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IMPACT OF DIGITAL MATHEMATICS LABORATORY ON SENIOR SECONDARY SCHOOL STUDENTS' DEVELOPMENT OF ENTREPRENEURSHIP SKILLS IN KOGI STATE, NIGERIA

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Abstract
This study investigated the impact of the Digital Mathematics laboratory on senior secondary school students' development of entrepreneurship skills. The study adopted a descriptive research design, three research questions were raised and a research hypothesis was developed with a sample of 300 senior secondary school II students and 40 mathematics teachers, which were all purposively selected. Two instruments were used for data collection; the instruments were validated, and reliability indexes were obtained. The data collected were analyzed using mean, standard deviation while the hypothesis was tested using t-test at a significance level of 0.05 level. The findings of the study revealed that the Digital Mathematics Laboratory helped students develop entrepreneurship skills, and gender did not influence the impact of the digital mathematics laboratory. Hence, it was recommended that mathematics teachers should be trained in the use of digital mathematics laboratories to help students develop entrepreneurship skills.

Introduction

As digitalization increases in education systems worldwide, many countries issuing legislation and action plans to speed up the process (Mulenga & Marbán 2020). The issue of effectively integrating digital technology into teaching and learning practices has become critical. Related research is largely concerned with understanding how schools handle digitalization. Mathematics is the study of numbers, sets of points and various abstract elements, together with their relationships and operations performed on them. Mathematics goes beyond formulas. It gives a reasonable explanation of what, how and why, to invoke logical thinking that enables one to understand how formulas are derived as well as their applications. Digital technology, as a tool that is believed to

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make a significant contribution to the development of education, is also a challenge in its application, especially concerning the development of mathematical knowledge and skills, and, mathematical literacy. Sunday, et al (2023) highlighted the importance of mathematics in terms of four broad functions-utilitarian, cultural, social, and personal. Different approaches have been employed to the teaching of mathematics from time immemorial, but the use of instructional resources has been identified as the most meaningful way to approach mathematics teaching. This is because instructional resources reduce mathematical abstractions to a minimum reality of concrete evidence for learners' understanding of the concept, aside reducing the stress a teacher experiences in teaching the concept. Sunday, Olaoye, and Hauwa (2021) attested to the fact that instructional materials, when properly used in the teaching and learning situations, can arouse and sustain interest necessary for co-opting conceptual thinking and making learning more permanent for students. According to Abdulaziz (2021). Instructional resources for mathematics teaching are those resources (both human and material) used for stimulating and maintaining interest as well as facilitate learning in the mathematics classroom. Instructional resources enhance the teaching-learning process and enhance entrepreneurship skills since learning is hands-on and mind-on when adequate instructional resources are kept and used in the mathematics laboratory.

The mathematics laboratory is a place where learners are exposed to explain difficult mathematical concepts and verify mathematical facts, formulae and theorems/results in various activities. It helps students create mathematical awareness, skill-building, and positive attitudes toward the subject and, above all, ideas of learning by doing (Esangbedo, 2014). This implies that it is an effective tool for the effective teaching and learning of mathematics which will help to sustain students' interest and performance in Mathematics. Salman (2002) argued that the teaching of Mathematics must be practical, exploratory and experimental, which could easily be carried out in the mathematics laboratory. The mathematics laboratory could be an intelligent synergy of the physical structure of a classroom equipped with different mathematics manipulatives and an instructional strategy of refocusing the role of the teacher and the students such that the students take the dominant role in a lesson while the teachers' role is drastically reduced to a facilitator. The students are the focal point of learning in the mathematics laboratory, not the teacher. The students use manipulative, construct models, and design all forms of mathematics activities that suit their interests either as an individual, in a group of four or five students or as a whole class.

Adenegan (2011), while applying the macro-instructional versus a micro-instructional role of activity learning, which takes place in the mathematics laboratory, believed the macro-instructional use of mathematics laboratory could mean its application to many contents and objectives of a given class. The micro-instructional use of the mathematics laboratory is application to teaching a single concept. For example, the Macro-use of a mathematics laboratory could mean using a mathematics laboratory to teach either the SS1, or SS2, or SS3 mathematics content. Micro-use could also be used for teaching concepts such as geometry. The micro-use of mathematics could be very expensive if a mathematics laboratory could be developed only for teaching and learning a single concept. However, the focus of this study will be on the micro-use of teaching geometry. The mathematics laboratory is mathematics, and its consequent connectivity to the real world is entrepreneurship. It is learning by doing instead of being told. A highly structured learning strategy involving planned experiences with concrete embodiments of certain mathematical concepts which could be seen as totally unstructured, open-ended involvement in well or loosely defined real-world situations (Maschietto, 2012).

