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IMPACTS OF DIGITAL PUZZLE GAME-BASED LEARNING ON UNDERGRADUATE STUDENTS' GROWTH MINDSET IN INTEGRATED SCIENCE EDUCATION IN NORTH-EAST, NGERIA

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Abstract

This study examined the impact of puzzle game-based learning on the growth mindset of undergraduate students in universities located in Northeast Nigeria. A post-test non-equivalent quasi-experimental design was adopted, complemented by qualitative-interpretive methods. The participants included 128 third-year chemistry students enrolled in integrated science education programs and 8 lecturers from two federal universities offering the program. The students were divided into two groups: 57 students were assigned to the conventional lecture method (control group), while 71 students participated in digital puzzle game-based learning (experimental group). The lecturers provided detailed observations on the growth mindset of students in both groups. A validated instrument, the Integrated Science Education Students' Growth Mindset Questionnaire (ISESGMQ, r = 0.87), was administered to the students after a six-week intervention. Quantitative data were analyzed using descriptive statistics to address the research questions and the Mann-Whitney U test to test the hypotheses at a 0.05 significance level. Qualitative data from in-depth interviews were manually transcribed, annotated, and coded to identify recurring themes. The results revealed a statistically significant improvement in the growth mindset of students in the experimental group compared to the control group. Based on these findings, the study recommends incorporating digital puzzle game-based learning into integrated science education programs and provides further suggestions for enhancing instructional practices.

Keywords: Digital Puzzle game-based learning approach, Students' Growth mindset, Integrated science education, University.

Introduction

Science education encompasses the teaching and learning of various scientific disciplines, including biology, chemistry, physics, and earth sciences. Its primary goal is to enhance students' comprehension of scientific concepts, processes, and the essence of science itself. This area of education has gained significant global attention and importance, drawing interest from educators and various stakeholders (Kayan-Fadlelmula et al., 2022). Science education seeks to cultivate new talents equipped with 21st-century skills, such as computational, critical, and creative thinking (Wahono et al., 2020). Integrated science education, as a key component of science education, plays a vital role in addressing real-world challenges related to energy, the environment, and health (Struyf et al., 2019). Consequently, many nations view integrated science education as a national strategy for reforming and advancing basic education (Dou, 2019). However, integrated science education currently faces several challenges. Traditional classroom settings often struggle to engage students (Gao et al., 2020), and they also tend to lack the resources and time necessary to provide effective hands-on activities that foster students' mindsets for solving complex problems (Klopfer & Thompson, 2020).

Mindset is a psychological concept that encompasses the beliefs and attitudes individuals have regarding their abilities and potential. These beliefs greatly affect how people tackle challenges, engage in learning, and pursue personal growth. Dweck and Yeager (2019) presented the idea of mindsets as a significant psychological framework frequently explored in educational psychology research. Generally, individuals hold one of two views about intelligence: some believe it is a fixed trait that cannot be changed (fixed mindset), while others believe that intellectual capabilities can be developed through effort and perseverance (growth mindset). Essentially, a growth mindset reflects the belief that "our talents can be developed through practice" (Tao et al., 2022). One of the key strengths of this mindset is its influential role in enhancing critical thinking and academic achievement (Yeager et al., 2019).Therefore, new instructional and learning methods are urgently needed to improve integrated science teaching and learning. One of such is puzzle game-based instructional and learning activities.

Recently, educators and researchers have explored the benefits of digital puzzles for teaching and learning in scientific disciplines such as chemistry, biology, and physics. Educational digital puzzle games can serve as effective tools in contemporary education, enhancing traditional teaching methods and making learning more engaging and enjoyable, especially as technology continues to permeate all aspects of life. Digital puzzles are interactive games that can be played on electronic devices like computers, tablets, and smartphones. They come in various formats, including jigsaw puzzles, crossword puzzles, and Sudoku, among others. These puzzles often include features like hints, timers, and the option to save progress, adding both challenge and convenience to the experience.

Digital puzzle game-based learning (DPGBL) is recognized as a prominent pedagogical approach for the twenty-first century (Kukulska-Hulme et al., 2021) and offers distinct advantages for enhancing science education compared to other teaching methods (Ishak et al., 2021). These digital educational puzzle games create an engaging learning environment, enabling learners to interact with game mechanics in a virtual setting, which results in a meaningful gaming experience and significantly boosts their motivation to learn (Ball et al., 2020; Ishak et al., 2021). Additionally, digital puzzle games provide an effective learning context that offers players numerous opportunities for simulation, addressing real-world issues, and receiving extensive instructional support. In this setting, learners can practice problem-solving skills, cultivate critical thinking, and improve their science literacy (Kayan-Fadlelmula et al., 2022).

