

Effect of Problem-Based Learning with Simulation on Secondary School Students' Digital Literacy in Computer Studies in Imo State

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Abstract- The effect of problem-based learning with simulation on secondary school students' digital literacy in Computer studies in Imo state, Nigeria was investigated. Guided by two research questions and three hypotheses tested at 0.05 significance level was used. The study adopted the quasi-experimental design. A total of 94 senior secondary school two (SS2) students offering Computer studies drawn using purposive and random sampling techniques were involved in the study. The instrument for data collection was Digital Literacy Test (DLT) validated by three experts. The reliability DLT was established using Kuder-Richardson Formula 20 which yielded coefficient of internal consistency of 0.84. Students in the experimental group were taught Computer studies using problem-solving with simulation whereas the control group was taught using lecture method. Data were generated for the study by administering the DLT as pretest and posttest. The data obtained were analyzed using mean, standard deviation and analysis of covariance. The findings of the study revealed among others that there is a significant difference in the mean digital literacy scores of students taught Computer studies using problem-based learning with simulation (PBLWS) and lecture method in favour of PBLWS. Significant difference was observed between male and female students' digital literacy scores when taught with PBLWS in favour of males. It was concluded that PBLWS is more effective than the lecture method in enhancing students' digital literacy. It was recommended among others that, state ministry of education and schools should provide professional development for teachers to effectively implement PBLWS and other technology-enhanced pedagogies in their classroom.

Keywords: *Problem-based learning, Simulation, Digital Skill, Computer studies*

I. INTRODUCTION

The growing importance of digital literacy in the 21st century has transformed the educational landscape, compelling schools to integrate digital skills into their

curriculum. Digital literacy encompasses the ability to access, evaluate, and utilize digital tools effectively (Ng, 2018). With the rise of the global knowledge economy, the need for students to be digitally literate has become more critical than ever before. This necessity is particularly pronounced in developing countries such as Nigeria, where the integration of technology into education remains uneven and fraught with challenges (Adebowale, Agbatogun, and Aladejana, 2020). The rapid advancement of technology has brought about significant shifts in secondary education, highlighting the urgent need to adopt innovative instructional strategies to improve students' learning outcomes including digital literacy. In the context of secondary education, Computer studies typically covers a variety of areas such as: computer programming; where students learn to write code in different programming languages; computer hardware, where they understand the physical components of computers; software applications, which teach them how to use tools like word processors, spreadsheets, and graphic design software; and topics like networking, databases, and internet usage. The emphasis in learning Computer studies is on both theoretical knowledge and practical skills. Students are taught to solve problems using technology, understand the ethical implications of digital tools, and develop critical thinking abilities related to technology. The ultimate objective of Computer studies is therefore to foster digital literacy, which is becoming increasingly essential in almost every aspect of modern life, including education, work, and communication.

Digital literacy, according to Lombardi (2023) refers to the ability to effectively and critically navigate, evaluate, and create information using a range of digital technologies. It encompasses more than just the ability to use digital tools or devices; it involves

understanding how to access, manage, and communicate information in various digital formats, while also being aware of the ethical, social, and security considerations of digital interactions. Digital literacy is essential in today's world, as technology plays a central role in education, work, communication, and daily life (Mariscal, Mayne, Aneja and Sorgner, 2019). A digitally literate individual, Agbai and Okechukwu (2024) noted, possesses the skills to perform a variety of tasks, such as using the internet to search for information, critically assessing the credibility of online sources, creating and editing documents, using social media responsibly, and understanding how to protect personal data and privacy. Digital literacy also involves the ability to adapt to new technologies and stay updated with digital trends (Adediran, Opadiji, Faruk, and Bello, 2016). In an educational context, digital literacy empowers students to not only use technology for learning but also to engage with complex information, solve problems creatively, and collaborate effectively in a digital environment. As technology continues to evolve, digital literacy is increasingly seen as a fundamental skill that is crucial for personal, academic, and professional success.

