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Effect of a WhatsApp-Supported Learning Platform on Biology Achievement among University Undergraduates in Ekiti State, Nigeria: A Quasi-Experimental Study

Toluwani Oniya*
Ekiti State University, Nigeria; oniyatoluwa@gmail.com

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Abstract
This quasi-experimental study examined whether a six-week WhatsApp-supported learning intervention improved the Biology performance of 200-level Biology Education undergraduates in Ekiti State, Nigeria. The submitted study records describe a two-group pre-test-post-test design with 200 students, comprising 108 students in the WhatsApp Learning Platform group and 92 students in a conventional face-to-face group. Instruction focused on introductory developmental and cell biology. Achievement was measured with a 30-item Biology Performance Test that had been reviewed by three specialists for face and content validity and had a reported test-retest reliability coefficient of 0.82. At baseline, the groups were statistically comparable, $t(198) = 0.34$, $p = .732$. The WhatsApp group increased from $M = 55.20$ ($SD = 8.50$) to $M = 75.60$ ($SD = 7.20$), whereas the conventional group increased from $M = 54.80$ ($SD = 7.90$) to $M = 68.50$ ($SD = 8.10$). The post-test mean difference was 7.10 reported score units, 95% CI [4.97, 9.23], $t(198) = 6.56$, $p < .001$, with an editorially reconstructed Hedges' g of 0.93 from the supplied summary statistics. The result supports the educational value of structured mobile instant messaging as an extension of university Biology instruction, but the non-randomized design, absence of raw participant-level data, unresolved source-document inconsistencies in institutional sampling details, and undocumented conversion of the 30-item test to the reported score scale limit causal and measurement claims. The findings therefore support WhatsApp as a supplementary instructional channel rather than as a replacement for laboratory and classroom teaching.

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1. Introduction

Digital communication has become part of the infrastructure of university learning rather than a peripheral convenience. Students routinely use smartphones to retrieve information, coordinate group work, exchange files, and communicate with lecturers. The educational question is therefore no longer whether mobile devices are present in higher education, but whether their use is designed well enough to support learning. This distinction matters because ordinary social-media use and intentionally structured mobile learning are not equivalent. General social-network use can compete with study time and attention, whereas a designed instructional activity can use the same device to distribute explanations, prompt retrieval, support peer interaction, and extend access to academic materials.

A substantial research base supports the potential of mobile learning. In their systematic review of higher education, Crompton and Burke (2018) found that achievement was one of the most frequently investigated outcomes and that undergraduate students dominated the empirical literature. A broader meta-analysis by Sung et al. (2016), which synthesized experimental and quasi-experimental studies, reported an overall moderate positive effect of integrating mobile devices into teaching and learning. These findings do not imply that a smartphone or messaging application produces learning by itself. They indicate that mobile technology can become educationally productive when pedagogy, learner readiness, course design, and support systems are aligned. Sophonhiranrak (2021) similarly identified learner and instructor readiness, learning management, and institutional support as central conditions for effective mobile learning in higher education.

This conditional view is especially important in resource-constrained environments. Conventional learning-management systems may require stable broadband access, continuous computer availability, and technical support that are not equally available to all students. Okai-Ugbaje et al. (2022), drawing partly on work in a Nigerian university, argued that mobile learning in low-resource settings must be designed around local socioeconomic and sociocultural conditions rather than imported as a purely technical solution. Applications that students already use can reduce the entry barrier, but their familiarity does not eliminate problems of connectivity, data cost, device inequality, distraction, privacy, or information overload. A credible evaluation must therefore examine both learning outcomes and the conditions under which the technology was used.

Biology provides a demanding context for such evaluation. University Biology requires students to connect terminology with processes, structures, and relationships that operate across multiple scales. Cell division, differentiation, organelle function, molecular structure, and developmental processes can be difficult to learn through one-way exposition alone. Students benefit from repeated explanations, diagrams, short questions, opportunities to revisit concepts, and timely feedback. These affordances fit the capabilities of mobile instant messaging, particularly when the application is used to supplement rather than substitute face-to-face and laboratory instruction. In the source study, the intervention addressed introductory developmental and cell biology, including the history and current trends of cell biology, reproduction, cell division, cell differentiation, cell growth, molecular foundations of cell structure and development, organelles, proteins, and nucleic acids.