Despite the great potential of digital educational puzzle games, there is no consensus among researchers on the effectiveness of DPGBL in science education. On one hand, some researchers showed that, compared to traditional instructions, DPGBL could support learners to improve learning motivation, understand science concepts and develop practical skills (Masek et al., 2017). On the other hand, some researchers believed that DPGBL may not have significant advantages over traditional methods for science education learning (Riopel et al., 2019). Moreover, poorly designed educational puzzle games may produce extra cognitive load, which may make the learning worse compared with traditional instructional approaches (Wang, 2020). Therefore, several synthesis studies have pooled the findings of previous studies involving DPGBL in science education disciplines. For example, previous reviews have examined the effects of digital puzzle game-based science learning (Tsai & Tsai, 2020), examined the effectiveness of digital puzzle game-based math learning (Tokac et al., 2019), or examined the effects of puzzle digital game-based education on student knowledge gains (Wang et al., 2022). These synthesis studies, however, are limited to few subject or single learning outcome of science fields, without providing insight understanding about the effects of DPGBL in integrated science education in the university.

One of the underlying factors and variables that could influence the effectiveness of DPGBL in integrated science education courses effectively is students' computer literacy skills. Students with higher computer literacy are more likely to engage with digital puzzle games effectively. Their familiarity with digital tools and interfaces reduces the learning curve, allowing them to focus on the educational content rather than struggling with the technology itself (Videnovik et al., 2023). It also enhances students' ability to navigate and solve digital puzzles, which are often designed to develop critical thinking and problem-solving skills. This familiarity with digital environments can lead to more effective and efficient problem-solving strategies (Gui et al., 2023). Digital puzzle games often require collaboration and communication among students. Those with strong computer literacy skills can more easily use digital communication tools, facilitating better teamwork and collaborative problem-solving.

Students with higher computer literacy are generally more adaptable to new technologies and digital learning environments. This adaptability is crucial in digital puzzle game-based learning, where students must quickly understand and utilize various digital tools and platform (Wang et al., 2022). Besides, computer literacy enables students to better interpret and utilize the feedback provided by digital puzzle games. This ability to understand and act on feedback is essential for continuous improvement and the development of a growth mindset (Wang et al., 2022). Familiarity with digital tools allows students to explore creative solutions within digital puzzle games. This exploration can lead to innovative approaches to scientific problems, fostering a more creative mindset (Videnovik et al., 2023).

Up to now, there have been several meta-analyses that attempted to integrate existing research on DPGBL related to science education disciplines, and the results from these meta-analytic reviews were inconsistent. Byun and Joung (2018) investigated the effect of digital educational games on K-12 students' mathematics performance. This meta-analysis including 17 empirical studies found that game-based math learning produced a small to medium effect size ($d = 0.37$). Riopel et. al. (2019) focuses on the effect of digital educational games on students' scientific knowledge compared with traditional instructions. The meta-analysis pooled 79 studies and found that digital educational puzzle games produced small to medium effect sizes on science learning ($d = 0.31–0.41$).

Digital educational puzzle games exhibit substantial promise in advancing STEM education. Nevertheless, the empirical evidence on both the efficacy of digital game-based learning and its designs in STEM education is characterized by notable inconsistencies. Gui, et al. (2023) conducted a meta-analytic review to investigate the general effect of digital puzzle game-based STEM learning over conventional STEM learning. Two meta-analyses were conducted in this study. Based on the 136 effect sizes extracted from 86 studies, the first meta-analysis revealed a medium to large general effect of digital game-based STEM learning over conventional STEM learning ($g = 0.624$, 95% CI [0.457, 0.790]). In addition, digital game-based STEM learning appeared to be differentially effective for different learning outcome, different types of game, and different subject. A total of 44 primary studies and 81 effect sizes were identified in the second meta-analysis. The results revealed a small to medium enhancement effect of added game-design elements over base game versions ($g = 0.301$, 95% CI [0.163, 0.438]). Furthermore, the results indicated that the game-design elements added for content learning were more effective than those added for gaming experience. Summarily, the study found a medium to large general effect of digital game-based STEM learning on students' learning outcome