The problem of poor digital literacy commonly among secondary school students in Imo State, Nigeria, is likely linked to the gap between theory and practice in the teaching and learning of Computer studies (Adeosun, Oni and Ifeoma, 2020). This gap has been a significant obstacle to effective digital literacy development, as students are not provided with the hands-on, practical experiences necessary to fully grasp and apply the theoretical knowledge they acquire in the classroom. In theory, the Computer studies curriculum in Nigerian secondary schools, including Imo State, covers a range of essential topics such as computer hardware, software, programming, networking, and digital ethics. These concepts according to Adetumbi and Oluwafemi (2020) are crucial to fostering digital literacy, as they provide students with the foundational knowledge needed to understand how technology functions and its societal impact. However, while these theoretical components are part of the curriculum, they are often not translated effectively into practical, real-world learning experiences.

It appears some secondary schools in Imo State face infrastructural challenges, such as limited access to computers, inadequate internet facilities, and interrupted electricity supply. As a result, students are unable to engage in hands-on activities, simulations, or practical exercises that would allow them to apply the theoretical knowledge they learn. Students may be taught the theory behind programming languages, yet they lack the opportunity to write and test actual code or develop software applications. Similarly, while students may learn about computer hardware, they may not have access to the equipment needed to assemble or repair computers. This lack of practical application creates a significant barrier to mastering the concepts that are essential to digital literacy. Perhaps, inadequate resources and infrastructure are some of the most pressing challenges in Imo State, where many schools lack well-equipped computer laboratories, up-to-date software, and stable internet connections. Without these resources, the theoretical aspects of Computer studies may not be effectively reinforced through practice.

The lack of access to modern digital tools means students are not exposed to the real-world technologies they will encounter in higher education or the workforce. Even if students are taught about topics such as internet browsing, online research, or digital communication, without consistent access to the internet or devices, their understanding of these concepts remains superficial. Moreover, the infrequent or inconsistent use of computers in the classroom further exacerbates the gap. While Computer studies may be part of the curriculum, the actual time spent using computers is often limited to theoretical discussions or brief, infrequent laboratory sessions. This leaves students with insufficient opportunities to develop the technical skills and digital competencies they need to navigate the digital world effectively.

The implications of poor digital literacy in Imo State are far-reaching. Students who graduate from secondary school without adequate digital skills are at a significant disadvantage in higher education and the job market. As technology becomes an increasingly central component of education, business, healthcare, and government, the lack of digital literacy limits students' ability to access and utilize essential resources. This digital divide contributes to social

inequality, as students from areas with limited access to technology fall behind their peers in more digitally connected areas. Furthermore, the lack of practical experience with technology means students are less equipped to navigate online platforms, engage in digital communication, or participate in e-learning opportunities. As the world moves towards more technology-driven education and professional environments, students without strong digital literacy skills may struggle to adapt and succeed in these contexts.

To address this issue, it is essential to bridge the gap between theory and practice in the teaching and learning of Computer studies by using instructional strategies that integrate theoretical knowledge with practical experience, encouraging students to engage actively with the subject matter, apply concepts in meaningful contexts, and develop skills that are essential for digital literacy. One of such method that has been shown in literature to have the beneficial boost for this attainment is Problem-Based Learning (PBL) with Simulation (Hung, Jonassen and Liu, 2008).

Problem-Based Learning with Simulation (PBL with Simulation) according to Hae (2023) is an instructional strategy that combines two powerful educational approaches: Problem-Based Learning (PBL) and Simulation-Based Learning. Problem-Based Learning (PBL) is an instructional method in which students learn through the process of solving complex, open-ended problems rather than through direct instruction (Hwang, Sung and Chang, 2020). The primary focus is on students' active engagement with a problem or challenge that requires them to explore, research, and collaborate to develop solutions. In PBL, students are usually presented with real-world or realistic problems that are designed to be multifaceted and may not have one definitive solution. Simulation-Based Learning, according to Mhamed, Mohamed, Abdesselam, Taoufik and El (2021) involves using digital or physical simulations to replicate real-world systems or scenarios. In a simulated environment unlike traditional learning environment found in traditional teaching methods, students can practice skills, test hypotheses, and make decisions in a controlled and safe setting, where they

can see the consequences of their actions without real-world risks (Ibezim and Asogwa, 2020).