WhatsApp is a particularly relevant platform because it combines text messaging, group communication, document exchange, images, audio, short video, and asynchronous participation in a familiar interface. So (2016) evaluated WhatsApp-supported instruction in higher education and found that bite-sized materials and teacher-student interaction outside scheduled class hours could improve achievement when they supplemented conventional teaching. Pimmer et al. (2021) likewise showed that moderated WhatsApp groups could support knowledge development and professional resilience, while also warning that participation frequency should not automatically be treated as evidence of high-quality engagement. During emergency online learning, Mulyono et al. (2021) documented the use of WhatsApp as a practical support environment for university learning, emphasizing the platform's accessibility while also identifying pedagogical and interactional constraints. In Malaysia, Lee et al. (2023) reported that university students valued WhatsApp for information exchange, academic interaction, group work, and rapid knowledge sharing, although perceived benefits did not extend uniformly to every dimension of team effectiveness.

Recent Nigerian studies make the present investigation more contextually relevant. Okoli and Ukala (2025) compared WhatsApp and Google Classroom in relation to Biology interest among university students in south-east Nigeria. Ukala and Okoli (2025) subsequently examined engagement in Basic Biology using the two platforms. These studies demonstrate continuing local interest in low-cost digital environments for Biology education, while also showing that platform effects depend on the outcome being measured and the way instruction is structured. More recently, Odunuga et al. (2026) reported a quasi-experimental Cell Biology study in Nigeria in which a WhatsApp-supported group outperformed a conventional lecture group at post-test. The convergence of these studies strengthens the case for examining messaging-based support in Nigerian tertiary Biology, but it does not remove the need for careful design-specific interpretation.

The distinction between structured academic use and unstructured social-media use is central to the theoretical rationale. Meta-analytic evidence on general social-network use has identified small negative associations with academic achievement in many contexts (Huang, 2018; Liu et al., 2017). A more recent synthesis by Kuş (2025) similarly found weak negative associations between several forms of problematic or intensive technology use and academic performance. These findings are not inconsistent with positive instructional effects. They suggest that the educational value of a platform depends on task purpose, moderation, content structure, and boundaries around use. A WhatsApp group that distributes concise learning materials, prompts discussion, and provides feedback is pedagogically different from unrestricted social messaging during study time.

A useful theoretical interpretation combines constructivist learning with self-regulated access to instructional resources. Constructivist approaches emphasize that learners do not acquire complex scientific understanding through exposure alone. They organize new information, compare it with prior knowledge, articulate explanations, receive feedback, and revise their understanding. A moderated messaging environment can support those processes when the lecturer uses it for questions, explanations, peer exchange, and purposeful follow-up. The platform can also create a persistent record of explanations that students can revisit after a classroom session. This persistence may be valuable in Biology, where students often need to connect verbal descriptions to sequences, structures, and causal relations rather than memorize isolated definitions.

Self-regulated learning provides a complementary lens. Mobile access gives students greater control over when they revisit a resource, but greater access also shifts responsibility toward planning, attention management, and task completion. The same notification system that reminds a student about an assignment can also interrupt concentrated study. The pedagogical challenge is therefore to provide flexibility without creating continuous cognitive intrusion. Sophonhiranrak (2021) identifies learning management and learner readiness as central to effective mobile learning, while Okai-Ugbaje et al. (2022) emphasize contextual design in resource-constrained environments. Together, these perspectives suggest that successful WhatsApp learning depends on a managed relationship among content, interaction, timing, access, and learner autonomy.

The present study did not directly measure constructivism, self-regulation, cognitive load, social presence, or engagement as mediators. These concepts are used only to interpret plausible instructional mechanisms. This distinction is methodologically important. A positive achievement difference cannot demonstrate which psychological process produced that difference unless the process itself is measured. The revised paper therefore keeps the theoretical claims proportional to the evidence: the intervention combined repeated access, messaging, assignments, discussion, and support, and those features are consistent with established mobile-learning principles, but the study only measured the reported Biology performance outcome.