Alan (2012) viewed mathematics laboratory as an activity-centered instruction where the child is placed in a problem-solving situation, and through self-exploration and discovery, a solution is provided based on the experiences, needs, and interest of the learner. The author stated that there exist some common characteristics of

mathematics laboratories: First, the room is well organized by staging several activities where the learner(s) can work at the same time on several materials at different rates. Second, the room is equipped with several materials (foreign-made, local-made, teacher-made, students-made, parents-made, school-made) devices. Third, the teacher works with all students who wants to learn in the mathematics laboratory atmosphere, either as individual, group, Whole class, Whole class or a whole school in this learners-centered environment of instruction.

Moreover, the students' progress with their discoveries in their own space as far as they wish. In addition, the organization and structure of the mathematics laboratory is flexible, and it gives room for learners to easily switch from one mathematical activity to another based on their needs and interest. Furthermore, there is a multi-media or multi-sensory approach to teaching and learning using video tapes, films, concrete objects, projectors, flipped classrooms among others. The full use of textbooks, encyclopedias, four figure tables, charts, and other reference materials that the learner could easily consult on their own for further discoveries as the concluding part of the bond.

There are four types of mathematics laboratory as a physical structures

i. Centralized/full hall mathematics laboratory
ii. Decentralized or classroom mathematics laboratory
iii. Team-room mathematics laboratory
iv. Roving or Moving Mathematics Laboratory
v. Digital Mathematics Laboratory

This study focused on the digital Mathematics Laboratory. Digital Mathematics laboratory. A Digital Mathematics Laboratory is a computer-based learning environment that allows students to interact with mathematical concepts through virtual simulations and interactive software. It provides a space where students can explore, manipulate, and visualize mathematical ideas in a hands-on manner, like a traditional laboratory but without physical constraints. Students can use virtual tools and models to explore mathematical concepts and solve problems. Digital Mathematics Laboratory often includes gamified elements and interactive activities to make learning more enjoyable and engaging. Students can directly manipulate virtual objects and experiment with different scenarios to deepen their understanding of mathematical principles. Digital Mathematics Laboratory can be tailored to individual learning styles and needs, allowing students to work at their own pace and focus on areas where they need more practice. Digital Mathematics Laboratory can facilitate collaborative learning, allowing students to work together on problems and share their findings. Virtual simulations help students visualize abstract mathematical concepts and make them more Interactive activities and gamified elements can make learning more enjoyable and motivate students to participate more actively. Students develop critical thinking and problem-solving skills as they work through different scenarios and challenges in the laboratory, Digital Mathematics Laboratory can provide access to mathematical resources and learning materials for students who may not have access to traditional labs or materials. The Digital Mathematics Laboratory can be used in various learning environments, including traditional classrooms, blended learning courses, and online platforms. Examples of Digital Mathematics Laboratory are Geometric Modeling: Data Visualization, Algebraic Manipulation and Calculus Simulations.

An entrepreneur is defined as someone who is willing to take risks that other people dare not take while or as someone who starts and builds successful business (Mind Tools, 2012). Ajileye and Adebayo (2004) in Agbo-Egwu, Abakpa and Adikwu (2013) described entrepreneurs as people who could see and evaluate business opportunities, gather the necessary resources, take advantage of them, and initiate the appropriate action to ensure success. Othman, Othman and Ismail (2012) identified entrepreneurship as a catalyst for expanding economic

growth and maintaining competitiveness in facing global challenges. Entrepreneurship education is a pathway to tertiary education levels. Furthermore, they described entrepreneurial skills as individuals' ability to explore and develop risk awareness, creativity, and innovations in business and employment- related activities. Also, Reich in Wikipedia (2013) considered leadership, management ability, and term-building as essential qualities of an entrepreneur. According to Mind Tools (2012), successful entrepreneurs have some common traits. These include personal characteristics; interpersonal skills; critical and creative thinking skills; and practical skills. Other authors listed six basic skills that successful entrepreneurs should possess. These are:

(i) Communication skills
(ii) Mathematics skills
(iii) Human relation skills
(iv) Business mathematics skills
(v) Technique skills
(vi) Basic business skills (www.powerhomebiz.com/-/skill).

