GREEN EDUCATION: CAN TASK-BASED LEARNING STRATEGY MAKE SUSTAINABLE COMPUTING MATHEMATICS STICK?

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Abstract: *The global push for a healthier environment emphasizes the importance of sustainable computing in achieving the Sustainable Development Goals. However, the Chief Examiners of major examination bodies described students' achievement in senior secondary school mathematics topics related to sustainable computing as weak. This study investigated the effect of a task-based learning (TBL) strategy on students' learning of these topics, with gender as a moderating variable. A pretest-posttest control group quasi-experimental design with a 2 × 2 factorial was employed. The sample comprised 114 senior secondary school students from two purposively selected public schools in the Ijebu-Education Bloc of Ogun State, Nigeria. The data collection instruments were the Task-Based Learning Strategy Instructional Guide (TBLSIG) and Sustainable Computing Mathematics Achievement Test (SCMAT), with a reliability coefficient of 0.71. The finding revealed that students exposed to the TBL strategy significantly outperformed those taught using conventional methods ($F(1,109) = 77.968$, $p < 0.05$). Gender was not found to significantly affect students' sustainable computing mathematics learning ($F(1,109) = 0.408$, $p > 0.05$), as the TBL strategy was gender-neutral. The interaction effect of strategy and gender on learning achievement was not significant ($F(1,109) = 0.784$, $p>0.05$). Based on these findings, it is recommended that teachers adopt the TBL strategy for teaching sustainable computing mathematics and consider its application in other subject areas. The Computer Studies curriculum should also include sustainable computing mathematics to prepare students for sustainable development.*

Keywords: *sustainable computing; task-based learning; green education; gender difference; mathematics achievement.*

Introduction

The world is interested in achieving a healthier planet and a better life for all by 2030. Towards this, United Nations members, including Nigeria, emphasize responsible use of the environment, a just society, and economic viability. United Education, Scientific and Cultural Organization (UNESCO, 2023) described education as a vital component of the Sustainable Development Goals (SDGs) and a critical enabler of the goals because it empowers individuals to be sustainable development change-makers through the acquisition of knowledge, skills, values, and attitudes needed to act responsibly in their environment. Education is, indeed, a means of achieving all other sustainable goals.

Meanwhile, in a world dominated by computing resources, rapid economic development and competition from human activities adversely affect the environment, threatening the achievement of a healthier planet, as aspired to by member nations. For instance, the information technology industry has a negative environmental impact, ranging from the energy consumed by data centers to the toxic materials used in electronics. Similarly, a vast amount of energy is usually consumed by data centers, contributing to greenhouse gas emissions and climate change. Therefore, sustainability is crucial in designing, efficiently utilizing, and optimizing computing resources, as computing has significant costs, particularly the pronounced environmental impact of technology. As a result, individuals with sustainable computing skills are increasingly sought after to develop sustainable computing solutions.

Given the crucial role of sustainable computing practices in mitigating the environmental impact of technology and the recommendation that computer scientists should contribute significantly to addressing the impact, schools should shift their focus toward equipping learners with the skills needed to contribute to environmental sustainability through computing. These practices promote responsible energy consumption and reduce adverse environmental impacts. Sustainable computing encompasses the application of sustainability principles to computer systems, including hardware manufacturing, software development, resource consumption (Mocigemba, 2006), and the proper disposal of computing resources after use. According to Gomes et al. (2019), sustainable computing identifies, formalizes, and provides solutions to computational problems in a way that balances economic and societal needs, ensuring a sustainable future.

Meanwhile, Mathematics plays a crucial role in developing sustainable computing practices. It is argued that applying advanced mathematical algorithms can significantly reduce energy consumption (Rodrigues, 2023). Similarly, Xu et al. (2019) found that mathematical compression techniques can reduce data storage requirements by 30%. Mathematics also improves efficiency in other areas. Chen and Lin (2018) demonstrated that mathematical models can enhance the accuracy of predictive analytics by 40%, enabling better resource allocation and reduced waste in computing systems. It has also been maintained that cutting the data center costs will result in more efficient end-user services. Thus, the hardware can be rationalized for optimal resource utilization through hardware virtualization, reducing costs while improving efficiency, which is achievable by designing efficient algorithms to support sustainable computing (Kumar & Chander, 2020). Furthermore, the mathematical optimizations in cloud computing can lower operational costs by 20%, making sustainable practices both environmentally friendly and economically viable (Miller, 2019).

However, at the secondary school level, where the learners' foundational mathematics skills are to be sharpened, students' performance in the subject has been unsatisfactory. According to the Science and Technology Education Policy, the Federal Ministry of Education (FME, 2018) expressed concern that students' performance in mathematics and science consistently fell below 50%. The situation remains unabated, as exemplified by the reports of the West African Examinations Council (WAEC) Chief Examiners (2018-2023). It is also worrisome that areas of mathematics needed for sustainable computing practices are identified as the students' weak areas. These areas included algebra, vectors and matrices, statistics, probability, and number systems. For instance, algebra helps to represent real-world problems with variables and equations for easy solutions. Likewise, statistics can help understand energy-use patterns in computing for trend analysis and prediction of future energy use. Machine learning, an essential aspect of sustainable computing, relies on vectors and matrices to design algorithms to optimize energy consumption.

