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BLENDED-HYBRID LEARNING MODEL'S EFFECT ON SENIOR SECONDARY STUDENTS' HOLISTIC DEVELOPMENT AND ACADEMIC PERFORMANCE IN BIOLOGY IN BENUE STATE, NIGERIA

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Abstract

This study investigated the effect of an activity-based blended-hybrid learning model to address challenges of low academic performance and holistic development among senior secondary school students in Benue State, Nigeria, using a pre-test–post-test quasi-experimental control group research design. Two research questions and two hypotheses guided the study. The population comprised 8,673 SS2 Biology students in public senior secondary schools in Makurdi and Gboko Local Government Areas of Benue State. A sample of 162 students was selected using purposive and simple random sampling techniques, comprising an experimental group taught using the blended-hybrid learning model (n = 76) and a control group taught using the discussion method (n = 86). Data were collected using the Biology Academic Performance Test (BPT) and Holistic Development Rating Scale (HDRS), with reliability coefficients of 0.84 and 0.81, respectively. Research questions were answered using mean and standard deviation, while hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). Findings revealed a statistically significant difference in academic performance between the groups, $F(1, 159) = 149.388$, $p < .05$, with a large effect size (0.484). A statistically significant difference was also found in holistic development, $F(1, 159) = 35.966$, $p < .05$, with a moderate effect size (0.184). It was concluded that the blended-hybrid learning model enhances students' academic performance and holistic development in Biology. It was recommended that Biology teachers should adopt blended-hybrid learning model, while education stakeholders should provide adequate digital infrastructure and teacher training to support effective implementation.

Keywords: Blended-Hybrid Learning Model, Academic Performance, Holistic Development, Biology, Senior Secondary School Students

Introduction

Science education has greatly change in the 21st century, mainly driven by rapid advances in Information and Communication Technologies (ICT). In Nigeria especially, there is increase in digitalisation, global interconnectedness, and evolving perspectives on effective teaching and

learning of science especially Biology. Consequently, education in science has shifted from predominantly teacher-centred method towards flexible, technology-supported, learner-centred learning environments that are capable of promoting active engagement, collaboration, creativity, and lifelong learning among all learners. Emerging technologies which are more common and accessible, like learning management systems, mobile applications, artificial intelligence, virtual learning platforms, and multimedia resources, have aided in transforming knowledge accessibility, construction, communication, and assessment (Zawacki-Richter & Jung, 2023; Otor et al., 2025). Educational digitalisation extends beyond technology adoption to encompass the transformation of pedagogy, assessment, teacher roles, and learning environments to improve educational quality and inclusiveness. Moreover, Rasheed et al. (2020) and Ye et al. (2022) opined that technology alone may not guarantee improved learning outcomes, as successful digital transformation depends on the interaction among technological infrastructure, teacher competence, institutional support, and learners' readiness to engage with digital tools. Hence, the need to examine it closely.

The Coronavirus Disease 2019 (COVID-19) pandemic accelerated educational digitalisation by compelling institutions worldwide to adopt technology-supported learning during school closures. Although the pandemic exposed disparities in digital access and infrastructure, it also highlighted the importance of flexible and resilient learning systems, leading to increased adoption of blended and hybrid learning approaches. Blended learning integrates face-to-face instruction with online or technology-mediated learning within a coherent pedagogical framework, whereas hybrid learning combines physical and virtual participation simultaneously. Anthony et al. (2022) and Graham and Halverson (2022) explained that, despite conceptual differences, both approaches seek to combine the strengths of classroom interaction with the flexibility and accessibility of digital learning environments. Contemporary blended-hybrid learning therefore represents a redesign of teaching through the integration of instructional objectives, pedagogy, assessment, digital resources, and learner interaction (Rasheed et al., 2020). Consequently, contextually relevant blended-hybrid learning models that integrate digital resources and learner-centred approaches are essential for enhancing students' academic performance and holistic development.

Blended learning can be implemented through several models, including the rotation, flex, and enriched virtual models. Graham and Halverson (2022) argued that these models should be selected according to learners' characteristics, curriculum requirements, technological availability, and institutional context. Among these models, the station rotation model was considered most appropriate for secondary school Biology because it integrates teacher-guided instruction, collaborative learning, independent activities, and digital resources within a structured classroom environment. According to Horn and Staker (2015), students rotate through structured learning stations that support differentiated instruction and active participation. Previous studies have shown that the station rotation model enhances students' academic performance and retention in Biology compared with conventional instructional approaches (Horn & Staker, 2015; Yoade & Asaaju, 2024; Osuji & Abraham, 2024). Therefore, the station rotation model provides a suitable blended-hybrid framework for Biology instruction by integrating teacher support, digital resources, and collaborative activities which may improve students' academic

performance and facilitate holistic development.