Studies have shown that traditional teaching methods, such as Lecture-Based Instruction, often fail to promote active learning and the development of digital literacy skills (Aluko and Adedayo, 2020). Consequently, there is a growing demand for instructional approaches that not only enhance students' understanding of Computer studies but also foster their ability to retain knowledge and apply it in real-life contexts. PBL with Simulation has been identified as an effective strategy for achieving these goals, as it allows students to explore complex problems, collaborate with peers, and develop practical solutions using digital tools irrespective of gender.

Research also indicates that girls exhibit lower digital literacy confidence despite comparable cognitive abilities, stemming from gendered stereotypes discouraging technical engagement (Eze, Oludipe and Eze, 2019). To bridge this gap, a problem-solving with simulation instructional approach could be transformative, as simulations provide a gender-neutral, interactive environment where students collaboratively tackle real-world computing tasks, reducing anxiety and fostering equitable participation (Onyegegbu and Eze, 2018). There is need therefore to investigate the effectiveness of problem-solving with simulation on students' digital literacy as a way to provide recommendations that could guide practical classroom interventions.

II. PURPOSE OF THE STUDY

The purpose of the study was to effect of Problem-Based Learning with simulation on secondary school students' digital literacy in Computer studies in Imo state. Specifically, the study sought to determine the:

- 1 Mean digital literacy scores of secondary school students taught Computer studies using Problem-Based Learning with Simulation (PBLWS) and that of those taught using Lecture Method (LM).
- 2 Mean digital literacy scores of secondary school male and female students taught Computer studies using PBLWS and that of those taught using Lecture Method.

- 3 Interaction effect of instructional strategies (PBLWS and LM) and gender (male and female) on students' digital literacy scores in Computer studies.

Research Questions

1. What are the mean digital literacy scores of secondary school students taught Computer studies using Problem-Based Learning with Simulation (PBLWS) and that of those taught using Lecture Method?
2. What are the mean digital literacy scores of secondary school male and female students taught Computer studies using PBLWS and that of those taught using Lecture Method?

Hypotheses

- 1 There is no significant difference between the mean digital literacy scores of secondary school students taught Computer studies using Problem-Based Learning with Simulation (PBLWS) and that of those taught using Lecture Method (LM).
- 2 There is no significant difference between the mean digital literacy scores of secondary school male and female students taught Computer studies using PBLWS and that of those taught using Lecture Method.
- 3 There is no interaction effect of instructional strategies (PBLWS and LM) and gender (male and female) on students' digital literacy scores in Computer studies.

III. METHOD

The study adopted the quasi-experimental design; specifically the pretest-posttest non-randomized control group design was used. The area of the study was Imo State. The population of the study comprises 5,192 senior secondary year two (SS2) students offering Computer studies in the Imo state, Nigeria. The sample size for the study is 94 SS2 students offering Computer studies in Imo state. The multi-stage sampling procedure was used as follows: First, two out of the three education zones were selected at random. From the two education zones selected, one public secondary school each was selected purposively at the second stage. The schools were selected based on the criteria that they have functional

computer laboratory, are co-educational and at situated miles apart to avoid subject's contamination. At the third stage, the selected schools were assigned to the one experimental group and one control group at random using balloting with replacement. The control group has 48 students (22 males and 26 females), while experimental group has 46 students (21 males and 25 females).

The instrument for data collection was Digital Literacy Test (DLT). Digital literacy test is a 50-item objective test bordering on overall digital concepts. The DLT was adapted and generated from an online test bank on digital literacy for students at the secondary school level of education. The test was designed with two sections: section A to generate demographic information on the students and section B to measure students' digital literacy. DLT is attached as Appendix B on page 168. Each correct answer on DLT earned the student two marks giving a maximum mark of 100. Lesson package in form of lesson plans were developed by the researcher using the instructional strategies. The lesson plans have uniform contents except for the activities of the teachers and students and the instructional strategies that were used which includes lecture method for control group and problem-based learning with simulation for experimental group. The instrument was validated by three experts from Departments of Science Education and Department of Educational Foundations (Measurement and Evaluation Unit) and one from Computer Science, Nnamdi Azikiwe University, Awka. The reliability of DLT was determined using the Kuder-Richardson Formula 20 (KR-20) which yield a coefficient of internal consistency of 0.84, because the instruments are dichotomously scored.