The FME (2018) called for a paradigm shift in teaching methods because the teacher-centered approach, which is abstract and theoretical, cannot enhance learning as effectively as student-focused methods that encourage hands-on activities. The reports of WAEC Chief Examiners (2018-2023) suggested that teachers should make teaching and learning mathematics more engaging and practical. They should assign more tasks involving problem-solving in class and as homework. Abdullah and Haji (2022) noted that the task-based

learning (TBL) strategy has shown potential in enhancing learning outcomes in various science subjects. However, its implementation in mathematics learning, especially in the areas identified, has not been widely explored within the Nigerian teaching and learning context. Therefore, the decision to use the TBL strategy to teach the identified areas of mathematics is to assess its effectiveness in building the foundational skills needed for sustainable computing.

Task-based learning (TBL), initially developed in language education, helps learners engage with challenging problems through individual or collaborative efforts. Sholeh et al. (2020) defined TBL as a teaching approach that promotes authentic language learning tasks. This approach is well-suited for implementing skills-based learning, as it motivates and engages students in the learning process. In a TBL class, the teacher facilitates, overseeing the students' tasks and guiding their learning and thought processes. Students collaborate, focus on assigned tasks, and connect their daily experiences to classroom activities. The method assumes that students learn more effectively when concentrating on tasks that stimulate the critical thinking necessary for positive learning outcomes. TBL requires students to use pragmatic language processing to optimize learning (Dewi & Falqotur, 2022), holding them accountable for their learning through focused interaction with the materials (Abdullah & Haji, 2022). Azlan et al. (2019) categorized TBL tasks into three stages: pre-task activities, where students and teachers discuss the task before implementation; the task cycle, which focuses on how the tasks are performed; and the post-task stage, where students share the outcomes of the tasks with their peers.

Radwan (2023) investigated the impacts of TBL on students' achievement in English creative reading skills and found that the strategy improved learning outcomes compared to the conventional teaching method. The finding was attributed to TBL's tendency to make learners focus and situate their learning within their everyday experience. Although there is a geographical difference, this finding aligns with the study by Naqsyabandiyah and Dehghani (2023), which employed the Define, Design, Develop, and Disseminate modes of the TBL to determine their effectiveness in teaching 11th-grade students linguistics in secondary schools. Their study also reported the effectiveness of the strategy over the conventional teaching method, finding that TBL helped learners retain vocabulary and transfer knowledge. They suggested that further studies should be conducted on the factors necessary for adopting and using TBL in schools. Faridaman et al. (2024) also assessed how the task-based learning (TBL) model could enhance English achievement among Grade IV students at SD Negeri 201 Palembang. Their findings indicated that the

strategy had a significant impact on student outcomes in the subject. Anives and Ching (2022) also found that TBL effectively improves students' computational thinking skills in mathematics. Students who engaged with the task-based learning (TBL) module demonstrated notable gains in problem-solving, decision-making, sequencing, algorithm development, and quantitative measurement, outperforming those in the control group taught using traditional methods. This TBL module, structured around pre-task, task, and review phases, was recommended due to its effectiveness in enhancing mathematics learning. Highlighting TBL's interdisciplinary potential, Burdujan (2024) implemented it to promote both linguistic proficiency and subject-specific knowledge through teamwork. The study examined TBL's goal-oriented nature and ability to simulate real-world scenarios. The results revealed that task-based learning (TBL) effectively enhanced students' linguistic abilities, critical thinking skills, and comprehension of real-world issues. In a related study, Zambrano et al. (2023) examined the effectiveness of TBL on the mathematics learning of Ecuadorian students in four phases: preparation, learning, retention testing, and delay testing. The study found that the task-based group outperformed its counterparts in the control group due to the interaction among learners, which reduced their cognitive load. The experimental group demonstrated higher levels of cognitive interaction and retained more knowledge than their control group peers.

Gender differences in mathematics achievement are pervasive in the literature, contradicting the sustainable development agenda of educational equality. This difference is attributed to sociocultural factors, including the belief that mathematics is a male-dominated field and that females should limit their involvement. However, several studies on gender achievement in mathematics have yielded mixed results. For instance, Egara and Mosimege (2023), who investigated students' achievement in algebra after exposure to computer-simulated lessons, reported that female students outperformed their male colleagues. However, Vos et al.'s (2023) study, which explored whether there is a gender discrepancy in students' performance on arithmetic and cognitive reflection tests, showed that females scored significantly lower than males in these areas. It was also found that the gender difference in achievement was mediated by mathematics anxiety and gender-related stereotypes. Using a self-regulated learning strategy, Akinsola et al. (2023) examined the gender difference in students' performance in Mathematics. It was found that gender did not significantly impact students' achievement. However, male students

taught with self-regulated learning scored higher than female students. Conversely, the females outperformed the males in the retention test.