Hybrid learning integrates face-to-face instruction with online learning experiences to create a flexible, interactive, and student-centred learning environment (Setiawan et al., 2023). In Biology teaching and learning, a teacher adopting a hybrid learning strategy combines classroom teaching, laboratory activities, demonstrations, and discussions with digital resources such as virtual laboratories, simulations, multimedia materials, and online assessments, enabling Biology learners to engage with complex biological concepts through diverse learning pathways. Recent studies (Bandarlipe, 2024; Edokpolor & Omoifo, 2024) indicate that hybrid learning improves students' conceptual understanding, academic performance, engagement, scientific inquiry skills, and self-directed learning by combining traditional teaching with technology-enhanced experiences. Although hybrid learning has reported benefits, limited empirical evidence exists on the effectiveness of blended-hybrid learning models for improving Biology students' academic performance and holistic development, particularly in Nigerian secondary schools. Thus, further studies are needed to determine whether integrating hybrid and blended learning may enhance academic performance and holistic development in Biology.

The effectiveness of blended-hybrid learning is supported by constructivist learning theories, which views learners as active constructors of knowledge through interaction, experience, reflection, and collaboration. Consistent with this perspective, active learner engagement promotes meaningful learning while reducing unnecessary cognitive load during knowledge acquisition (Kpiranyam et al., 2024b). Similarly, the Community of Inquiry framework emphasises teaching, cognitive, and social presence in creating meaningful blended learning experiences (Halverson & Graham, 2019), whereas the Technological Pedagogical Content Knowledge (TPACK) framework highlights the integration of technological, pedagogical, and content knowledge for effective technology-enhanced instruction (Archibald et al., 2021). Together, these frameworks provide a strong theoretical basis for adopting blended-hybrid learning in Biology classrooms.

A growing body of evidence demonstrates the educational benefits of blended learning. Meta-analyses and systematic reviews consistently show that blended learning improves academic performance, learner engagement, motivation, learning attitudes, autonomy, and knowledge acquisition when supported by effective instructional design and teacher competence (Bernard et al., 2014; Vo et al., 2017; Anthony et al., 2022; Cao et al., 2023). Li et al. (2022) further confirmed these benefits among K–12 learners. In science education, blended learning provides opportunities through digital simulations, multimedia resources, virtual laboratories, and inquiry-based activities that strengthen conceptual understanding, scientific reasoning, and problem-solving skills (Wang et al., 2023). These advantages are particularly relevant to Biology, where concepts often require visualisation, experimentation, and interactive exploration. Similarly, Samba et al. (2021), Kpiranyam et al. (2023), Kpiranyam et al. (2024a), Kpiranyam et al. (2024b), and Kpiranyam (2025) reported that innovative instructional strategies improve Biology students' performance by promoting active engagement, meaningful learning, deeper conceptual understanding, and reduced cognitive load.

Beyond academic performance, blended-hybrid learning contributes to students' holistic development by promoting behavioural, cognitive, emotional, and social engagement (Halverson & Graham, 2019). Meaningful interaction with peers, instructors, and learning resources enhances learner satisfaction, self-regulated learning, communication, collaboration, and critical thinking (Manwaring et al., 2017; Martin & Bolliger, 2018). Therefore, assessing both academic performance and holistic development provides a more comprehensive understanding of the effectiveness of blended-hybrid learning, as the model aims not only to improve students' knowledge acquisition but also to foster engagement, self-regulation, collaboration, creativity, and other competencies essential for lifelong learning. Across Africa, blended learning has increasingly been recognised as a strategy for addressing educational challenges such as teacher shortages, overcrowded classrooms, and unequal access to quality education (Ashraf et al., 2021; Anthony et al., 2022). However, successful implementation remains dependent on adequate infrastructure, internet connectivity, institutional commitment, teacher competence, and learners' socioeconomic circumstances (Bozkurt, 2022; Rasheed et al., 2020; Ye et al., 2022).