Wang, et al. (2022) carried out meta-analysis of the effect of digital game-based STEM education on the learning achievement of K-12 or higher education students. The analysis results of effect sizes from 33 studies ($N = 3894$) published from 2010 to 2020 showed that digital games contributed to a moderate overall effect size ($ES = 0.667$, 95% CI [0.520–0.814], $p < 0.001$) when compared with other instructional methods. Furthermore, the study explored multiple moderator variables and their potential impacts on learning outcomes such as control treatment, subject discipline, educational level, game type, gaming platform, and intervention duration. The findings suggest that digital games are a promising pedagogical method in STEM education that effectively improves students' mindset and learning gains.
Adipat,et al. (2021) carried out a study that explored the fundamental concepts of game-based learning and its impact on student

engagement and educational outcomes. This study provides an innovative framework for the adoption of the educational games learning approach at university. This is done to ensure lifelong learning and interdisciplinary learning opportunities for students. It highlighted the role of game elements in improving students' cognitive and social skills, which are linked to mindset improvement and growth. The study introduces social skills and knowledge training to address topics of gaming and learning. It describes the point at which learning is expected to occur and the role that game elements play in relation to student engagement and educational gaming content interaction. The study further describes the principles governing collaborative learning which are the key pillars for acquiring cognitive and social skills. The contribution of game-based learning is further linked with mindset improvement and growth. The study further examines three theories that are essential to the development of the game-based learning approach: narrative-centered learning theory, problem-solving theory, and engagement theory. Upon providing the theoretical underpinnings, teachers' perceptions towards the game-based learning approach are further addressed.

Li and Deng (2024) investigated the effects of digital educational games on students' learning outcomes. A detailed questionnaire was disseminated to students from three distinct university in Thailand. After the exclusion of invalid responses, a robust sample of 434 valid responses was curated and utilized for analysis. Utilizing SPSS and MPLUS software, empirical analyses were conducted to explore the impact of digital educational games on student's motivation for learning. Research results indicate that: First, digital educational games positively influence student's motivation for learning; Second, learning engagement serves as a mediator between digital educational games and student's motivation for learning; Third, the digital environment moderates the relationship between digital educational games and student's learning engagement. Notably, the positive impact of digital educational games on student learning engagement is amplified in a more immersive digital environment. It found that digital games can enhance students' motivation, understanding of knowledge concepts, and problem-solving abilities

Yida (2023) analyzed the positive and negative influences of puzzle games on learners' learning in a study. The paper focuses on recent studies about puzzle games, learning theories, and any other related topics. Overall, this paper finds that the positive influences of puzzle games include immersive learning, motivational learning, and high-level learning, while negative influences involve low efficiency and declined learning outcomes caused by imbalance. The finding indicates that educational game designers should take these possible influences into consideration, maximizing the positive ones and avoiding the negative ones. It found that puzzle games can lead to immersive learning, motivational learning, and high-level learning, although there can be challenges related to efficiency and learning outcomes

Ainley (2018) explores the importance of computer literacy in education and its impact on students' learning outcomes. It highlights how computer literacy influences students' ability to engage with digital learning tools, including digital puzzle game. Assessments of computer literacy, even though they vary, indicate that there are substantial variations in levels of computer literacy among students in the lower years of secondary school. In technologically developed countries, approximately one half of Year 8 students demonstrate proficiency, or advanced proficiency, in computer literacy, but up to 10% have very limited computer literacy. Assessments of computer literacy can also provide the basis for progression maps that could be used to inform curriculum development. Those progression maps will be more valuable if the frameworks on which they are based become more strongly integrated with each other. In addition, computer literacy appears to be influenced by student background, including familiarity with computers, as well as the emphases placed on it in classrooms and schools and the support provided by ICT in education systems.

Timotheou et al. (2023) conducted a non-systematic literature review studies on Impacts of Digital Technologies on Education and Factors Influencing Schools' Digital Capacity and Transformation. This includes review on the effects of digital technologies on education, including the role of computer literacy in enhancing students' engagement and learning outcomes. It discusses how digital puzzle games can be integrated into science education to foster a growth mindset. The results of the literature review were organized thematically based on the evidence presented about the impact of digital technology on education and the factors that affect the schools' digital capacity and digital transformation. The findings suggest that ICT integration in schools impacts more than just students' performance; it affects several other school-related aspects and stakeholders, too. Furthermore, various factors affect the impact of digital technologies on education. These factors are interconnected and play a vital role in the digital transformation process.

Audrin and Audrin (2022) conducted a systematic review study and identifies key factors in digital literacy and their impact on education using text mining. It reviews 1037 research articles published on the topic between 2000 and 2020. This review reveals that there is a plurality of terms associated with digital literacy. Moreover, their research identifies six key factors that define the literature, which are information literacy, developing digital literacy, digital learning, ICT, social media, and twenty-first century digital skills. These factors can be grouped into three main streams, which are 1) digital literacy, 2) digital learning and 3) twenty-first century digital skills. These three streams are supported by informational and technological foundations. These results provide research avenues and offer a framework for digital literacy in education. It emphasizes the importance of computer literacy in enabling students to effectively use digital learning tools, such as digital puzzle games, to enhance their learning experiences and develop a growth mindset

Alona and Melinda (2024) investigates the relationship between students' computer literacy and their academic performance of junior high students. It provides insights into how computer literacy skills can enhance students' ability to engage with digital learning tools, including digital puzzle games, and improve their mindset and learning outcome. Employing descriptive-correlational analysis, the study examined the significant differences in the extent of students' computer literacy in said areas when paired according to their attitude toward computers and the significant relationship between their academic performance and the extent of their computer literacy in terms of the identified areas. Generally, the findings of the study revealed that the students needed to enhance the extent of their computer literacy in the areas of word processing, spreadsheet, presentation, and general computing. The results also signified that the greater the extent of their computer literacy in said areas, the higher their academic performance.