The source manuscript was motivated by concerns about undergraduate Biology performance and by the practical difficulty of providing sufficient explanation, follow-up, and access to materials within conventional lecture periods. It described large classes, limited time, uneven opportunities for feedback, and difficulties experienced by students who miss classes. It also noted that smartphones and WhatsApp were already common in students' everyday communication. The intervention therefore used an existing communication channel as a structured learning extension. Rather than treating technology as an end in itself, the study tested whether guided WhatsApp-supported learning was associated with better performance than conventional instruction alone.

The revised article addresses three linked questions. First, were the experimental and comparison groups similar in Biology performance before treatment? Second, how did performance change from pre-test to post-test within each instructional condition at the descriptive level? Third, did the groups differ in post-test performance after the six-week intervention? The source draft also listed an objective concerning the interaction between instructional condition and gender. However, no gender-disaggregated sample counts, means, standard deviations, or inferential results were supplied. That objective is therefore not tested or reconstructed in this revision. Excluding an unsupported analysis is preferable to generating an apparent result without data.

The study was guided by two null hypotheses retained from the source records: (H01) there is no statistically significant difference in pre-test Biology performance between undergraduates assigned to the WhatsApp Learning Platform and conventional groups; and (H02) there is no statistically significant difference in post-test Biology performance between the two groups. The contribution of the present revision lies not in changing the reported study, but in organizing it as an IMRaD article, strengthening the statistical reporting with confidence intervals and standardized between-group effects that can be reconstructed from the supplied aggregate statistics, and situating the findings within verified mobile-learning literature. All additional calculations are explicitly identified so that the boundary between reported data and editorial statistical reconstruction remains transparent.

2. Methods

2.1 Research design

The study used a two-group quasi-experimental pre-test-post-test control-group design. The experimental group received the WhatsApp Learning Platform intervention, while the comparison group received conventional face-to-face instruction. Both groups completed the Biology Performance Test before and after the six-week treatment period. The design is quasi-experimental because the submitted records do not document individual random assignment to conditions. This distinction is important. Pre-test similarity can reduce concern about initial achievement differences, but it cannot remove all threats from selection, unmeasured confounding, instructor effects, differential exposure, or other baseline characteristics that were not recorded in the material supplied for editorial revision.

The design can be represented as follows: experimental group, O1-X-O2; comparison group, O1-C-O2. O1 denotes the pre-test, O2 denotes the post-test, X denotes structured WhatsApp-supported instruction, and C denotes the conventional instructional condition. The primary outcome was Biology performance as represented by the reported Biology Performance Test scores.

2.2 Study setting, population, and sample

The submitted manuscript consistently frames the purpose, population, and delimitation of the study around public universities in Ekiti State, Nigeria. It reports a target population of 1,219 undergraduates studying Biology Education and identifies 200-level students as the participants selected for treatment because they were available during the instructional period and were not engaged in teaching practice or undergraduate project work. The analytic sample comprised 200 students: 108 in the WhatsApp Learning Platform condition and 92 in the conventional condition.

The source documentation contains two inconsistencies that cannot be responsibly resolved without the original field records. One sentence in the sampling subsection refers to two public universities in Ondo State, although the title, purpose, population, problem statement, and delimitation refer to Ekiti State. The same subsection also refers once to three universities despite describing a two-university sample. No university names or allocation records were provided. The revised article therefore reports the state-level setting supported by the dominant study documentation, retains the verified analytic group sizes, and does not invent institutional identities. Before formal publication, the author should reconcile the state and institution-count statements against the original sampling log.

Purposive sampling was used according to the source manuscript. The stated rationale was curricular comparability: participating students were taking Introductory Developmental and Cell Biology (BIO 205), with little reported variation in course content and academic calendar. Because purposive sampling does not yield a probability sample, generalization should be limited to students and settings reasonably similar to those represented in the study.

2.3 Instructional content and intervention

The treatment lasted six weeks and was organized around three stages: pre-treatment, treatment, and post-treatment. Before treatment, both groups completed the Biology Performance Test to establish baseline performance. During treatment, the experimental group used WhatsApp to receive lecture materials, notes, assignments, reminders, and discussion prompts. The platform also provided a channel for academic discussion and technical support. Research assistants were reported to monitor participation, remind students about assignments, and provide technical guidance when needed. The comparison group continued with conventional face-to-face instruction.