In experimental group, the teacher started the lesson by introducing the topic of the day. After giving an explanation of the concept, the teacher took the students to the computer laboratory, where a projection was made on the screen on various problems relating to the concept and how they are solved. The solution was presented using simulations. For instance, when teaching spreadsheet packages, the students would be told to compute the mean of a set of scores. The solution to that computation was projected on the screen and displayed in the form of simulation. The strategy was used to teach the remaining concept.

After the teachers' solutions to related problems, the students were given other related problems to solve. At the end of the lesson, the teacher gave the students evaluation problems to solve together with assignments that they solved at home.

The control group was taught using the traditional instructional strategy involving lecture method. Students were taught the same content as those in the experimental group but no use was made of problem-solving approach or simulation. The teacher presented the information to the students allowing them to ask questions for clarification. The teacher also permitted the students to also show-case their ideas and understanding on the concepts taught while using the

proper instructional materials to enrich the students' learning experiences. DLT was given to students as pretest before treatment and as posttest after treatment. Data relating to the research questions was analyzed using mean and standard deviation whereas data pertaining to the hypotheses was analyzed using analysis of covariance (ANCOVA). The decision rule for accepting or rejecting the null hypotheses is as follows: if the probability value (p-value) is greater than 0.05 ($P > 0.05$), do not reject the null hypothesis; otherwise, if p-value is less than or equal to 0.05 ($P \leq 0.05$), reject the null hypothesis.

IV. RESULTS

Table 1: Mean Digital Literacy Scores of Students taught Computer studies using Problem-Based Learning with Simulation (PBLWS) and Lecture Method (LM)

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
PBLWS	48	33.04	10.68	81.17	9.78	58.13
LM	46	33.13	7.60	43.35	9.21	10.22
Diff.		0.09		37.82		47.91

Table 1 shows that students taught Computer studies using PBLWS had higher mean gain digital literacy score than those taught using lecture method.

Table 2: Mean Digital Literacy Scores of Male and Female Students taught Computer studies using Problem-Based Learning with Simulation (PBLWS) and Lecture Method (LM)

Method	Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
PBLWS	Male	22	36.05	9.42	86.23	4.57	50.18
	Female	26	30.50	11.19	76.88	10.99	46.38
Diff.			5.55		9.35		3.80
LM	Male	21	34.62	6.22	43.90	10.66	9.28
	Female	25	31.88	8.52	42.88	7.981	11.00
Diff.			2.74		1.02		1.72

Table 2 shows that male students taught Computer studies using PBLWS had higher mean gained digital literacy score than those taught using LM and also, female students taught Computer studies using PBLWS had higher mean gained digital literacy score than the female students taught using LM.

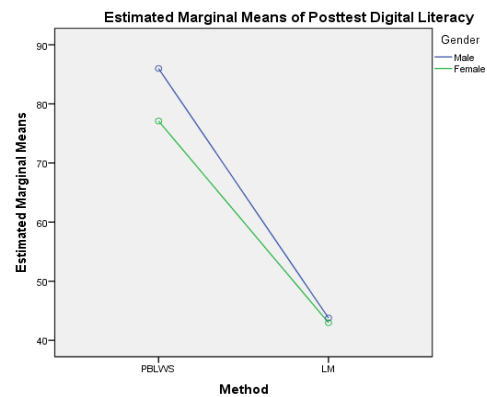
Table 3: ANCOVA Test of Significance of Difference in the Mean Digital Literacy Score of Students taught Computer studies using PBLWS and LM