Videnovik et al. (2023) carried out review study on the use of game-based learning in computer science education and its impact on students' learning outcomes. It discusses the role of computer literacy in enabling students to effectively engage with digital puzzle games and develop a growth mindset. Using standard methodology for scoping review, they identified 113 articles from four digital libraries published between 2017 and 2021. Those articles were analyzed concerning the educational level, type of the game, computer science topic covered by the game, pedagogical strategies, and purpose for implementing this approach in different educational levels. The results show that the number of research articles has increased through the years, confirming the importance of implementing a game-based approach in computer science. Different kinds of games, using different technology, concerning different computer science topics are presented in the research. The obtained results indicate that there is no standardized game or standardized methodology that can be used for the creation of an educational game for computer science education. Analyzed articles mainly implement a game-based approach using learning by playing, and no significant focus is given to the effectiveness of learning by designing a game as a pedagogical strategy.

Statement of the Problem

In recent years, there has been a growing interest in the integration of digital puzzle game-based learning in university science education. However, there is a notable gap in understanding the specific impact of these tools on students' growth mindset. Traditional teaching methods often fail to fully engage students, resulting in diminished motivation, creativity, and enthusiasm for learning. In contrast, digital puzzle games, with their interactive and engaging nature, hold significant potential to transform the learning experience by fostering critical thinking, problem-solving skills, and a growth mindset among students. Despite this promise, empirical evidence on the effectiveness of digital puzzle game-based learning in higher education remains limited, particularly in the context of universities in Northeast Nigeria. This study seeks to bridge this gap by investigating the effects of digital puzzle game-based learning on the growth mindset of students enrolled in university-level science courses. It aims to provide insights into innovative teaching strategies that can enhance academic performance and better prepare students for challenges in the evolving educational landscape.

Purpose of the Study

This study investigated the impact of puzzle game-based learning approach on undergraduate students' growth mindset in integrated science education in university, Northeast, Nigeria. Specifically. the objectives of the study were to:

1. Find out the perception of students on students' growth mindset who are exposed to puzzle game-based learning approach and their counterparts who are taught conventional method.
2. Investigate the impact of students' computer literacy skills on students' growth mindset in integrated science education

Research Questions

The following research questions guided the study:

1. What extent is the impact of DPGBL on students' growth mindset who are exposed to puzzle game-based learning approach ?
2. What extent is the impact of Conventional Lecture Learning Approach (CLLA) on students' growth mindset who are taught with conventional lecture learning approach?

Hypotheses

1: There is no statistically significant difference between students exposed to digital puzzle game-based learning and those in conventional lecture learning approach in their growth mindset in integrated science education.

2: There is no statistically significant difference between students who are proficient in computer literacy skills and those who are not proficient in computer literacy skills on student' growth mindset in integrated science education.

Methodology

This study employed a post-test non-equivalent quasi-experimental design, combined with a qualitative-interpretive research approach. The qualitative component involved collecting extensive narrative data over time to provide insights into the impact of Digital Puzzle Game-Based Learning (DPGBL) on undergraduate students' growth mindset in integrated science education at universities in Northeast Nigeria. The study population included all 128 third-year students enrolled in Integrated Science Education programs and eight lecturers teaching chemistry courses at two federal universities in the region.

Two universities offering integrated science education programs were purposively selected for the study. All third-year students enrolled in the program participated, with 71 students assigned to the experimental group (exposed to DPGBL) and 57 to the control group (taught using the conventional lecture method). Simple random sampling was used to allocate universities to the experimental and control groups. Specifically, Abubakar Tafawa Balewa University (ATBU), Bauchi, served as the experimental group, while the Federal University of Kashere (FUK) served as the control group. Eight integrated science lecturers teaching chemistry courses were purposively selected to provide comprehensive reports on the growth mindset of students in both groups. To ensure participant anonymity, pseudonyms "A" and "B" were assigned.