The Biology content covered introductory developmental and cell biology. The source record lists the history and current trends of cell biology, reproduction, cell division, cell differentiation, cell growth, the molecular basis of cell structure and development, organelles, proteins, and nucleic acids. These topics provide a plausible instructional rationale for supplementary mobile support because students may need repeated access to explanations and visual or textual resources. However, the source file does not provide a week-by-week lesson plan, message archive, dosage measure, attendance log, or fidelity checklist. The revision therefore does not claim a standardized number of WhatsApp posts, files, or interaction minutes.

The pedagogical role of WhatsApp is interpreted as structured extension rather than technological replacement. This interpretation is consistent with So (2016), who used mobile instant messaging to supplement classroom learning through concise instructional materials and interaction, and with the broader mobile-learning literature that emphasizes alignment between technology and learning design (Crompton & Burke, 2018; Sophonhiranrak, 2021). In the present study, the platform's instructional functions were distribution, reinforcement, interaction, assignment support, and access beyond scheduled class periods.

Table 1. Study design, participants, intervention, and measurement characteristics.

Component	WhatsApp Learning Platform	Conventional condition	Evidence boundary

Analytic sample	n = 108	n = 92	Reported group sizes; total N = 200
Participant level	200-level Biology Education undergraduates	200-level Biology Education undergraduates	State-level setting reported as Ekiti State; institution details require author verification
Course content	BIO 205 introductory developmental and cell biology	Same course domain reported	Topics include reproduction, cell division, differentiation, cell growth, organelles, proteins, and nucleic acids
Duration	Six weeks	Six weeks	Three stages: pre-treatment, treatment, post-treatment
Delivery	WhatsApp-supported lectures, notes, assignments, discussion, reminders, technical guidance	Conventional face-to-face instruction	Message dosage and fidelity logs not supplied
Outcome	Biology Performance Test	Biology Performance Test	30 items; reported test-retest reliability = 0.82; reported score scale needs clarification

Note. All entries are limited to information supported by the submitted manuscript. Institutional sampling details and the BPT score transformation require author verification.

2.4 Biology Performance Test

One instrument, the Biology Performance Test (BPT), was used to assess performance. The source manuscript describes 30 single-answer items based on the BIO 205 course outline. Section A collected personal information, while Section B contained the achievement items. Each correct response received one mark and an incorrect response received zero. The test was subjected to face and content review by three experts in Science Education and Test Measurement and Evaluation. The submitted document states that the reviewers' comments were used to refine clarity, relevance, and alignment with the study objectives.

Reliability was assessed through pilot administration to students with characteristics similar to the target sample who were not part of the main study. A test-retest procedure yielded a reported reliability coefficient of 0.82. The source file does not provide the pilot sample size, retest interval, coefficient type, item-level statistics, or validity indices. These missing details should be added from the original instrument-development records if available.

A further measurement issue requires explicit disclosure. The BPT is described as a 30-item dichotomously scored test, yet the reported group means range from 54.80 to 75.60, which exceeds the maximum raw score of 30. The most plausible explanation is that raw scores were transformed to another scale, such as percentages, but the transformation formula is not documented in the supplied manuscript. The present article therefore refers to these values as reported BPT score units rather than asserting a percentage scale. This inconsistency does not affect the arithmetic of the between-group comparisons performed on the supplied means and standard deviations, but it does limit interpretation of the absolute score level. Author clarification is required before the score can be labeled as a percentage.

2.5 Procedure

At the pre-treatment stage, research assistants administered the BPT to both groups and clarified instructions to support uniform understanding. During the six-week treatment stage, students in the experimental condition used the WhatsApp Learning Platform for instructional communication and learning activities, whereas students in the comparison condition continued with the conventional teaching method. At the post-treatment stage, both groups completed the BPT again. The source manuscript does not state whether the same item order was used at both administrations, whether test forms were parallel, whether assessors were blinded to condition, or whether there was attrition. Because the reported post-test group sizes sum to the full analytic sample of 200, the revision uses those counts but does not infer a zero-attrition process without participant-flow records.

2.6 Data analysis and editorial statistical reconstruction

The original analysis plan used means and standard deviations to answer the descriptive research question and independent-samples t-tests to test the two reported hypotheses at alpha = .05. The present revision retains those analyses. Baseline and post-test mean differences were also expressed with 95% confidence intervals. Standardized between-group effects were reconstructed from the reported sample sizes, means, and standard deviations using the pooled standard deviation. Hedges' g was reported because it applies a small-sample correction to Cohen's d and is useful for cumulative evidence synthesis (Lakens, 2013).