Specifically, the Nigerian government is displeased with the gender gap due to the abysmally low involvement of females in science and technology-related studies and occupations, preventing female folk from reaching their full potential, excluding them from decision-making and making them unable to contribute to social change (FME, 2018). Hence, this study explored the moderating effect of gender on the academic achievement of students in sustainable computing mathematics.

According to Peters et al. (2024), sustainable computing education research is still in its infancy, as most articles in this area lack robust empirical procedures on the importance of sustainable computing in sustainable development. Similarly, evidence in the literature is that mathematics is critical for sustainable computing and that students are underperforming in senior secondary school mathematics aspects essential for sustainable computing, operationally defined as sustainable computing mathematics in this study. Thus, this study investigated how the Task-Based Learning (TBL) strategy affects students' mathematics learning. It also examined how gender moderated the effect of the strategy on their performance.

The main objective of this study was to assess the impact of the Task-Based Learning (TBL) strategy on students' achievement in sustainable computing mathematics. In particular, the research explored how TBL affects students' academic performance in sustainable computing mathematics. Additionally, it examined the moderating role of gender on their learning achievement after exposure to the TBL strategy. Two research questions and three hypotheses guided the study in achieving its objectives.

Research questions

i. What are the students' pretest and posttest mean achievement scores by strategy?
ii. What are the students' pretest and posttest mean achievement scores by gender?

Hypotheses

$H_0$1: The teaching strategy (task-based learning versus conventional teaching method) does not significantly affect students' academic achievement in senior secondary school sustainable computing mathematics

$H_0$2: Gender does not significantly affect students' academic achievement in senior secondary school sustainable computing mathematics.

$H_0$3: Strategy and gender do not significantly interact to affect students' academic achievement in senior secondary school sustainable computing mathematics.

Methodology

This study used a quasi-experimental pretest-posttest control group design with a 2x2 factorial structure. Gender was used as a moderating variable alongside the TBL strategy to assess its effect on students' learning of sustainable computing mathematics.

The study targeted all public senior secondary school two (SS 2) students in the Ijebu Education Bloc of Ogun State. In Nigeria, mathematics is a core subject for all secondary school students. The sample consisted of one hundred and four (114) students from two purposively selected public secondary schools in the Ijebu Education Bloc of Ogun State, such that 55 and 59 students were in the control and experimental groups, respectively. The two schools were selected based on the criteria that they were co-educational and had qualified mathematics teachers with a minimum of a BSc. Ed (Mathematics), the school authorities approved the study to use one of the timetable's mathematics and computer studies periods. The two schools were far from one another to prevent experimental contamination. In each school, an intact science class was also purposively selected, as only science students were qualified to study computer science, where more sustainable computing skills would be learned and applied.

A procedural instrument, the Task-Based Learning Strategy Instruction Guide (TBLSIG), and a measuring instrument, the Sustainable Computing Mathematics Achievement Test (SCMAT), were used for data collection. The SCMAT was an instrument created by the researcher, consisting of two sections. Section A collected demographic information from the students, while Section B included 30 questions related to mathematics topics pertinent to sustainable computing. The 30-item SCMAT was derived after subjecting the scores from the initial 90-item test administered to 105 students from non-selected schools to item difficulty and discrimination analysis. Experts in test construction, mathematics education, and computer education from Olabisi Onabanjo University, Ago-Iwoye, and secondary school mathematics and computer studies teachers scrutinized the instrument's face and content validity. The instrument's reliability was obtained by administering copies to 20 students from non-participating schools with characteristics comparable to those of the selected schools twice a week. The test-retest statistics yielded a reliability coefficient of 0.71. Similarly, a task-based learning instructional guide was developed for the experimental group to ensure

compliance with the study design. In contrast, the teacher in the control group used the usual lesson guide, which did not involve task-based learning.

The researcher obtained permission from the authorities of the participating schools and held discussions with the mathematics and computer teachers to explain the study's purpose, seeking their support. Additionally, the students were informed about the study's objectives, assured of ethical conduct, and encouraged to lend their full support to achieve the goals.

The study lasted six weeks, with the first week used for pre-intervention discussions with school authorities and administering the Sustainable Computing Mathematics Achievement Test (SCMAT) as a pretest to the members of the control and experimental groups. The second through sixth weeks were dedicated to teaching algebra, statistics, probability, and number systems, with each topic covered twice a week in the experimental group. The tasks for each class were structured into three phases: pre-task, task-cycle, and post-task (Solechah, 2016), following the task-based learning strategy. This design was to actively engage students in meaningful tasks that reflect real-world applications of mathematics in sustainable computing.