The study utilized the **Integrated Science Education Students' Growth Mindset Questionnaire (ISESGMQ)**, a structured questionnaire designed on a five-point Likert scale: "Extremely," "Significantly," "Moderately," "Slightly," and "Not at all." The instrument consisted of 15 items assessing students' growth mindset. Validation of the instrument was performed by experts in chemistry education and educational technology from the Federal University of Kashere. Reliability was tested using the Cronbach's alpha statistical tool with SPSS software, yielding a reliability coefficient of 0.87. The validation process involved analyzing item-total correlation, squared multiple correlation, and the Cronbach's alpha value for the scale if any item was deleted. Items with significant variance were modified or removed, and the reliability analysis was repeated to finalize the scale.

Experimental Procedure

Two lecture guides were developed for the study: one for the digital puzzle game-based learning (DPGBL) approach and another for the conventional lecture method. Both guides were designed for one-hour instructional sessions. Course lecturers served as research assistants and delivered the treatments over a six-week period. The research team sought permission from the universities' management to conduct the study and integrated the experimental activities into the regular lecture schedules without disruption. The researchers provided validated lecture guides to the research assistants and monitored the process as supervisors.

The treatment phase involved two instructional methods:

1. **Digital Puzzle Game-Based Learning Approach (DPGBL):**
   - Instruction began with a 15-minute inquiry, question-and-answer session to introduce concepts.
   - Students were then divided into small groups (4–5 members) and interacted with digital puzzle games incorporating chemistry concepts for 30 minutes.
   - Students followed written instructions, manipulated puzzle game resources, solved puzzles, recorded observations, and drew conclusions individually. Group members collaborated, and winners of the games were recognized based on their recorded scores.
2. **Conventional Lecture Method (CLM):**
   - Lecturers followed a structured lecture guide for 40 minutes, using verbal instruction, examples, and illustrations to explain the same concepts taught in the DPGBL group.
   - A 15-minute question-and-answer session followed to enhance understanding.

After the six-week intervention, the ISESGMQ was administered to all participants to assess their growth mindset. Data were analyzed using descriptive statistics for research questions and the Mann-Whitney U test for hypotheses at a significance level of 0.05.

Qualitative Data Collection

In-depth interviews were conducted with the eight participating lecturers to gather qualitative data. The semi-structured interviews were designed to align with the study's objectives and research questions, focusing on the growth mindset of undergraduate students. Each interview lasted 20 minutes and was recorded with participants' consent using a mobile device. Transcriptions were returned to the interviewees for member-checking to ensure accuracy.

Data Analysis

Qualitative data were manually transcribed, annotated, and coded. Common themes across interviews were identified and categorized. Excerpts from interviews were grouped into batches based on thematic patterns. These patterns were analyzed to provide a comprehensive understanding of the data.

The findings of this study contribute to understanding the effectiveness of DPGBL in fostering growth mindset development among undergraduate students in integrated science education, offering valuable insights for improving instructional strategies in higher education.

Results

Research Question 1: What extent is the impact of DPGBL on students' growth mindset who are exposed to puzzle game-based learning approach

Table 1: Participants' Response of Impact of Digital Puzzle Game-based Learning on Students' Growth Mindset in Integrated Science Education

S/N	Item	EM (%)	SG (%)	MD (%)	SL (%)	NA (%)	Mean	Std. d
1	Engagement: How has puzzle-game based learning engaged and motivated you in learning activities in your science courses?	23(31.1)	33(45.8)	13(18.3)	1(1.4)	1(1.4)	4.07	.834
2	Problem-Solving Skills: How has puzzle game-based learning influenced your ability to solve complex problems in science?	22(30.6)	29(40.3)	12(23.6)	3(4.2)	0(0)	3.99	.853
3	Critical Thinking: To what extent has puzzle game-based learning enhanced your critical thinking skills in science subjects?	29(40.3)	35(48.6)	6(8.3)	1(1.4)	0(0)	4.3	.684
4	Creativity: How has participating in puzzle game-based learning activities affected your creativity in approaching scientific problems?	19(26.4)	35(48.6	16(22.2)	1(1.4)	0(0)	4.01	.746
5	Collaboration: To what extent has puzzle game-based learning help you collaborate with your peers during learning activities in your science courses?	21(29.2)	35(48.6)	12(17.7)	2(2.8)	0(0)	4.07	.767
6	Feedback and Reflection: To what extent has puzzle game-based learning help you find the immediate feedback provided by puzzle game-based learning activities in improving your understanding of scientific concepts?	22(30.6)	38(52.8)	10(13.9)	1(1.4)	0(0)	4.14	.703
7	Interest in Science: How has puzzle game-based learning influenced your interest in science subjects?	23(31.9)	39(54.2)	9(12.5)	0(0)	0(0)	4.2	.646
8	Confidence: How has puzzle game-based learning affected your confidence in tackling scientific problems?	20(27.8)	35(48.6)	14(19.4)	2(2.8)	0(0)	4.03	.774
9	Self-Efficacy: How has puzzle game-based learning impacted your belief in your ability to succeed in science courses?	21(29.2)	39(54,2)	11(15.3)	0(0)	0(0)	4.14	.661
10	Persistence: To what extent has puzzle game-based learning help you persist through difficult problems during learning activities?	24(33.3)	41(56.9)	6(8.3)	0(0)	0(0)	4.25	.603