For two independent groups, the standard error of the mean difference was calculated from the group standard deviations and sample sizes. Confidence intervals used the t distribution with 198 degrees of freedom, matching n1 + n2 - 2. Cohen's d used the pooled standard deviation, and Hedges' g applied the conventional correction factor. These computations can be reproduced from the aggregate values in Table 2. No paired-sample effect size was calculated for within-group change because the correlation between pre-test and post-test scores, or the standard deviation of individual change scores, was not provided. Computing such an effect without the required dependence information would create false precision.

The source draft reports the post-test result as $t = 6.56$, $df = 198$, $p = .0001$. Recalculation from the supplied group summaries reproduces $t = 6.56$ but yields a probability far below .001. Because an exact original software output is unavailable, the result is reported conservatively as $p < .001$. At baseline, recalculation yields $t = 0.34$ and $p = .732$, which is consistent with the source report of $p = .73$.

A stronger analysis of a pre-test-post-test quasi-experiment would ordinarily consider a post-test regression or analysis of covariance with baseline performance as a covariate, provided model assumptions and participant-level data can be assessed. Raw data were not supplied for this revision, so ANCOVA, multilevel modeling, subgroup analysis, and robustness checks were not reconstructed. The article therefore makes only the claims supported by the reported aggregate statistics.

2.7 Data-integrity boundaries

The editorial revision follows a conservative data-integrity rule: no student-level value, demographic distribution, institution name, intervention dosage, gender effect, ethics approval number, funding source, or missing-data mechanism was created when it was absent from the source records. Statistical additions are limited to quantities mathematically recoverable from the reported n, mean, and standard deviation values. This approach preserves the empirical core of the study while clearly identifying documentation that the author should verify before the article enters production.

3. Results

3.1 Baseline performance

The pre-test results indicate that the two instructional groups began the study with very similar reported Biology performance. The WhatsApp Learning Platform group had a pre-test mean of 55.20 (SD = 8.50), while the conventional group had a mean of 54.80 (SD = 7.90). The mean difference was 0.40 score units. The independent-samples comparison was not statistically significant, $t(198) = 0.34$, $p = .732$. The 95% confidence interval for the difference extended from -1.90 to 2.70, and the reconstructed Hedges' g was 0.05. Both the interval estimate and standardized effect indicate a negligible baseline difference in the measured outcome.

This finding supports rejection of any claim that the groups were already separated by a large achievement difference on the measured pre-test. It does not prove equivalence on unmeasured characteristics, because the design was non-randomized and the source material contains no information about prior GPA, age distribution, socioeconomic status, device access, instructor assignment, or other potential confounders. Baseline similarity is therefore treated as evidence about the measured outcome only.