At the pre-task stage, the researcher introduced the concept of sustainable computing, focusing on its role in promoting sustainable development. The learning objectives for each topic —algebra, statistics, and probability — were explicitly stated to help students understand the real-world relevance of the mathematics they were about to learn. This set the context for the tasks, making students aware that acquiring sustainable computing mathematical skills would enable them to contribute to solving sustainability challenges through computing.

To prepare for the upcoming task cycle, students were grouped into teams of four (two males and two females per group) based on their first-term mathematics examination scores, ensuring a mix of abilities. This grouping promoted peer learning and collaboration, critical components of task-based learning. In the task-cycle stage, students engaged in meaningful and authentic tasks related to sustainable computing - for example, the algebra lesson involved using algebraic equations to model heat emissions reduction strategies. Similarly, during the statistics lesson, students worked on analyzing real-world data related to sustainability, such as energy consumption trends. The students worked on these tasks individually and in groups, emphasizing collaborative problem-solving. They were encouraged to think critically, exchange ideas, and apply mathematical concepts to tackle these real-life problems. The researcher moved around the

classroom as a facilitator to observe the groups' progress, offering feedback and guidance without providing direct solutions. This allowed students to develop autonomy and take ownership of their learning, a crucial aspect of the task-based approach. The tasks were designed to enhance mathematical proficiency and help students understand how mathematics can be applied to real-world scenarios, particularly in addressing sustainability through computing. In contrast, the same topics were taught in the control group using the conventional method.

Task example: A company wants to reduce its heat emissions by 20% over the next five years. Let x represent the company's current yearly emissions in tons. The company plans to reduce its emissions by a constant amount each year. Write an algebraic equation to represent the emissions reduction each year.

Solution: Let the total reduction over 5 years be 0.20x. Each year, the reduction will be 0.20x/5=0.04x. The equation representing the company's yearly emissions y after t years is:

$Y = 0.04xt$

After completing the tasks, students reflected on their work, discussing the mathematical processes they used and the relevance of their solutions to sustainable computing. This reflection helped reinforce the connections between the mathematics they learned and its application in solving practical problems related to sustainability. Students who struggled with certain concepts were provided with additional support through remedial activities, ensuring that no student was left behind. This process stage also allowed for the consolidation of learning, as students could revisit challenging areas and further internalize the skills they had developed. The students were typically given mathematics assignments related to sustainable computing for further practice in this area. A reshuffled Sustainable Computing Mathematics Achievement Test (SCMAT) was also administered to the control and experimental groups during this stage as a posttest.

The data analysis was conducted using descriptive statistics, including bar charts, to address the research questions. For hypothesis testing and inferential statistics, specifically analysis of covariance (ANCOVA), a significance level of 0.05 was employed, utilizing the Statistical Package for the Social Sciences (SPSS) Version 23.

Result

The results are presented by the research questions and hypotheses.

Research questions

Research Question 1. What are the students' pretest and posttest mean achievement scores by strategy?

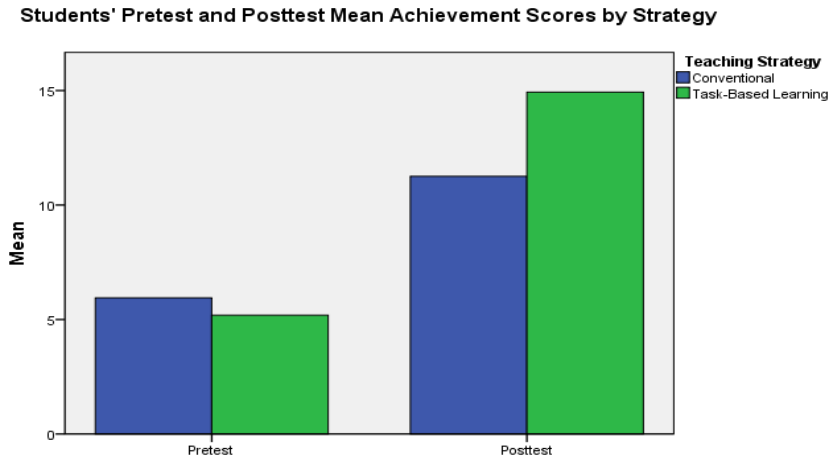

Figure 1. Students' pretest and posttest mean achievement scores by strategy

Figure 1 indicates that students in the control group had marginally higher pretest mean achievement scores than those instructed with the Task-Based Learning (TBL) strategy. However, the students instructed with the TBL approach obtained higher mean posttest scores than their peers in the control group.

Research Question 2. What are the students' pretest and posttest mean achievement scores by gender?