11	Mindset: How has puzzle game-based learning influenced your mindset towards learning and overcoming challenges in science?	19(26.4)	45(62.5)	7(9.7)	0(0)	0(0)	4.17	.585
12	Adaptability: How has puzzle game-based learning helped you adapt to new and challenging scientific concepts?	23(31.9)	36(50.0)	8(11.1)	3(4.2)	1(1.4)	4.08	.858
13	Real-World Applications: To what extent has puzzle game-based learning activities help you understand the real-world applications of scientific concepts?	21(29.2)	43(59.7)	7(9.7)	0(0)	0(0)	4.20	.600
14	Enjoyment: How much do you enjoy participating in puzzle game-based learning activities in your science courses?	19(26.4)	42(58.3)	9(12.5)	1(1.4)	0(0)	4.11	.667
15	Overall Impact: How has puzzle game-based learning helped you rate the impact of puzzle game-based learning on your growth and development in science education?	20(27.8)	44(61.1)	7(9.7)	0(0)	0(0)	4.18	.593

Table 1 reveals the response of students exposed to DPGBL of the impact digital puzzle game learning on students' growth mindset in integrated science education. Item 1 shows that 76.9% of the respondents indicated that DPGBL enhanced students' engagement and motivation hence facilitated their mindset in integrated science education. 70.9%, 88.9%, 75%, 77.8%, 83.4% of the respondents claimed that in items 2, 3, 4, 5, 6 claimed that they were able to solve complex problems, think critically, boost creativity, collaborated with peers and find the immediate feedback provided by puzzle game-based learning activities in learning science concepts. Besides, all the stated skills enhance participants' growth mindset that could lead to overall students' performance in science education. Similarly, 75% and above of the respondents indicated that DPGBL improves their interest in Science, having self-confident, self-efficacy, persistence, adaptable to challenges in difficult concepts, real-world application of science, enjoying using digital puzzle game to learn science, increased mindset and hence, growth and development in science education courses in items 7 to 15 respectively.

Research Question 2. What extent is the impact of Conventional Lecture Learning Approach on students' growth mindset who are taught with conventional lecture learning approach

Table 2: Participants' Response of Impact of Conventional Lecture Learning Approach on Students' Growth Mindset in Integrated Science Education

S/N	Item	EM (%)	SG (%)	MD (%)	SL (%)	NA (%)	Mean	Std. d
1	Engagement: How has lecture learning approach engaged and motivated you in learning activities in your science courses?	1(1.7)	3(5.1)	13(22.0)	35(59.3)	5(8.5)	2.30	.778
2	Problem-Solving Skills: How has CLLA influenced your ability to solve complex problems in science?	0(0)	2(3.4)	10(16.9)	31(52.5)	14(23.7)	2.00	.756
3	Critical Thinking: To what extent has CLLA enhanced your critical thinking skills in science subjects?	0(0)	0(0)	5(8.5)	36(61.0)	16(27.1)	1.81	.581
4	Creativity: How has participating in CLLA activities affected your creativity in approaching scientific problems?	0(0)	1(1.7)	6(10.2)	30(50.8)	20(33.9)	1.79	.700
5	Collaboration: To what extent has CLLA help you collaborate with your peers during learning activities in your science courses?	0(0)	0(0)	8(13.6)	29(49.2)	20(33.9)	1.79	.674
6	Feedback and Reflection: To what extent has CLLA help you find the immediate feedback provided by puzzle game-based learning activities in improving your understanding of scientific concepts?	0(0)	0(0)	9(15.3)	30(50.8)	18(30.5)	1.84	.676
7	Interest in Science: How has CLLA influenced your interest in science subjects?	0(0)	0(0)	2(3.4)	29(49.2)	26(44.1)	1.58	.565
8	Confidence: How has CLLA affected your confidence in tackling scientific problems?	0(0)	1(1.7)	4(6.8)	30(50.8)	22(37,3)	1.72	.675
9	Self-Efficacy: How has CLLA impacted your belief in your ability to succeed in science courses?	0(0)	0(0)	2(3.4)	34(57.6)	21(35.6)	1.67	.546
10	Persistence: To what extent has CLLA help you persist through difficult problems during learning activities?	0(0)	1(1.7)	4(6.8)	31(52.5)	21(35.6)	1.74	.669
11	Mindset: How has CLLA influenced your mindset towards learning and overcoming challenges in science?	0(0)	3(5.1)	8(13.6)	30(50.8)	16(27.1)	1.96	.801
12	Adaptability: How has CLLA helped you adapt to new and challenging scientific concepts?	0(0)	0(0)	2(3.4)	33(55.9)	22(37.3)	1.65	.551
13	Real-World Applications: To what extent has CLLA help you understand the real-world applications of scientific concepts?	0(0)	0(0)	7(11.9)	29(49.2)	21(35.6)	1.75	.662