3.2 Descriptive change from pre-test to post-test

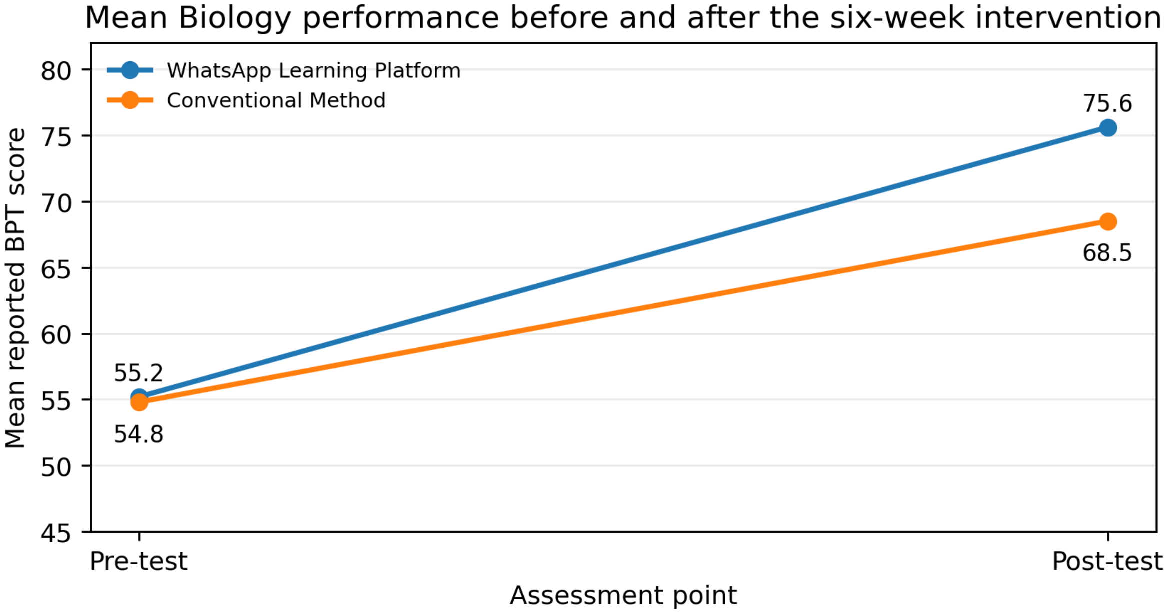
Both groups improved over the six-week period. The WhatsApp group increased from 55.20 to 75.60, producing a raw mean gain of 20.40 reported score units. Relative to its own pre-test mean, this corresponds to an approximate descriptive increase of 37.0%. The conventional group increased from 54.80 to 68.50, a raw gain of 13.70 units, corresponding to an approximate descriptive increase of 25.0%. These percentages are descriptive ratios derived from group means and should not be interpreted as individual-level percentage improvement.

Table 2. Descriptive Biology performance before and after the six-week intervention.

Group	N	Pre-test M	Pre-test SD	Post-test M	Post-test SD	Raw gain	Approx. gain (%)
WhatsApp Learning Platform	108	55.20	8.50	75.60	7.20	20.40	36.96
Conventional Method	92	54.80	7.90	68.50	8.10	13.70	25.00

Note. Gain percentages are descriptive ratios based on group means: (post-test mean − pre-test mean) / pre-test mean × 100. They are not individual-level percentage changes.

Figure 1. Mean reported Biology Performance Test scores at pre-test and post-test.



Source: Graph constructed from the aggregate means reported in the submitted study.

Table 3. Independent-group comparisons and reconstructed effect-size estimates.

Comparison	**Mean difference**	**SE**	**95% CI**	**t**	**df**	**p**	**Hedges' g**
Pre-test: WLP – conventional	0.40	1.17	[-1.90, 2.70]	0.34	198	.732	0.05
Post-test: WLP – conventional	7.10	1.08	[4.97, 9.23]	6.56	198	< .001	0.93

Note. Confidence intervals and Hedges' g were reconstructed editorially from the reported n, mean, and SD values. The original post-test p value is reported more conservatively as p < .001 because the summary-statistic recalculation yields a probability below .001.

The difference in raw mean gains was 6.70 score units in favor of the WhatsApp group. Because the source records do not provide the variance of individual change scores or the pre-test-post-test correlation, an inferential test of the difference in gains is not reconstructed. The line graph in Figure 1 is therefore descriptive. It shows that the two groups start from almost the same mean and diverge by post-test, with a steeper increase in the WhatsApp-supported condition.

3.3 Post-test comparison

At post-test, the WhatsApp group obtained a mean of 75.60 (SD = 7.20), compared with 68.50 (SD = 8.10) in the conventional group. The between-group mean difference was 7.10 score units. The independent-samples t-test was statistically significant, $t(198) = 6.56$, $p < .001$. The 95% confidence interval for the mean difference ranged from 4.97 to 9.23. Because the interval excludes zero and remains substantively positive across its plausible range, the aggregate evidence is consistent with higher post-test performance in the WhatsApp-supported group.

The standardized post-test difference was Cohen's $d = 0.93$ and Hedges' $g = 0.93$ after small-sample correction. These statistics indicate that the observed post-test separation was large relative to the pooled within-group standard deviation. The standardized effect should nevertheless be interpreted as an effect estimate from a quasi-experimental comparison, not as an unbiased causal parameter. Selection, intervention fidelity, instructor effects, and unmeasured baseline characteristics cannot be ruled out using the available data.