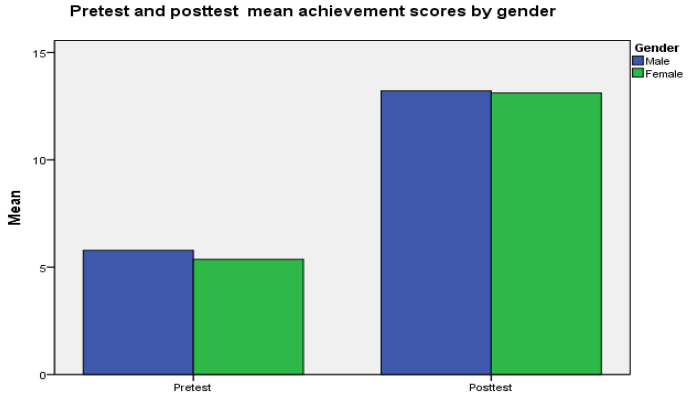

Figure 2. Students' pretest and posttest mean achievement scores by gender

Figure 2 shows that although male students' pretest mean achievement scores before exposure to the strategy appear higher than those of females, the posttest mean achievement scores of both genders appear similar after exposure to the strategy.

Test of Hypotheses

$H_0$1: The teaching strategy (task-based learning versus conventional teaching method) does not significantly affect students' academic achievement in senior secondary school sustainable computing mathematics.

Table1. Analysis of Covariance of students' achievement in senior secondary school sustainable computing mathematics

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	403.516[a]	4	100.879	23.923	0.000	0.467
Intercept	2349.707	1	2349.707	557.212	0.000	0.836
Pretest	16.088	1	16.088	3.815	0.053	0.034
Strategy	328.785	1	328.785	77.968	0.000	0.417
Gender	1.720	1	1.720	0.408	0.524	0.004
Strategy * Gender	3.305	1	3.305	0.784	0.378	0.007
Error	459.642	109	4.217			
Total	20600.000	114				
Corrected Total	863.158	113				

R Squared = .467 (Adjusted R Squared = 0.448)

Table 1 reveals that the strategy (TBL and conventional teaching method) significantly impacts students' academic achievement in senior secondary sustainable computing mathematics ($F_{(1,109)} = 77.968$, $p<0.05$). This result indicates a significant difference in the posttest mean achievement scores between students taught through the conventional method and those exposed to the Task-based learning strategy. Consequently, the hypothesis that the teaching strategy (task-based learning and conventional method) does not significantly affect students' academic achievement in sustainable computing mathematics in senior secondary school is rejected.

A multiple classification analysis was performed to assess the extent of the effect of each teaching method, with results presented in Table 2.

Table 2. Multiple classification analysis of students' achievement in sustainable computing by strategy and gender

Grand Mean = 13.16							
		Predicted Mean		**Deviation**		**Factor Summary**	
	N	**Unadj**	**Adju**	**Unadj**	**Adju**	**Et**	**Beta**

			usted	**sted for factors**	**usted**	**sted for factors**	**a**	**adjusted for factors**
Strategy	Conventional method	55	11.25	11.25	-1.903	-1.904	0.688	0.668
	Task-based learning	59	14.93	14.93	1.744	1.755		
Gender	Male	51	13.22	13.24	0.058	0.086	0.019	0.028
	Female	63	13.11	13.09	-0.047	-0.070		

Table 2 revealed that, with a grand mean of 13.16, students exposed to the Task-based Learning strategy achieved a significantly higher adjusted posttest mean score of 14.93, compared to 11.25 for those taught using the conventional method. This suggests that TBL is more effective in enhancing students' learning of sustainable computing mathematics compared to the conventional teaching method. The Table also shows that the teaching strategy accounted for 66.8% of the variance in students' achievement in sustainable computing mathematics.

$H_0$2: Gender does not significantly affect students' academic achievement in senior secondary school sustainable computing mathematics.

As shown in Table 1, gender does not significantly affect students' academic achievement in sustainable computing mathematics ($F_{(1,109)} = 0.408$, $p > 0.05$). This finding indicates that the gender difference in the students' posttest mean achievement scores is insignificant. Therefore, the hypothesis that gender does not significantly affect students' academic achievement in senior secondary school sustainable computing mathematics is retained. Table 2 further illustrates that while males had an adjusted posttest mean achievement score of 13.24, the females scored an adjusted mean of 13.09, which is not statistically significant.

$H_0$3: Strategy and gender do not significantly interact to affect students' academic achievement in senior secondary school sustainable computing mathematics.

The results in Table 1 indicate that there is no significant interaction effect of the teaching strategy (TBL versus conventional method) and gender on students' academic achievement in senior secondary school sustainable computing mathematics ($F_{(1,109)} = 0.784$, $p > 0.05$). This finding suggests that the posttest mean achievement scores for male and female students do not differ significantly across the two instructional methods. Therefore, the hypothesis that strategy and gender do not significantly interact to influence students' academic achievement in senior secondary school sustainable computing mathematics is retained.