The implication of the above definitions is that successful entrepreneurs require certain levels of mathematical skills to manage their entrepreneurial work more efficiently than their counterparts that are not proficient in the subject. Okpala and Anene (2013) also reported that successful entrepreneurs are good at mathematics. This shows that a strong mathematical foundation is key to a successful career in any industry. Weintraub (2018) further argued that issues in business whether in small or big organization, the ability to compute percentages, decimals, fractions, financial statements, salary negotiation, and incentive-based performance depends on basic mathematical ability. This implies that there exists a strong positive relationship between mathematics skills and entrepreneurial skills. Language entrepreneurship is likely to attract youth because it speaks on their ability to make wealth. The lack of entrepreneurial skills among learners may be attributed to several factors. Notable among them is the influence of the learning environment. The environment determines the opportunity that a child may use. From the environment, they will be able to relate learning experiences in a meaningful form to the learners' understanding. Thus, mathematics teachers have the herculean task of developing the basic skills that an entrepreneur requires.

Literature Review

Ausubel's Learning Theory

Ausubel's (1962) learning theory emphasized that meaningful learning occurs when new concepts are linked with concepts existing in the learners' cognitive structure. Meaningful learning implies achieving a deep understanding of complex ideas relevant to students' lives. It assumes that students already have some knowledge relevant to a new experience they are about to encounter and that they are ready and willing to do the mental work necessary to create connections with the new knowledge they are about to acquire. Ausubel's cognitive theory states that learning is only meaningful to the extent to which the learner can integrate old learning experiences with new learning experiences. This theory rests principally on two major issues: i. the most general ideas of a subject should be presented first and then progressively differentiated in terms of details and specificity and ii. Instructional materials should attempt to integrate new material with previously presented information through comparisons and cross-referencing of new and old materials. Ausubel is concerned with the learning of content, facts, principles, and concepts, among others, as opposed to mastering skills and processes. There are four principles underlining Ausubel's theory: Principle of Subsumption or Integration; Principle of Progressive Differentiation; Principle of Integrative Reconciliation; and Principle of Consolidation.

In a study by Sunday, Akanmu and Fajemidagba (2016) on fostering entrepreneurship using mathematics laboratory in Abuja, the study suggested that mathematics teachers should be encouraged to use mathematics laboratory to enhance students' entrepreneurship skills. In another study Sunday, et al (2023) discovered that mathematics laboratory enhances students' creative skills in entrepreneurship. Naugra (2021) in a study

discovered that mathematics laboratories bring out the creative skills of students in mathematics classrooms which could enhance their entrepreneurship abilities. None of these studies were carried out in a digital mathematics laboratory for the development of entrepreneurship skills which this study sought to achieve. The findings of several studies (Muhammad and Ibrahim (2015); Musa and Bolaji(2015); Akanmu, Sunday and Ayinla (2016); Ahmed and Iliyasu (2017); Sunday and Anaduaka (2021)) indicated that students taught using the mathematics laboratory approach outperformed all their counterparts in terms of understanding and mastery of concepts of mathematics of which gender is of no effect on using the strategy. These studies show that the mathematics laboratory indeed enhances students' knowledge, positive attitudes and achievement in mathematics since students have greater opportunity to relate with concrete mathematical materials that help them to bridge the gap between the abstract and real world. However, none of these studies have investigated the efficacy of digital mathematics laboratory on students' development of entrepreneurship skills, hence the need for this study.

The relevance of gender as a difference in students' variables that influences students' mathematics is often reported. Researchers have argued severally that high or otherwise achievement of students is closely linked to the students' gender,

Statement of the Problem

Ogwu (2023) considered entrepreneurship as a process of creating or developing a new business venture to make a profit. Similarly, Ogunode and Adanna (2022) views the entrepreneur as a person who possesses the ability and innovation to develop a business where none exists. Therefore, an entrepreneur constantly engages with new markets and tries to determine how to supply those markets efficiently to make a profit (Ogwu, 2023). Here, one can easily conclude that an entrepreneur can be considered an innovator or creator of wealth. Entrepreneurs do not engage in any business that does not generate profit. He/she usually takes risks creating products to maximize profit and create wealth. Entrepreneurship is a platform for youths to transform opportunities to business ventures towards creation of jobs and poverty reduction (Okehi, 2019). In Nigeria, particularly in North Central Nigeria, millions of teenage girls are forced into poverty because of early pregnancy, which is a result of forced into early marriage (Aborisade, 2019). To arrest this ugly trend among these vulnerable groups of people, the Ministry of Women Affairs, Non-Governmental Organizations (NGOs), and some religious bodies in Nigeria organized entrepreneurial skills training to help teenagers get out of poverty. However, no group has exploited the digital mathematics laboratory to develop students' entrepreneurship skills. However, the researcher seeks to determine whether the Digital mathematics Laboratory helps students in entrepreneurial skills development in the Kogi State of Nigeria.