In Nigeria, blended-hybrid learning has become increasingly relevant because of expanding digital technologies, educational reforms, and the need to improve instructional quality. United Nations United Nations Educational, Scientific and Cultural Organization ([UNESCO] (2023) reported that educational institutions are increasingly adopting digital resources to complement conventional teaching despite persistent challenges relating to infrastructure, internet access, and teacher preparedness. Emerging Nigerian studies also indicate that blended learning improves students' engagement, motivation, and achievement; however, most investigations have focused on tertiary education or isolated subject areas (Yoade & Asaaju, 2024). Consequently, empirical evidence on structured blended-hybrid learning models in secondary school Biology remains limited. This gap provides justification for further investigation to improve students' holistic development and academic performance.

Academic performance in this study refers to students' level of learning outcomes in Biology, measured by their scores obtained from a Biology Performance Test (BPT) after exposure to the instructional intervention. Despite the importance of Biology, students' performance in the subject has remained unsatisfactory and inconsistent, as indicated by researchers and WAEC reports (Bamidele & Yaode, 2017; WAEC, 2015–2024; Kpiranyam, 2025). Evidences (WAEC, 2015–2024) show that fewer than 50% of WASSCE candidates in some years obtained credit passes or above in Biology, limiting access to Biology-related courses and careers. Nzeodibe et al., 2022) noted that persistent poor performance has generated concerns among stakeholders, including parents, educators, and government agencies, with some individuals resorting to unapproved examination centres to improve grades. Consequently, there is a need for effective instructional strategies to improve students' academic performance in Biology.

Holistic development has become an important educational objective that extends beyond examination performance to include cognitive, emotional, social, ethical, creative, and technological competencies. Contemporary education emphasises the development of critical thinking, collaboration, communication, creativity, resilience, digital literacy, self-regulation, and responsible citizenship as essential twenty-first-century skills (Organisation for

Economic Co-operation and Development [OECD] 2021; Zawacki-Richter & Jung, 2023). Although academic performance remains an important indicator of educational success, it provides only a partial measure of learning because effective education should also foster learners' creativity, collaboration, independence, and lifelong learning. Blended learning environments can support these broader outcomes through collaborative platforms, simulations, inquiry-based learning, and technology-supported interaction (Halverson & Graham, 2019; Martin & Bolliger, 2018). Nevertheless, previous studies have focused predominantly on academic performance, with comparatively little attention given to holistic development.

Previous studies have consistently shown that blended learning improves students' academic performance, engagement, learner autonomy, and broader learning outcomes compared with conventional instructional approaches (Means et al., 2013; Bernard et al., 2014; Vo et al., 2017; Garrison & Vaughan, 2008; Hrastinski, 2019). However, evidence remains inconsistent, as Ustun (2012) reported no significant advantage of blended learning over traditional instruction. Furthermore, most existing studies have focused on academic achievement, with limited attention to students' holistic development, particularly in Nigerian senior secondary schools. Consequently, empirical evidence on the effect of a Blended-Hybrid Learning Model on both academic performance and holistic development in Biology among senior secondary school students in Benue State remains limited. This study was therefore conducted to address these gaps. Addressing these gaps, the present study investigated the effect of a blended-hybrid learning model on academic performance and holistic development among senior secondary school students in Benue State, Nigeria.

Statement of the Problem

Biology education should develop students' academic knowledge alongside critical thinking, creativity, collaboration, communication, self-regulation, and digital competence. However, senior secondary students in Nigeria continue to experience unsatisfactory academic performance, while broader dimensions of holistic development receive limited attention. This may weaken students' readiness for higher education, employment, lifelong learning, and responsible citizenship, ultimately constraining Nigeria's human capital and national development. Conventional teacher-centred methods may not adequately provide the active, flexible, collaborative, and technology-supported experiences required to address these challenges. A Blended-Hybrid Learning Model may provide a viable solution. However, evidence of its effect on both academic performance and holistic development in Biology, particularly in Benue State, remains limited, justifying this study. Therefore, this study investigated the effect of a blended-hybrid learning model on students' academic Performance and holistic development in Benue State, Nigeria.

Objectives

Specifically, the study sought to:

1. determine the difference in the mean academic performance scores of students taught Biology using the blended-hybrid learning model and those taught using the discussion method;
2. determine the difference in the mean holistic development scores of students taught Biology using the blended-hybrid learning model and

those taught using the discussion method.

Research Questions

The following research questions guided the study:

1. What is the difference in the mean academic Performance scores of students taught Biology using the blended-hybrid learning model and those taught using the discussion method?
2. What is the difference in the mean holistic development scores of students taught Biology using the blended-hybrid learning model and those taught using the discussion method?