Source	SS	Df	Mean Square	F	Sig.	Decision
Corrected Model	34699.204 ^a	4	8674.801	107.142	.00	
Intercept	22568.123	1	22568.123	278.739	.00	
Pretest	51.065	1	51.065	.631	.429	
Method	33959.435	1	33959.435	419.433	.00	Sig.
Gender	519.061	1	519.061	6.411	.013	Sig.
Method * Gender	378.890	1	378.890	4.680	.033	Sig.
Error	7205.902	89	80.965			
Total	41097.000	94				
Corrected Total	41905.106	93				

Table 3 shows that there is a significant main effect of the treatment on students' digital literacy in Computer studies, $F(4, 89) = 419.433, P = .000 < 0.05$. Therefore, the null hypothesis is rejected meaning that there is a significant difference between the mean digital literacy scores of secondary school students taught Computer studies using Problem-Based Learning with Simulation (PBLWS) and that of those taught using Lecture Method (LM) in favour of PBLWS.

Table 3 also shows that there is a significant main influence of gender on students' digital literacy in Computer studies, $F(4, 89) = 6.411, P = .013 < 0.05$. Therefore, the null hypothesis is rejected meaning that

there is a significant difference between the mean digital literacy scores of secondary school male and female students taught Computer studies using PBLWS and that of those taught using lecture method. Table 3 further shows that there is a significant interaction effect of the instructional strategies and gender on students' digital literacy in Computer studies, $F(4, 89) = 4.680, P = .033 < 0.05$. Therefore, the null hypothesis was rejected meaning that there is a significant interaction effect of instructional strategies (PBLWS and LM) and gender (male and female) on students' digital literacy scores in Computer studies as shown below in Figure 3.



Covariates appearing in the model are evaluated at the following values: Pretest Digital Literacy = 33.09

Figure 1: Plot of interaction effect of instructional strategies (PBLWS and LM) and gender on students' digital literacy score in Computer studies

The plot of interaction effect of instructional methods and gender on students' digital literacy in Computer studies as shown in Figure 1 is significant and ordinal. This shows that the instructional strategies had similar effect with respect to gender and are therefore gender biased. Given the significant interaction effect, the possible interactions are shown in the simple main effect analysis as presented in Table 4 and Table 5.

Table 4: Pairwise Comparison and Univariate Test of Simple Main Effect of Methods within Each Level of Combination of the other Effects

Gender	(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	F-value	Sig. ^b
Male	PBLWS	LM	42.205*	2.749	235.688	.000
	LM	PBLWS	-42.205*	2.749		.000

Female	PBL WS	LM	34.118*	2.52 5	182.6	.00 0
	LM WS	PBL	-34.118*	2.52 5	51	.00 0

on digital literacy is although gender-biased, the bias is with respect to PBLWS.

V. DISCUSSION

Table 4 shows that there is a significant difference between the mean digital literacy score of male students taught Computer studies using PBLWS and male students taught Computer studies using LM in favour of PBLWS, $F(1, 89) = 235.688, P = .000 < 0.05$. Also, there is a significant difference between the mean digital literacy score of female students taught Computer studies using PBLWS and female students taught Computer studies using LM in favour of PBLWS, $F(1, 89) = 182.625, P = .000 < 0.05$. This implies that with respect to gender (male and female), PBLWS is a superior instructional method for teaching Computer studies to improve digital literacy than lecture method.

Students taught Computer studies using Problem-Based Learning with Simulation (PBLWS) had higher mean gain digital literacy score than those taught using lecture method. The findings of the study indicating that students taught Computer studies using Problem-Based Learning with Simulation (PBLWS) achieved higher mean gain digital literacy scores compared to those taught via the lecture method align with the growing body of research emphasizing the efficacy of active, technology-integrated learning approaches in fostering digital competencies. This outcome can be contextualized within the broader discourse on how innovative pedagogical strategies enhance digital literacy, as evidenced by several related studies. For instance, Rizal, Rusdiana, Wawan, and Parsaoran (2021) demonstrated that a Problem-Based Learning Management System supported by smartphones (PBLMS3) significantly improved students' digital literacy by providing interactive, self-directed learning opportunities. Their study, grounded in the ADDIE model, highlighted how structured, problem-based digital tools engage learners in critical thinking and technological application, thereby cultivating skills such as information navigation, digital communication, and media literacy. The PBLWS approach similarly leverages simulations to immerse students in dynamic problem-solving scenarios, requiring them to manipulate digital tools, analyze data, and collaborate virtually activities that inherently build digital proficiency.

