entrepreneurial skills in the construction of standard-variable resistor;
2. The effect of concept mapping learning strategy on students' acquisition of entrepreneurial skills on the construction of standard-variable resistor considering their level of creativity;
3. the difference in the male and female students' acquisition of entrepreneurial skills on the construction of standard-variable resistor when exposed to concept mapping learning strategy.

Research Questions

The following research questions were raised and answered.

1. What is the difference in the students' entrepreneurial skill acquisition in the construction of standard-variable resistor using concept mapping learning strategy and using traditional method?
2. What is the effect of the use of a concept mapping learning strategy on students' acquisition of entrepreneurial skills in the construction of standard-variable resistors considering their level of creativity?
3. What is the difference in the students' acquisition of entrepreneurial skills in the construction of standard-variable resistors when exposed to concept mapping learning strategy based on gender?

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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 students' entrepreneurial skills acquisition in the construction of standard-variable resistor using concept mapping learning strategy and using the conventional method;

H_{02}: There is no significant difference in students of high, average, and low creative ability in entrepreneurial skills acquisition in the construction of standard-variable resistor using concept mapping learning strategy, and;

H_{03}: There is no significant difference in the male and female students' entrepreneurial skills acquisition in the construction of standard-variable resistor when exposed to concept mapping learning strategy

Methodology

This quantitative study used a 2 x 2 x 3 pre-test, post-test, quasi-experimental, non-equivalent, and non-randomised control group design. The first two are for the concept mapping learning approach and the conventional instructional method, the second two are for the two levels of gender, and the third represents the three levels of creativity. This design is deemed appropriate for the study since it allows the use of intact classrooms while not interfering with the content. The study had two groups: one experimental and one control. Students in the experimental group were taught utilising the idea mapping strategy, whereas students in the control group were taught conventionally. The dependent variable is the students' entrepreneurial skill acquisition throughout the creation of the standard-variable resistor, whereas the independent variable is the therapy, which is a concept-mapping learning approach. Gender is the moderating variable, with two levels (male and female).

Table 1:Frequency Distribution of Sample for the Study

Gender	N	%
Male	51	41.13
Female	73	58.87
Total	124	100.0

The study's population consisted of all senior secondary school 3 students in Ilorin, with a sample of 124 students drawn from two secondary schools in Ilorin, 51 males and 73 females. Because of the gender status of students, the two schools were chosen using a purposive sampling technique, and co-educational schools were considered for this study. Senior School 3 (SS III) students participated in the study because the concept of standard-variable resistor is scheduled for the second term of the third year in the most recent edition of the senior secondary school physics curriculum (Federal Republic of Nigeria, 2014). This study's data was collected using two research instruments: The Physics Creative Ability Test (PCAT) and the Physics Entrepreneurial Skills Acquisition Test (PESAT). The PCAT, adopted from Hu and Adey's (2002) Scientific Creativity Test Scale, is divided into two sections (A & B). Section A comprised background information of the respondent, whereas Section B has seven questions on creativity considering the construction of a standard-variable resistor. Each question was scored five points, for a total of thirty. The PCAT was used to categorise the respondents' creative abilities (high, moderate, and low). The second instrument, the PESAT, has two sections (A & B). Section A provides background information about the respondent. Section B includes five procedures about hands-on activities involving measurement skills (questions 1 and 3), manipulative skills (question 2), and finger dexterity skills (questions 4 and 5). Each procedure was scored 5 marks.

The collected data were analyzed using descriptive and inferential statistics. Specifically, frequency count, percentage, mean, and standard deviation were used to answer research questions 1, 2, and 3, while hypotheses 1, 2, and 3 were also tested using Analysis of Covariance (ANCOVA) and a t-test at the 0.05 level of significance. The data collected from the study was analysed using Statistical Package for Social Science (SPSS) software, version 23.0. The collected data were analyzed using descriptive and inferential statistics. Specifically, frequency count, percentage, mean, and standard deviation were used to answer research questions 1, 2, and 3, while hypotheses 1, 2, and 3 were also tested using Analysis of Covariance (ANCOVA) and a t-test at the 0.05 level of significance. The data collected from the study was analysed using Statistical Package for Social Science (SPSS) software, version 23.0.

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Results

Research Question One: What is the difference in the students' entrepreneurial skill acquisition in the construction of standard-variable resistor using concept mapping learning strategy and using traditional method?

Table 2: The t-test Analysis of Students' Posttest Scores of entrepreneurial skills acquisition on the Construction of Standard-variable Resistor using Concept Mapping Learning Strategy and those exposed to the Conventional Method

Group	N	Posttest Mean	SD	df	t-cal.	Mean diff.	Sig. (2-tailed)
Concept mapping	81	61.43	9.30				
				122	5.27	9.15	0.00
Conventional	43	52.28	9.01				

$p<0.05$

Table 2 shows the mean gain scores for the students who took the physics entrepreneurial skills acquisition test. The mean gain score of students instructed to construct a standard-variable resistor using the concept mapping learning technique was 61.43, while the mean gain score of students in the control group was 52.27. The mean gain score of the experimental group was 9.15 higher than that of the control group, demonstrating that students taught utilising the concept mapping learning technique developed more entrepreneurial skills than students in the control group.

H01: There is no significant difference in the students' entrepreneurial skills acquisition in the construction of standard-variable resistor using concept mapping learning strategy and using conventional method

Table 2 shows a t-value of 5.27 with a degree of freedom of 122 and a p-value of 0.00. Since the p-value is less than the 0.05 level of significance, the hypothesis is rejected. Thus, there is no significant difference in the students' entrepreneurial skills acquisition on the construction of standard-variable resistor using concept mapping learning strategy and those taught using conventional methods in favour of the experimental group. $t_{(122)}=5.27$, $p<0.05$.