Research Hypotheses

The following null hypotheses were tested at the 0.05 level of significance:

H_{O1}: There is no significant difference between the mean academic Performance scores of students taught Biology using the blended-hybrid learning model and those taught using the discussion method.

H_{O2}: There is no significant difference between the mean holistic development scores of students taught Biology using the blended-hybrid learning model and those taught using the conventional instructional method.

Method

This study adopted a quasi-experimental pre-test–post-test control group design. The design was considered appropriate because it enabled the researcher to examine the effect of the blended-hybrid learning intervention on students' academic Performance and holistic development while accounting for the practical limitations of random assignment in school settings. The design allowed comparison of students' performance before and after the intervention across experimental and control groups, with pre-test scores used as covariates during analysis to control for initial group differences.

The population comprised 8,673 Senior Secondary School II (SS2) students enrolled in public senior secondary schools in Makurdi and Gboko Local Government Areas of Benue State, Nigeria. A sample of 162 students, consisting of 76 students in the experimental group and 86 students in the control group, participated in the study. Two schools in each local government area were selected. Purposive sampling was used to select schools with the required characteristics, including the availability of qualified Biology teachers, functional learning facilities, willingness to participate in the study, and representation of both male and female students, while simple random sampling was used to assign one school to the experimental and control groups in each local government area.

Two instruments; Student Academic Performance Test (SAAT) and the Holistic Development Rating Scale (HDRS) developed by the researchers were used for data collection. The SAAT was a 40-item multiple-choice test with four options developed based on the Senior Secondary Certificate Examination (SSCE) Biology curriculum and the topics covered during the intervention period. Each question was scores 1 marks with a total of 40 marks. The HDRS was a 30-item five-point Likert-type scale designed to assess students' holistic development across three dimensions: cognitive engagement and self-directed learning (10 items), affective well-being and motivation (10 items), and social interaction and collaborative disposition (10 items). The response categories ranged from Strongly Agree (4) to Strongly Disagree (1). The instruments were validated by one expert Science Education, one in Educational Psychology and another expert in Measurement and Evaluation.

A trial test was conducted on a class of 32 SS II students offering Biology in a school that was not included in the sample. The reliability of the instrument was determined using Cronbach's alpha, which yielded a coefficient of 0.81, indicating satisfactory internal consistency. The reliability of the SAAT was established using the Kuder–Richardson Formula 20 (KR-20), which produced a coefficient of 0.84, indicating high internal consistency.

The intervention lasted for eight weeks. In the blended-hybrid learning (station rotation) model, the teachers used a combination of teacher instruction, digital resources, collaborative activities, and inquiry tasks to teach biological climate change concepts, promoting active participation, deeper understanding, and problem-solving skills. During the conventional instructional method, lessons followed teacher explanations, use of textbooks, note-taking, and classroom discussions, with students mainly receiving information and demonstrating learning through exercises and assessments on biological climate change concepts. This treatment lasted for six weeks before post-test.

The extraneous variables controlled in the study included students' initial ability levels, teacher-related factors, learning environment, gender composition, instructional content and time, assessment procedures, and school location differences, which were minimised through pre-testing, purposive school selection, use of qualified teachers, standardised instructional procedures, and the application of Analysis of Covariance (ANCOVA).

Data collected were analysed using descriptive and inferential statistics. Mean and standard deviation were used to answer the research questions by comparing students' academic Performance and holistic development scores across the experimental and control groups. Analysis of Covariance (ANCOVA) was used to test the null hypotheses at the 0.05 level of significance, with pre-test scores serving as covariates. ANCOVA was considered appropriate because it adjusted for possible initial differences between groups and provided a more accurate estimate of the effect of the blended-hybrid learning model on measured outcomes (SAAT and HDRS).

Results

Data analysis and interpretation are presented in Tables 1–4. Research Questions 1 and 2 are addressed in Tables 1 and 2, respectively, while Hypotheses 1 and 2 are tested and presented in Tables 3 and 4, respectively.