14	Enjoyment: How much do you enjoy participating in CLLA activities in your science courses?	0(0)	2(3.4)	3(5.1)	36(61.0)	16(27.1)	1.84	.676
15	Overall Impact: How has CLLA helped you on your growth and development in science education?	0(0)	2(3.4)	4(6.8)	36(61.1)	15(25.4)	1.88	.683

Table 2 shows the response of participants exposed to CLLA on the impact of conventional lecture learning activities on students' growth mindset in integrated science education. Items 1, 2, 3, 4 and 5 with 26.8%, 20.3%, 8.5% 11.9%%, and 13.6% of the respondents claimed that CLLA positively influenced students' engagement and motivation, able to solve complex problems, think critically, boost creativity and collaborated with peers. The items 6, 7, 8, 9, 10. 11, 12, 13 and 15 follow the same pattern of less than 16% of the respondents respectively who claimed that CLLA positively enhanced students' ability to find the immediate feedback provided by puzzle game-based learning students' interest in Science, self-confident , self-efficacy, persistence, adaptable to challenges in difficult concepts, real-world application of science, enjoying using digital puzzle game to learn science, increased mindset and hence, growth and development in science education courses respectively.

HO_1: There is no statistically significant difference between students exposed to digital puzzle game-based learning and those in conventional lecture learning in their growth mindset in integrated science education.

Table 3: Mann-Whitney Analysis of Impact of Puzzle Game-Based Learning on Students' Growth Mindset in Integrated Science Education According to Treatment

Treatment	N	Mean Rank	U	P value	Remark
digital puzzle game-based learning	71	90.52	176.00	.000	Significant
conventional lecture method	57	32.09			

Significant at P<0.05

Mann Whitney test analysis of the difference between student' to digital puzzle-based game learning and those exposed to conventional lecture puzzle game-based learning of the impact of puzzle game-based learning on students' growth mindset as shown in Table 3. This implies that the difference between digital puzzle-based game learning and conventional lecture learning on the impact of puzzle game-based learning on students' growth mindset in integrated science education was statistically significant (U= 176.00, N1 = 71 N2, =57, P = .000, two-tailed). Hypothesis 2 is therefore rejected.
Ho_2: There is no statistically significant difference between students who are proficient in computer literacy skills and those who are not proficient in computer literacy skills on student' growth mindset in integrated science education.

Table 4: Mann-Whitney Analysis of Impact of Students' Literacy Skills on Students' Growth Mindset in Integrated Science Education

Students' computer proficiency skills	N	Mean Rank	U	P value	Remark
proficient	61	85.22	779.50	.000	Significant
not proficient	67	45.63			

Significant at P<0.05

Mann Whitney test analysis of the difference between students who are proficient in computer literacy skills and those who are not proficient in computer literacy skills in students' growth mindset as indicated in Table 4. This implies that the difference between students who are proficient in computer literacy skills and those who are not proficient in computer literacy skills on student' growth mindset in integrated science education course was statistically significant (U= 779.50, N1 = 61 N2, =67, P = .000, two-tailed). Hypothesis 2 is therefore rejected.

Results of Interview

This question was asked to find out the social characteristics and practices of the factors that implicitly promote students' growth mindset. The characteristics of the variables that were found out include:

How has students who were exposed digital puzzle game-based learning to develop their mindset to study integrated science education courses in your course?

This question was raised to find out the extent to which digital puzzle game-based learning activities have positively affected students' growth mindset. The mindset characteristics considered to include:

Engagement, problem-solving skills, critical thinking skills, creativity, collaboration with peers, feedback and reflection, interest in science, confidence and self-efficacy. Others are persistence, mindset, adaptability, real-world applications, enjoyment and overall impact.