Research Questions

1. What mathematics skills are required for entrepreneurship?
2. What is the influence of the Digital mathematics laboratory on students' development of entrepreneurship skills?
3. What is the difference in the male and female students' responses regarding the influence of the digital mathematics laboratory on students' development of entrepreneurship skills?

Research Hypotheses

$H0_1$: There is no significant difference between the mean responses of male and female students' regarding the influence of the digital mathematics laboratory on students' development of entrepreneurship skills.

Methodology

The study was descriptive study. The population for this study were all senior secondary school's mathematics teachers and students in Kogi state. The sample of this study consisted of 300 (150 male and 150 female) senior secondary school II students which were selected from schools based on schools that have digital mathematics laboratory and are co-educational schools and 40 mathematics teachers selected. Two instruments were used in this study: Digital Mathematics Laboratory Entrepreneurship Questionnaires (DMLQ) and Mathematics Skills Required for Entrepreneurship Questionnaires (MSRFEQ). The instruments were questionnaires developed by the researchers. The questionnaires were validated by three experts in Mathematics education and educational technology. The instruments were trial tested on 40 students and 10 teachers and reliability indexes of 0.73 and

0.69 were obtained for the two instruments, respectively. The questionnaires were distributed to both data students and mathematics teachers.

Data Analysis

Research Question One: What mathematics skills are required for entrepreneurship?

Table 1: *Identifying the responses of Mathematics Teachers to the mathematics skills required for entrepreneurship.*

S/N	Items	Mean	Standard dev.	Remark
1	Been very optimistic	3.8	0.6	Agreed
2	Initiative	3.1	0.8	Agreed
3	Risk taking	2.9	1.1	Agreed
4	Drive and persistence	4.2	0.7	Agreed
5	Resilience	3.4	0.8	Agreed
6	Critical thinking	4.1	1.2	Agreed
7	Problem-solving ability	3.5	0.9	Agreed
8	Goal setting	3.6	0.6	Agreed
9	Decision making	2.7	0.4	Agreed
10	Planning and organizing	3.9	0.9	Agreed
	Grand Mean	**3.8**		

Table 1 indicates that Being very optimistic(mean=3.8), Initiative(mean=3.1), Risk taking(mean=2.9), Drive and persistence(mean=4.2), Resilience(mean=3.4), Critical thinking(mean=4.1), Problem-solving ability(mean=3.5), Goal setting(mean=3.6), Decision making(mean=2.7), Planning and organizing(mean=3.9) with a grand mean of 3.8 were all agreed to as mathematics skills required for entrepreneurship by the responding mathematics teachers.

Research Question Two: What is the influence of the Digital mathematics laboratory on students' development of entrepreneurship skills?

Table 2: Showing teachers and students' responses to the influence of the Digital Mathematics Laboratory on their development of Entrepreneurship skills.

SN	Items	Mean	Standard Deviation	Remarks
1	The Digital Mathematics Laboratory helped me to develop the software skills required for Entrepreneurship	4.4	0.9	Agreed
2	The Digital Mathematics Laboratory have helped me to be very optimistic required for entrepreneurship.	3.6	1.1	Agreed
3	The Digital Mathematics Laboratory have helped me to acquire more initiatives skills required for entrepreneurship.	3.7	0.7	Agreed
4	The Digital Mathematics Laboratory helped me develop risk-taking skills required for entrepreneurship.	3.9	0.9	Agreed
5	The Digital Mathematics Laboratory helped me develop the drive and persistence skills required for entrepreneurship	3.5	0.9	Agreed
6	Digital Mathematics Laboratory have helped me develop resilient skills required for entrepreneurship.	2.6	1.2	Agreed
7	The Digital Mathematics Laboratory helped me develop the critical thinking skills required for entrepreneurship.	3.2	0.8	Agreed
8	The Digital Mathematics Laboratory helped me develop problem-solving skills required for entrepreneurship.	4.1	0.7	Agreed

9	The Digital Mathematics Laboratory helped me develop the goal setting skills required for entrepreneurship.	3.3	0.9	Agreed
10	The Digital Mathematics Laboratory helped me develop decision making skills required for entrepreneurship.	3.5	1.1	Agreed
11	The Digital Mathematics Laboratory helped me develop planning and organizing skills required for entrepreneurship.	4.1	0.6	Agreed