Research Question Two: What is the effect of the use of a concept mapping learning strategy on students' acquisition of entrepreneurial skills in the construction of standard-variable resistors considering their level of creativity?

Table 3: Descriptive statistics and ANOVA results on Students' Performance when Taught Construction of Standard-Variable Resistor using Concept Mapping learning strategy considering their level of creativity

Creative Ability Levels $F_{(2,120)} = 1.90, p=0.154$	N	Pretest Mean	SD	Posttest Mean	SD	Mean gain Score
Low	18	43.26	11.29	60.51	10.48	17.25
Moderate	57	40.60	10.04	56.05	9.59	15.45
High	18	45.06	12.08	59.11	10.07	14.05

Table 3 shows the pretest and posttest mean scores of low, moderate, and high creative ability levels of students taught the construction of a standard-variable resistor using the concept mapping learning strategy. The mean gain scores for low, moderate, and high, respectively, are 17.25, 15.45, and 14.05. The low-creative students had the highest mean gain score, followed by the moderately creative students, and the highly creative students had the lowest mean gain score.

H02: There is no significant difference in students of high, average, and low creative ability in entrepreneurial skills acquisition in the construction of standard-variable resistor using concept mapping learning strategy.

The result in Table 3 shows that $F_{(2,120)} = 1.90$, and the p-value is 0.154. Since the p-value is greater than the 0.05 level of significance, hypothesis two is rejected; therefore, there is a significant difference in students of high,

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average, and low creative ability in the acquisition of entrepreneurial skills acquisition on the construction of a standard-variable resistor using a concept mapping learning strategy in favour of the low creative students.

Research Question Three: What is the difference in the students' acquisition of entrepreneurial skills in the construction of standard-variable resistors when exposed to concept mapping learning strategy based on gender?

Table 4: The t-test Analysis of Results of Male and Female Students' Entrepreneurial Skills Acquisition on Construction of Standard-Variable Resistor using Concept Mapping Learning Strategy

Gender	N	Posttest Mean	SD	Df	t-val	Mean difference	p-value
Female	73	56.82	9.81				
				122	1.90	3.49	0.06
Male	51	60.31	10.38				

p> 0.05

Table 4 presents the mean gain scores of male and female students who participated in the study. The posttest mean gain score of female students entrepreneurial skills acquisition on construction of standard-variable resistor using the concept mapping learning strategy is 58.82, while the posttest mean gain score of male students' entrepreneurial skills acquisition on construction of standard-variable resistor using the same strategy is 60.31. The mean gain difference is 3.49 in favour of the male students.

H03: There is no significant difference in the male and female students' entrepreneurial skills acquisition in the construction of standard-variable resistor when exposed to concept mapping learning strategy

The result in Table 4 shows a t-value of 1.90 with a degree of freedom of 122 and a p-value of 0.06. Since the p-value is greater than the 0.05 level of significance, hypothesis 3 is rejected; hence, there is a significant difference in the male and female students' entrepreneurial skills acquisition on the construction of standard-variable resistor when exposed to concept mapping learning strategy in favour of the male students. $t_{(122)}$=1.90, p>0.05.

Discussion

This study looked into the effect of a concept mapping learning strategy on students' entrepreneurial skill acquisition in the construction of a standard-variable resistor. The concept mapping learning strategy resulted in a substantial difference in the acquisition of entrepreneurial skills among students compared to the control group. This shows that the strategy is effective at instilling entrepreneurial thinking in students through practical or hands-on activities. This aligns with Onwioduokit (2014), who believes that hands-on activities of the notion are a great method to teach physics. However, students with low creative ability benefited more from the learning strategy in terms of acquiring entrepreneurial skills than those with high or moderate creative ability. This challenges the common assumption that highly creative individuals are naturally better than others. The findings differ from that of Arokoyu and Nna (2012), who found that high-average and low-creative ability students performed much better when taught chemistry utilising a teacher demonstration approach. This study also discovered a substantial difference in how male and female students learned entrepreneurial abilities through the concept mapping learning strategy, with males having a greater advantage. This finding highlights a potential gender gap in entrepreneurial education.

Conclusion

This study investigated the effects of a concept mapping learning strategy on students' entrepreneurial skill acquisition on the construction of standard-variable resistors. The findings reveal a significant overall effect of the strategy on entrepreneurial skill acquisition. Interestingly, the effect differed based on students' creative ability and gender. The study observed that students with low creative ability benefited the most from the concept mapping strategy in terms of entrepreneurial skill acquisition. This suggests that the strategy may be particularly helpful for students who might struggle with independent learning approaches. On the other hand, the concept mapping strategy appeared to favour male students' entrepreneurial skill development compared to females. This finding necessitates further research to understand the underlying reasons for this gender difference and explore ways to optimize the strategy for all students.

In conclusion, while the concept mapping strategy offers a valuable tool for enhancing entrepreneurial skills in general, future studies should delve deeper into understanding how to tailor the approach to maximize its effectiveness for students with varying creative abilities and genders.

Recommendations

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

1. Investigate the reasons behind the impact of creativity level on entrepreneurial skills acquisition using a concept mapping learning strategy.
2. Explore the cause of the gender disparity in this specific learning environment.
3. Conduct a follow-up study to see if the acquired entrepreneurial skills translate into real-world applications.

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