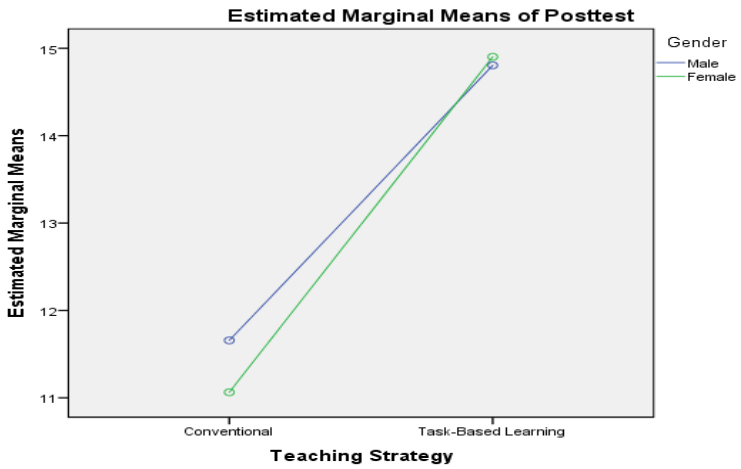

Figure 3. Graph of the interaction effect of strategy and gender

Figure 3 demonstrates that, regardless of gender, students exposed to the Task-Based Learning (TBL) strategy performed better than those taught using the conventional teaching method. Additionally, the difference in estimated marginal means between male and female students taught with TBL is smaller compared to their counterparts instructed with the conventional method.

Discussion

The demand for skills in sustainable computing practices has become increasingly important for achieving the Sustainable Development Goals. However, students are underperforming in sustainable computing mathematics. Therefore, this study investigated the effect of the Task-based learning (TBL) strategy on students' academic achievement in mathematics related to sustainable computing. The findings revealed that students exposed to the TBL strategy significantly outperformed those taught using the conventional teaching method in sustainable computing mathematics. This outcome

indicates that students taught with the TBL strategy achieved higher results than those instructed with the conventional method, confirming the effectiveness of the TBL approach over traditional teaching methods. The effectiveness may be due to active engagement, problem-solving, and real-life application, allowing students to explore ideas more deeply and interact with them in an authentic context. The strategy allowed the students to think critically and collaborate to exchange ideas. The authentic task enabled learners to apply theoretical knowledge to real-world scenarios, thereby improving their motivation and understanding. As an experiential approach, TBL might have made learning sustainable computing mathematics easier than those in the control group. This finding is unsurprising because a growing body of research has advocated for student-centered strategies to teach complex subjects like mathematics, especially in an interdisciplinary aspect like sustainable computing. Precisely, this finding aligns with that of Radwan (2023), who examined the effects of TBL on students' achievement in English as a foreign language (EFL) creative reading skills and found that the strategy improved learning outcomes compared to the conventional teaching method. It also concurred with that of Faridaman et al. (2024), who evaluated the impact of the TBL language teaching model on the achievement in English of Grade IV students at SD Negeri 201 Palembang and found the strategy to be significant in improving learning outcomes in the subject.

Another finding indicated that there was no significant main effect of gender on students' academic achievement in sustainable computing mathematics. This result suggests that there is no significant gender difference in the academic performance of students. These finding challenges common stereotypes and misconceptions regarding gender disparities in mathematical ability, particularly in the Science, Technology, Engineering, and Mathematics (STEM) fields, where male dominance is often emphasized. The lack of a significant gender difference suggests that both genders can achieve equally when provided with the same learning opportunities and instructional strategies, such as Task-Based Learning (TBL). This outcome supports the argument that factors such as teaching methods, learning environment, and engagement play a more significant role in academic performance than inherent gender-based differences in ability.

Furthermore, this finding aligns with broader research indicating that gender gaps in mathematics performance often stem from social, cultural, and environmental factors rather than biological differences. The finding on the non-significant main effect of gender on achievement aligns with that of Akinsola et al. (2023), who examined the gender difference in students' performance in Mathematics but

found no significant impact of gender on students' learning. However, the finding contradicts that of Egara and Mosimege (2023), who investigated students' achievement in algebra after exposure to computer-simulated lessons and reported that female students significantly outperformed their male colleagues.

This study hypothesized that there would be no significant interaction effect between strategy and gender on students' academic achievement in sustainable computing mathematics. The findings confirmed that there was indeed no significant interaction effect of strategy and gender on students' learning. This indicates that the effectiveness of the instructional strategy was consistent across genders, suggesting that both male and female students benefited equally from the Task-Based Learning (TBL) approach. Furthermore, the method of instruction did not disadvantage either gender, highlighting TBL as a gender-neutral strategy that allows both males and females to show similar improvements. Additionally, these results demonstrate TBL's adaptability in addressing students' learning needs regardless of their social and cultural backgrounds, thereby enhancing the quality of instruction without perpetuating gender disparities in learning. This finding aligns with that of Akinsola et al. (2023), who examined the gender difference in students' performance in mathematics and found that gender did not significantly impact students' achievement after exposure to self-regulated learning strategies. However, this finding contradicts Vos et al.'s (2023) study, which investigated the performance of male and female students in arithmetic and cognitive reflection tests after exposure to computer-simulated lessons, and showed that females scored significantly lower than males in these areas.