Table 1: Mean and Standard Deviation of Pre-test and Post-test SAAT Scores by Group

Method	**Sample (n)**	**Pre-SAAT**		**Post- SAAT**		**Gain**
		Mean	**St. D**	**Mean**	**SD**	
Blended-Hybrid Learning Model	76	12.12	6.63	32.13	6.73	20.01
Discussion Method	86	16.95	6.82	21.90	6.77	4.95
Difference		**4.83**		**10.23**		**15.06**

In Table 1, the mean scores show clear differences between the two instructional methods. The Blended-Hybrid Learning Model group recorded a pre-test mean score of 12.12, a post-test mean score of 32.13, and a mean gain score of 20.01. The Conventional Instructional Method group recorded a pre-test mean score of 16.95, a post-test mean score of 21.90, and a mean gain score of 4.95. At the pre-test level, the Conventional Instructional Method group recorded a higher mean score than the Blended-Hybrid Learning Model group by 4.83 points, indicating that the groups had some differences in their initial academic Performance before the treatment. However, at the post-test level, students taught using the Blended-Hybrid Learning Model achieved a higher mean score (32.13) compared with those taught using the Conventional Instructional Method (21.90), resulting in a mean difference of 10.23 points in favour of the Blended-Hybrid Learning Model. Considering the mean gain scores, students exposed to the Blended-Hybrid Learning Model improved by 20.01 points, while those taught using the Conventional Instructional Method improved by only 4.95 points. This yielded a mean gain difference of 15.06 points in favour of the Blended-Hybrid Learning Model. The findings indicate that the Blended-Hybrid Learning Model had a greater positive effect on students' academic Performance in Biology compared with the Conventional Instructional Method.

Table 2: Mean and Standard Deviation of Pre-test and Post-test HDRS Scores by Group

Method	**Sample (n)**	**Pre-HDRS**		**Post- HDRS**		**Gain**
		Mean	**St. D**	**Mean**	**SD**	
Blended-Hybrid Learning Model	76	1.67	0.26	3.39	0.27	1.72
Discussion Method	86	2.42	0.52	3.04	0.35	0.62
Difference		**0.75**		**0.35**		**1.10**

In Table 2, the mean scores show clear differences between the two instructional methods. The Blended-Hybrid Learning Model group recorded a pre-test mean score of 1.67, a post-test mean score of 3.39, and a mean gain score of 1.72. The Discussion Method group recorded a pre-test mean score of 2.42, a post-test mean score of 3.04, and a mean gain score of 0.62. At the pre-test level, the Discussion Method group recorded a higher mean score than the Blended-Hybrid Learning Model group by 0.75 points, indicating that the groups had differences in their initial levels of holistic development before the treatment. However, at the post-test level, students taught using the Blended-Hybrid Learning Model recorded a higher mean score (3.39) compared with those taught using the Discussion Method (3.04), resulting in a mean difference of 0.35 points in favour of the Blended-Hybrid Learning Model. Considering the mean gain scores, students exposed to the Blended-Hybrid Learning Model improved by 1.72 points, while those taught using the Discussion Method improved by only 0.62 points. This yielded a mean gain difference of 1.10 points in favour of the Blended-Hybrid Learning Model. This implies that the Blended-Hybrid Learning Model had a greater positive effect on students' holistic development compared with the Discussion Method.

Table 3: ANCOVA Summary Table for Differences in Academic Performance (SAAT) Between Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5677.081[a]	2	2838.540	77.268	.000	.493
Intercept	11903.018	1	11903.018	324.011	.000	.671
Pretest	1449.644	1	1449.644	39.461	.000	.199
Group	**5487.974**	**1**	**5487.974**	**149.388**	**.000**	**.484**
Error	5841.098	159	36.736			
Total	126985.000	162				
Corrected Total	11518.179	161				

The ANCOVA results in Table 3 provide evidence on whether the teaching methods significantly influenced students' academic performance after controlling for pretest scores. The effect of Teaching Method has shown F (1, 159) = 149.388, p = .000 < 0.05 and partial eta squared = 0.484. Since the p-value (0.000) is less than the 0.05 level of significance, the null hypothesis is rejected. This result indicates that there is a statistically significant difference in the mean academic performance of students taught using the Blended-Hybrid Learning Model and those taught using the Discussion Method, even after adjusting for pretest differences. The Partial Eta Squared value of 0.484 shows a large effect size, meaning that the teaching method accounts for a substantial proportion (48.4%) of the variation in students' academic performance.

Table 4: ANCOVA Summary Table for Differences in Holistic Development (HDRS) Between Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5.156[a]	2	2.578	25.813	.000	.245
Intercept	61.229	1	61.229	613.106	.000	.794
Pretest	.115	1	.115	1.152	.285	.007
Group	**3.592**	**1**	**3.592**	**35.966**	**.000**	**.184**
Error	15.879	159	.100			
Total	1683.180	162				
Corrected Total	21.034	161				

The ANCOVA results in Table 4 provide evidence on whether the teaching methods significantly influenced students' holistic development after controlling for pretest scores. The effect of Teaching Method has shown F (1, 159) = 35.966, p = .000 < 0.05 and partial eta squared = 0.184. Since the p-value (0.000) is less than the 0.05 level of significance, the null hypothesis is rejected. This result indicates that there is a statistically significant difference in the mean holistic development scores of students taught using the Blended-Hybrid Learning Model and those taught using the Discussion Method, even after adjusting for pretest differences. The Partial Eta Squared value of 0.184 shows a moderate effect size, meaning that the teaching method accounts for a substantial proportion (18.4%) of the variation in students' holistic development scores.