3.4 Hypothesis decisions

The first null hypothesis, which proposed no significant pre-treatment difference between the groups, was not rejected because $p = .732$. The second null hypothesis, which proposed no post-treatment difference between the WhatsApp Learning Platform and conventional conditions, was rejected because $p < .001$. The statistical results therefore show a pattern of baseline similarity followed by a substantial post-test difference favoring the WhatsApp-supported group.

No inferential result is reported for gender. Although the source manuscript listed gender interaction as an objective, it did not supply group-by-gender sample sizes, descriptive statistics, or an interaction test. Reporting a gender conclusion in the absence of those data would be unsupported.

4. Discussion

4.1 Principal finding

The central finding is straightforward: students in both conditions improved, but the group receiving structured WhatsApp-supported instruction showed a larger descriptive gain and a substantially higher post-test mean. The groups were almost indistinguishable on the measured pre-test, while the post-test difference was 7.10 reported score units with a 95% confidence interval from 4.97 to 9.23 and a reconstructed Hedges' g of approximately 0.93. Within the limits of a non-randomized design, this pattern is consistent with an educational benefit from extending Biology instruction through a structured mobile instant-messaging environment.

The result aligns with the broader mobile-learning evidence without requiring the stronger claim that any use of a smartphone will improve learning. Sung et al. (2016) found an overall positive effect of mobile-device integration across experimental and quasi-experimental studies, while Crompton and Burke (2018) showed that achievement has been a major focus of mobile-learning research in higher education. The present finding contributes a Nigerian Biology context to that evidence. Its importance lies in the combination of an accessible platform, discipline-specific instruction, and a pre-test-post-test comparison rather than in technological novelty.

The result is also consistent with platform-specific research. So (2016) reported improved achievement when WhatsApp delivered concise materials and supported interaction beyond classroom hours. Pimmer et al. (2021) found that moderated WhatsApp groups can support knowledge-related outcomes, although they cautioned against equating message frequency with learning quality. Mulyono et al. (2021) showed how WhatsApp could sustain online learning and communication when more formal systems were difficult to use. Lee et al. (2023) found that students perceived WhatsApp as useful for academic engagement, group projects, and rapid knowledge exchange. Taken together, these studies suggest that the platform's educational contribution comes from instructional organization, access, interaction, and reinforcement rather than from the application as a neutral communication tool.

4.2 Why WhatsApp may have supported Biology learning

Several plausible mechanisms connect the intervention to the observed pattern, although the present aggregate data cannot isolate their individual effects. First, WhatsApp can extend access to learning resources beyond scheduled lecture time. Biology students can reopen explanations, images, notes, and assignments when revising complex material. This temporal flexibility is particularly relevant for concepts such as cell division, molecular structure, organelle function, and developmental processes, where a single classroom explanation may not be sufficient.

Second, mobile messaging can increase the frequency of low-threshold academic interaction. Students who may hesitate to interrupt a lecture can ask a short question in a group, respond to peers, or revisit a lecturer's clarification later. Such interaction is compatible with a constructivist view of learning in which knowledge is elaborated through guided activity, explanation, and social exchange. The source study specifically describes notes, assignments, discussions, reminders, and technical guidance, which means the intervention included more than passive file distribution.

Third, the platform can support retrieval and spacing if learning prompts are distributed across time. A short question sent after a lesson can require students to recall rather than merely reread information. A discussion about a diagram can encourage explanation. An assignment reminder can improve task completion. These mechanisms are plausible instructional functions, but the source records do not provide message-level content or activity logs. They should therefore be treated as design interpretations, not as measured mediators.

Fourth, familiarity can reduce the technical burden of participation. Students do not need to learn an unfamiliar interface before they can access content or communicate. Sophonhiranrak (2021) emphasized readiness and support as important determinants of mobile-learning implementation. In resource-constrained contexts, Okai-Ugbaje et al. (2022) argued that sustainable mobile learning must reflect local infrastructure and socioeconomic realities. An application already embedded in students' communication practices may therefore lower access friction compared with a platform that requires higher bandwidth, repeated browser access, or more complex account management.

4.3 Relevance to Nigerian university Biology education

The study is particularly relevant because recent Nigerian evidence has moved beyond generic attitudes toward more discipline-specific comparisons. Okoli and Ukala (2025) examined Biology interest under Google Classroom and WhatsApp conditions. Ukala and Okoli (2025) compared engagement in Basic Biology. These studies show that WhatsApp can function as a serious instructional condition in Nigerian university research, while also demonstrating that outcomes such as interest, engagement, and achievement should not be assumed to respond identically. A platform may be convenient but less effective than another platform for organizing tasks, or it may increase participation without producing the same magnitude of achievement change.