Conclusion

The research investigated the effect of the task-based learning (TBL) strategy on students' learning of sustainable computing mathematics, with gender as a moderating variable. The findings established that the task-based learning strategy significantly improved students' learning outcomes, as evidenced by the higher posttest mean achievement scores recorded by the group taught with the strategy. Thus, the study concludes that teachers should adopt the TBL strategy for teaching mathematics topics related to sustainable computing.

Similarly, the study found that gender was not a significant factor in students' achievement when TBL was used, suggesting that the strategy effectively accommodates diverse learning needs. It is therefore implied that broader adoption of TBL—especially when social, cultural, and environmental barriers are minimized—could

contribute to reducing gender performance gaps in mathematics education.

Recommendations

Based on the effectiveness of the task-based learning strategy in enhancing students' academic achievement in sustainable computing mathematics, it is recommended that teachers adopt this approach to teach sustainable computing aspects of mathematics. Its application should also be extended to other subject areas and educational contexts to understand its effectiveness in many areas of learning. It is worth noting that the strategy requires more time than is allocated to mathematics in the school timetable. Therefore, the timetable needs to be restructured to accommodate the TBL strategy, which requires more time.

The government and other education stakeholders should organize workshops and training sessions where teachers can learn the tenets of task-based learning strategy to apply them in their teaching and learning. Since TBL is gender-neutral, with no significant difference in the posttest mean achievement scores between male and female learners, teachers should continue to develop gender-inclusive teaching strategies to bridge the gender performance gaps. Additionally, inclusive and supportive learning environments should be implemented to enhance students' learning and reduce gender disparities.

The Computer Studies curriculum should be restructured to include sustainable computing as a theme in mathematics. This theme will help students develop an adequate understanding of sustainable computing and its importance to the success of sustainable development, as well as acquire essential sustainable computing skills.

References

Abdullah, P. F. & Haji, S. J. (2022). The effectiveness of task-based learning strategy in the academic achievement by Soran University students in the subject of chemistry and developing their prospective thinking skills. Journal of Arts, Literature and Social Sciences, 83, 256-280. Htttps://doi.org/10.33193/JALHSS.83.2022.725

Akinsola, M., Ajobiewe, T., Agbato, S., & Usman, K. K. (2023). Rethinking the teaching and learning of mathematics in the pandemic era: Festschrift in honour of Professor Kamoru Olayiwola Usman mni, ff, fman.

Anives, J. B. & Ching, D. A. (2022). Application of task-based learning module in mathematics V. International Journal of

Educational Management and Development Studies, 3(1), 97-131

Azlan, N. A. B., Zakaria, S. B., & Yunus, M. M. (2019). Integrative task-based learning: Developing speaking skills and increasing motivation via Instagram. International Journal of Academic Research in Business and Social Sciences, 9(1), 620-636.

Burdujan, R. (2024). The potentials of task-based language learning (TBLL) in an interdisciplinary context. Acta et Commentationes, Sciences of Education, 35(1), 127-135. https://doi.org/10.36120/2587-3636.v35i1.127-135

Chen, J., & Lin, W. (2018). The role of mathematical models in predictive analytics. Journal of Computational Science, 14(2), 134-145.

Dewi, K., & Falqotur, R. (2022). The implementation of task-based leaning strategy by making video introduction to improve students speaking skills. Darussalam Journal, 2(2), 199-220. doi:10.30739/dej.v2i2.1778.

Egara, F. O., & Mosimege, M. D. (2023). Gender difference in secondary school students' retention in algebra: A computer simulation approach. Eurasia Journal of Mathematics, Science and Technology Education, 19(7), em2290. https://doi.org/10.29333/ejmste/13280

Faridaman, A., Djunaidi, D., Marleni, M. (2024). The influence of task-based language teaching (TBLT) in English Language learning outcomes of fourth grade students in SD Negeri 201 Palembang. Esteem Journal of English Education Study Programme, 7(1), 72-84.

Federal Ministry of Education. (2018). National policy on science and technology education. Retrieved from https://education.gov.ng/wp-content/uploads/2020/09/NationalPolicy-On-Science-and-Technology-Education.pdf

Gomes, C., Dietterich, T., Barrett, C., Conrad, J., Dilkina, B., Ermon, S., Fang, F., Farnsworth, A., Fern, A., Fern, X., Fink, D., Fisher, D., Flecker, A., Freund, D., Fuller, A., Gregoire, J., Hopcroft, J., Kelling, S., Kolter, Z., … Zeeman, M. L. (2019). Computational sustainability: Computing for a better world and a sustainable future. Communications of the ACM, 62(9), 56–65. https://doi.org/10.1145/3339399

Kumar, S., & Chander, S. (2020). Cost optimisation techniques in cloud computing: Review, suggestions and future Scope (SSRN Scholarly Paper 3562980). https://doi.org/10.2139/ssrn.3562980

Miller, T. (2019). Cost reduction through mathematical optimisations in cloud computing. Cloud Computing and Sustainability, 10(1), 89-97.