Discussion of Findings

This study was on the effect of a blended-hybrid learning model on academic Performance and holistic development among senior secondary school students in Benue State, Nigeria**.** This result indicates that there is a statistically significant difference in the mean academic performance of students taught using the Blended-Hybrid Learning Model and those taught using the Discussion Method. The finding also supports the report of Means et al. (2013), who found that students in blended learning environments performed better than those in discussion method. This finding agrees with Bernard et al. (2014), who, through a meta-analysis of blended learning research, reported that blended learning significantly improved students' Performance compared with traditional instructional approaches. Similarly, Vo et al. (2017) found that blended learning had a significant positive effect on students' academic performance compared with traditional classroom instruction. The improved Performance may as a result of learning opportunities, greater learner control, and enhanced engagement with instructional materials. This is supported by a large effect size (48.4%). In Biology education, the effectiveness of the Blended-Hybrid Learning Model may be explained by its ability to provide students with multimedia resources, visual representations, collaborative discussions, and opportunities for independent exploration of complex biological concepts. However, the finding disagrees with Ustun (2012), who reported that blended learning did not produce a significant difference in students' Performance compared with traditional instruction. The difference between the present finding and studies that reported no significant effect may be attributed to variations in implementation strategies, subject areas, duration of intervention, and the extent of technology integration.

Findings revealed that there is a statistically significant difference in the mean holistic development scores of students taught using the Blended-Hybrid Learning Model and those taught using the Discussion Method. This finding agrees with Garrison and Vaughan (2008), who reported that blended learning environments support holistic student development by promoting active participation, social interaction, reflective thinking, and self-directed learning. Similarly, Hrastinski (2019) reported that effective blended learning enhances interaction among learners, instructors, and learning resources, which contributes to broader learning outcomes beyond academic achievement. The finding also supports the results of Bernard et al. (2014), who found that blended learning significantly improves learner engagement and interaction compared with traditional instructional approaches. Furthermore, the finding is consistent with Vo et al. (2017), who reported that blended

learning positively influenced students' learning outcomes because it provides opportunities for flexible learning, active participation, and meaningful interaction. The improvement may be attributed to the blended learning environment, which promotes a community of inquiry through increased engagement, peer collaboration, learner autonomy, communication, and critical thinking. These interactive learning experiences may have contributed to the observed enhancement in students' holistic development. However, the finding differs from Ustun (2012), who reported that blended learning did not produce significant differences in student outcomes compared with traditional instruction.

The educational implication of this finding is that the blended-hybrid learning model extends the purpose of education beyond improving academic Performance to fostering students' holistic development. By integrating face-to-face instruction with technology-enhanced learning, the model creates opportunities for active participation, collaboration, communication, self-directed learning, critical thinking, and responsible use of digital resources. This suggests that Biology teachers should move beyond predominantly teacher-centred instructional approaches and adopt blended-hybrid pedagogies that intentionally cultivate cognitive, social, emotional, and digital competencies required for lifelong learning. For school administrators and policymakers, the finding underscores the need to invest in ICT infrastructure, teacher professional development, and supportive policies that facilitate the effective implementation of blended learning in secondary schools. Such investments are likely to produce graduates who are not only academically competent but also equipped with the skills, attitudes, and adaptability needed to thrive in higher education, the workplace, and an increasingly digital society.

Conclusion

Based on the findings, the study concluded that the Blended-Hybrid Learning Model enhanced students' academic performance and holistic development in Biology compared with the Conventional Instructional Method. Students exposed to the model demonstrated higher learning gains, indicating that blended-hybrid learning provides an effective learner-centred approach for improving cognitive, social, and personal learning outcomes.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Biology teachers should adopt the Blended-Hybrid Learning Model in classroom instruction, as it enhances students' academic performance and holistic development compared with the Conventional Instructional Method.
2. School administrators and education stakeholders should provide adequate digital infrastructure, resources, and professional development opportunities for teachers to ensure effective implementation of blended-hybrid learning in secondary schools.

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