Table 5: Pairwise Comparison and Univariate Test of Simple Main Effect of Gender within Each Level of Combination of the other Effects

Gender	(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	F-value	Sig. ^b
PBLWS	Male	Female	8.885*	2.669	11.079	.001
	Female	Male	-8.885*	2.669		.001
LM	Male	Female	.799	2.679	.089	.766
	Female	Male	-.799	2.679		.766

Table 5 shows that there is a significant difference between the mean digital literacy score of male and female students taught Computer studies using PBLWS in favour of male students, $F(1, 89) = 11.079, P = .001 < 0.05$. There is no significant difference between the mean digital literacy score of male and female students taught Computer studies using LM, $F(1, 89) = .089, P = .766 > 0.05$. This implies that with respect to instructional methods, male students are more favoured than males when PBLWS is used while both male and female students are equally favoured when the teacher adopts lecture method of instruction indicating that the effect of the instructional strategy

Further supporting this, Marpaung, Yolida, Faros, Priadi, Maulina, Rakhmawati, Meriza, Fatimatuzzahra and Fatmawati (2022) found that Problem-Based Learning (PBL) augmented with digital comics enhanced students' scientific literacy, a closely related competency to digital literacy. Their study revealed that the integration of multimedia elements within PBL fostered higher engagement and deeper understanding, as students interacted with digital content to construct knowledge. This mirrors the PBLWS methodology, where simulations serve as multimedia scaffolds, enabling learners to visualize abstract Computer studies concepts while

simultaneously honing technical skills like software operation and data interpretation. The interactive nature of simulations demands active participation, contrasting sharply with the passive reception of information in traditional lectures, which often fails to provide opportunities for practical digital skill application.

Moreover, the findings reinforce the notion that blended, project-based learning environments effectively accommodate digital literacy development. Their research illustrated that combining hands-on projects with digital tools, akin to the simulation component in PBLWS, encouraged students to utilize technology purposefully, from researching information online to presenting findings digitally. This aligns with the PBLWS framework, where students must navigate simulation software, synthesize digital resources, and communicate solutions electronically. The lecture method, by comparison, typically lacks these interactive dimensions, limiting students' exposure to the multifaceted digital tasks that are critical in contemporary education and workforce settings.

Collectively, these studies underscore that PBLWS's superiority in enhancing digital literacy stems from its alignment with constructivist principles, where learning is active, contextualized, and technologically mediated. The lecture method, while efficient for content delivery, does not inherently require students to engage with digital tools in meaningful ways. In contrast, PBLWS embeds digital literacy within the learning process, ensuring that students develop both subject mastery and essential 21st-century skills. This dual focus is increasingly vital in STEM education, where digital competence is inseparable from scientific inquiry. Thus, the findings not only validate PBLWS as a potent pedagogical strategy but also advocate for broader adoption of technology-enhanced, problem-based approaches to prepare learners for a digitized world.

VI. CONCLUSION

The study concludes that Problem-Based Learning with Simulation (PBLWS) is more effective than the lecture method in enhancing students' digital literacy,

as it actively engages them in technology-driven problem-solving, aligning with broader research that emphasizes interactive, student-centered learning for developing 21st-century skills.

VII. RECOMMENDATIONS

1. Computer studies teachers should incorporate Problem-Based Learning with Simulation (PBLWS) into Computer studies curricula to actively develop students' digital literacy skills.
2. Schools should provide professional development for teachers to effectively implement PBLWS and other technology-enhanced pedagogies.
3. Policymakers should support the integration of interactive digital tools in STEM education to bridge the gap between traditional teaching methods and 21st-century learning demands.

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