Mocigemba, D. (2006). Sustainable computing. Poiesis & Praxis, 4(3), 163–184. https://doi.org/10.1007/s10202-005-0018-8

Naqsyabandiyah, N., & Dehghani, N. (2023). Developing task-based learning materials to improve students' vocabulary mastery viewed from linguistic awareness. Journal of Language and Literature Studies, 3(1), 37–52. https://doi.org/10.36312/jolls.v3i1.1088

Peters, A. K., Capilla, R., Coroama, V. C., Heldal, R., Lago, P., Leifler, O., Moreira, A., Fernandes, J. P., Penzenstadler, B., Porras, J., & Venters, C. C. (2024). Sustainability in computing education: A systematic literature review. ACM Trans. Comput. Educ., 24(1), 13:1-13:53. https://doi.org/10.1145/3639060

Radwan, S. A. F. M. (2023). The impact of task-based learning strategy on enhancing some efl creative reading skills of secondary stage students. Reading and Knowledge, 23(261), 31–51. https://doi.org/10.21608/mrk.2023.306158

Rodrigues, M. P. (2023). Green computing and energy-efficient algorithms for sustainable computing. International Journal of Computing and Digital Systems, 14(1), 1–20. https://doi.org/10.12785/ijcds/XXXXXX

Sholeh, M., Nur, S., & Salija, K. (2020). Task based learning (TBL) in EFL Classroom: From theory to practice. International Journal of Humanities and Innovation (IJHI), 3, 139–144. https://doi.org/10.33750/ijhi.v3i4.97

Solechah, M. (2016). Task-Based Learning (TBL) in teaching speaking (Case study for the second semester (TLA) of English Education Department at STAIN Ponorogo in academic year 2015/2016). [PhD Thesis, STAIN Ponorogo]. http://etheses.iainponorogo.ac.id/1349/1/Mar%27atus%2C%20Abstrak%2C%20BAB%20I-V%2C%20DP.pdf

United Nations Educational, Scientific and Cultural Organization. (2023). Education for Sustainable Development Goals: Learning objectives | UNESCO. https://www.unesco.org/en/articles/education-sustainable-development-goals-learning-objectives

Vos, H., Marinova, M., De Léon, S. C., Sasanguie, D., & Reynvoet, B. (2023). Gender differences in young adults' mathematical performance: Examining the contribution of working memory, math anxiety and gender-related stereotypes. Learning and

Individual Differences, 102, 102255. https://doi.org/10.1016/j.lindif.2022.102255

West African Examinations Council. (2014). Candidates' weaknesses and suggested remedies. https://www.waeconline.org.ng/e-learning/Mathematics/maths223mw.html

West African Examinations Council. (2015). Candidates' weaknesses and suggested remedies. https://www.waeconline.org.ng/e-learning/Mathematics/maths224mw.html

West African Examinations Council. (2016). Candidates' weaknesses and suggested remedies. https://www.waeconline.org.ng/e-learning/Mathematics/maths225mw.html

West African Examinations Council. (2017). Candidates' weaknesses and suggested remedies. https://www.waeconline.org.ng/e-learning/Mathematics/maths226mw.html

West African Examinations Council. (2018). Candidates' weaknesses and suggested remedies. https://www.waeconline.org.ng/e-learning/Mathematics/maths227mw.html

West African Examinations Council. (2019). Candidates' weaknesses and suggested remedies. https://www.waeconline.org.ng/e-learning/Mathematics/maths228mw.html

West African Examinations Council. (2019). WASSCE (School) Candidates Results Statistics- May/June 2019. Retrieved from https://www.waecdirect.org/1635.html

West African Examinations Council. (2020). Candidates' weaknesses and suggested remedies. https://www.waeconline.org.ng/e-learning/Mathematics/maths231mw.html

West African Examinations Council. (2021). Candidates' weaknesses and suggested remedies. https://www.waeconline.org.ng/e-learning/Mathematics/maths233mw.html

West African Examinations Council. (2022). Candidates' weaknesses and suggested remedies. https://www.waeconline.org.ng/e-learning/Mathematics/maths235mw.html

Xu, L., Zhang, H., & Li, P. (2019). Data compression techniques for green computing. Journal of Green Computing, 23(3), 201-215.

Zambrano R., J., Kirschner, F., Sweller, J., & Kirschner, P. A. (2023). Effect of task-based group experience on collaborative learning: Exploring the transaction activities. British Journal of Educational Psychology, 93(4), 879–902. https://doi.org/10.1111/bjep.12603