The participated lecturers in the interview stated that digital puzzle game-based learning had positively changed students' mindset about study and learning integrated science education courses. Students were actively engaged in learning activities, exposed to problem-solving activities, develop critical thinking through solving puzzle that prove challenges to them, creative when they come across new challenges, collaborate with peers to ask for assistance and able to immediate feedback and reflection while playing puzzle games for learning. Student' interest in science was enhanced, through having confidence and elf-efficacy and increased persistence though repetition and practice. In summary students' growth mindset was established and enhanced because they were able to adapt easily to changes of new concepts they came across while learning, able to solve real life problems, feel happy and enjoyable while solving puzzle games installed or downloaded into android phones, tablets, laptop computers, and overall science development and growth. Interviewee "A" said this:

> *When students actively engaged in teaching and learning process, solving problems through critical thinking and creative, learning with keen interest and collaborate with peers for help wile facing challenges students' growth mindset about learning integrated science will be establishing and growing (Transcript of interview 16/08/2024)*

The responses indicate that DPGBL for teaching and learning integrated science education courses and other science education courses in the university plays great significant role in enhancing students' mindset and overall development in science education curriculum implementation. This aligns with the findings of Adipat, et al. (2021) that DPBGLwhen used appropriately improves students' mindset and general growth and development in science education

How has students who were exposed conventional lecture learning approach developed their mindset to study integrated science education courses in your course?

This question was raised to find out the extent to which CLLA activities have positively affected students' growth mindset. The mindset characteristics considered to include:

Engagement, problem-solving skills, critical thinking skills, creativity, collaboration with peers, feedback and reflection, interest in science, confidence and self-efficacy. Others are persistence, mindset, adaptability, real-world applications, enjoyment and overall impact

The participated lecturers in the interview stated that CLLA had slightly changed students' mindset about study and learning integrated science education courses. Students were not deeply engaged in learning activities, not well exposed to problem-solving activities, inability to think critical through solving challenges that seem difficult to them because were just explained to them verbally, creativity skills not well developed when they come across new challenges, collaborate with peers to ask for assistance and able to immediate feedback and reflection while playing puzzle games for learning not well pronounced. Student' interest in science was moderately enhanced, through having confidence and elf-efficacy and increased persistence though repetition and practice to certain extent. In summary students' growth mindset was not significantly established and enhanced because they were unable to adapt easily to changes of new concepts they came across while learning, able to solve few real life problems, because CLLA does not encourage collaboration, limit their involvement in learning process, among others, and slightly enhanced students' overall science growth and development.

Interviewee "B" stated that:

> *When students were not deeply participated in teaching and learning process, solving problems through critical thinking and creative, not learning with keen interest and collaborate with peers for help wile facing challenges students' growth mindset about learning integrated science will not significantly be developed and enhanced (Transcript of interview 18/08/2024)*

The responses indicate that CLLA for teaching and learning integrated science education courses and other science education courses in the university plays slight significant role in enhancing students' mindset and overall development in science education curriculum implementation. This aligns with the findings of Riopel et al., (2019that CLLA traditional lecture approach has not been proved to significantly enhanced students' growth mindset and general growth and development in science education.

Discussion

The study revealed that DPGBL significantly enhanced students' growth mindset in integrated science education in university. The result supports the finding of Gui, et al. (2023) that revealed medium to large general effect of digital game-based STEM learning over conventional STEM learning. Added to this, the finding corroborates the study of Byun and Joung (2018) that indicates medium to large effect of digital educational games on K-12 students' mathematics performance. Besides, the finding Li, et al. (2024) aligns with the finding of this study that digital educational games positively influence student's motivation for learning. It also found that digital games can enhance students' motivation, understanding of knowledge concepts, and problem-solving abilities. However, the results negate the finding of Wang (2020) that poorly designed educational puzzle games may produce extra cognitive load, which may make the learning worse compared with traditional instructional approaches

The finding also revealed that computer literacy skills enhanced students' growth mindset in integrated science education. This corroborates with the finding of Videnovik, et al. (2023) that computer literacy enables students to effectively engage with digital puzzle games and develop a growth mindset. Similarly, the study of Alona and Melinda (2024) agree with the finding of this study that students' computer literacy skills enhance students' ability to engage with digital learning tools, including digital puzzle games, and improve their mindset and learning outcome.

Conclusion

Based on the finding of this study, it demonstrates that students benefit most from digital puzzle game-based learning approach. This is because it encourages them to be actively engaged in learning process, solving problems, proactive, creative, togetherness, having fun in the course of learning and enhance growth mindset, hence improve learners' overall growth and development in science education. As a result, the puzzle game-based learning technique is appropriate for educating students since it provides an enabling learning environment for 21st century learners in which the use of technology is rapidly gaining ground in all human endeavours.

Recommendations

Based on the finding of this study, recommendations were made as following:

1. University teachers should adopt the use of digital puzzle game-based learning approach in teaching integrated science

education courses and by extension science education generally.

2. Governments, educational planners and university management should organize seminars, workshops and conferences for university teachers on how to use puzzle digital game-based learning approach for teaching.
3. Teacher education programs should be modified to reflect current and contemporary teaching practices and students should be encouraged to be proficient in computer literacy skills.
4. University management should encourage every student to possess a laptop computer to himself/herself

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