Table 2 indicated that the digital mathematics laboratory helped the students to develop the following skill required for entrepreneurship: Software skills (Mean =4.4), Being very optimistic(mean=3.6), Initiative(mean=3.7), Risk taking(mean=3.9), Drive and persistence(mean=3.5), Resilience(mean=2.6), Critical thinking(mean=3.2), Problem-solving ability(mean=4.1), Goal setting(mean=3.3), Decision making(mean=3.5), Planning and organizing(mean=4.1) with a grand mean of 3.5

$H0_1$: There is no significant difference between the mean responses of male and female students regarding on the influence of the digital mathematics laboratory on students' development of entrepreneurship skills.

Table 3

T-test analysis of the difference between the mean responses of male and female students' regarding the influence of the digital mathematics laboratory on students' development of entrepreneurship skills

Variable categories	N	Mean	STD	df	Level of sig	t-cal	t-val	Decision
Male	150	3.32	0.91	538	0.05	1.47	1.96	Not Rejected
Female	150	3.16	0.86					

Table 3 indicates that the calculated (CV) 1.47 is less than table value (tv) 1.96 at 0.05 level of significance, the hypothesis was therefore not rejected. This means that there is no significant difference in the mean responses of male and female students regarding the influence of the digital mathematics laboratory on students' development of entrepreneurship skills.

Summary of Findings

1. The mathematical skills required for entrepreneurship are being very optimistic, Initiative, Risk taking, Drive and persistence, Resilience, Critical thinking, Problem-solving ability, Goal setting, decision making, and planning and organizing, with a grand mean of 3.8, were all agreed to as mathematics skills required for entrepreneurship by the responding mathematics teachers.
2. The digital mathematics laboratory helped the students to develop the following entrepreneurship skills: digital mathematics laboratory helped the students to develop the following skills: software skills, being very optimistic, Initiative, Risk taking, Drive and persistence, Resilience, Critical thinking, Problem-solving ability, Goal setting, Decision making, Planning and organizing.
3. There is no significant difference in the mean responses of male and female students' regarding the influence of the digital mathematics laboratory on students' development of entrepreneurship skills.

Discussion of Findings

The mathematical skills required for entrepreneurship are being very optimistic, Initiative, Risk taking, Drive and persistence, Resilience, Critical thinking, Problem-solving ability, Goal setting, Decision making, and planning and organizing, which were all agreed to as mathematics skills required for entrepreneurship by the responding

mathematics teachers. These skills are necessary for any successful entrepreneur, and they showcase how useful mathematics is to the prosperity of any nation. This finding is in line with Ichipi and Panya (2016), whose findings revealed that tolerance, resilient, objectivity, teamwork and conflict management are the required mathematics skills necessary for setting-up small and medium enterprises. This is also supported by the findings of Ojo (2016), who believed organization and problem-solving techniques are skills required for entrepreneurship.

The digital mathematics laboratory helped the students to develop the following entrepreneurship skills: software skills, being very optimistic, Initiative, Risk taking, Drive and persistence, Resilience, Critical thinking, Problem-solving ability, Goal setting, Decision making, Planning and organizing. This could be as results of the hands-on and minds-on skills that the digital mathematics laboratory provides. This finding also agrees with the findings of Sunday, Akanmu and Fajrmidaga(2016) and Sunday et al (2023), whose findings revealed that mathematics laboratory helped students in the development of Entrepreneurship skills in secondary schools.

There is no significant difference in the mean responses of male and female students' regarding the influence of the digital mathematics laboratory on students' development of entrepreneurship skills. This finding agreed with that of Naugra (2021), (Muhammad and Ibrahim (2015); Musa and Bolaji (2015), whose findings revealed that students taught mathematics using mathematics laboratory performed equally well irrespective of gender.

Conclusion

This study concludes that the digital mathematics laboratory positively influenced students' development of entrepreneurship skills at the senior secondary schools' level, irrespective of their sex. In addition, mathematics skills required for entrepreneurship are Software skills, being very optimistic, Initiative, Risk taking, Drive and persistence, Resilience, Critical thinking, Problem-solving ability, Goal setting, Decision making, Planning and organizing.

Recommendations

1. Secondary schools should be equipped with digital mathematics laboratory as this will enhance the development of students' entrepreneurial skills.
2. Mathematics teachers should be properly trained on the use of digital mathematics laboratory for entrepreneurship.
3. The mathematics curriculum should clearly state the mathematics skills required for entrepreneurship.

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