Odunuga et al. (2026) provide an especially relevant comparison because their work also involved Cell Biology and a WhatsApp-supported classroom extension in a Nigerian tertiary setting. Their reported post-test pattern favored the WhatsApp-supported group. The present study is consistent with that direction and uses a larger analytic sample of 200. However, the two studies should not be treated as direct replications without comparing course level, assignment procedures, teaching personnel, assessment construction, baseline imbalance, and intervention intensity. Convergence across settings strengthens plausibility, but effect magnitudes remain design-specific.

For Nigerian universities, the practical appeal of WhatsApp is partly infrastructural. Mobile access can be more feasible than computer-dependent online learning, especially where network stability, institutional learning-management systems, and student device resources vary. Yet low entry cost is not the same as low pedagogical cost. Lecturers still need to organize content, define response expectations, moderate discussions, protect private time, and ensure that essential materials remain accessible to students with intermittent connectivity. Technology can redistribute workload rather than eliminate it.

4.4 Structured academic use versus unrestricted social-media use

A useful interpretation of the finding emerges from comparing instructional WhatsApp use with the literature on general social-media use. Huang (2018) synthesized 30 studies and found a small negative average association between social-network use and academic achievement. Liu et al. (2017), using a much larger pooled sample, also reported an overall negative relation between social-network-site use and academic performance. Kuş (2025) found weak negative associations for several technology-related risk factors, including problematic smartphone use. These studies are often cited as evidence that social media harms learning, but that conclusion is too broad for the present context.

The relevant distinction is purpose and structure. General use may displace study time, encourage multitasking, or introduce frequent attention shifts. Instructional use can instead direct the same communication channel toward course materials, questions, feedback, and peer explanation. Lee et al. (2023) illustrate this dual character: students valued WhatsApp for academic communication but also recognized potential concentration and language-quality concerns. Therefore, universities should not simply encourage more WhatsApp use. They should design bounded academic use that minimizes the conditions under which messaging becomes distraction.

Practical safeguards follow from this distinction. Lecturers can establish posting windows, use concise and clearly labeled materials, separate administrative messages from learning tasks, summarize important discussion threads, and avoid requiring immediate responses late at night. They can provide downloadable documents that remain usable offline and avoid making essential assessment information dependent on a fast-moving chat history. Where possible, the WhatsApp group can be paired with a more stable repository for final course files. These strategies transform the platform from a stream of messages into a managed instructional extension.

Table 4. Evidence-informed safeguards for instructional use of WhatsApp in higher education.

Implementation issue	Evidence-informed risk	Recommended instructional safeguard
Connectivity and data cost	Mobile access can remain unequal in resource-constrained settings (Okai-Ugbaje et al., 2022; Sophonhiranrak, 2021).	Use low-bandwidth files, downloadable resources, reasonable deadlines, and an alternative access route.
Message overload	Continuous streams can obscure key academic content and increase cognitive/attention burden.	Use labeled posts, scheduled learning windows, weekly summaries, and a stable repository for final course files.
Distraction and multitasking	General social-network use has small negative associations with achievement in meta-analytic research (Huang, 2018; Liu et al., 2017).	Separate academic tasks from social chat, limit notifications, and specify when students are expected to engage.
Lecturer availability	Instant messaging can create an expectation of immediate, continuous response.	Publish response hours, use FAQs or pinned summaries, and distribute moderation across planned sessions.
Equity and digital readiness	Learning benefits depend on readiness and support, not device access alone (Sophonhiranrak, 2021).	Provide orientation, technical support, and non-phone alternatives for essential learning materials.

Assessment alignment	High activity in a chat does not necessarily represent deep learning (Pimmer et al., 2021).	Connect prompts and discussions directly to course outcomes and use independent assessment of learning.

Note. The table synthesizes implications from cited literature and is not a record of additional intervention components in the present study.

4.5 Interpreting the effect size responsibly

The post-test Hedges' g of about 0.93 is large relative to the pooled within-group variability, but several cautions are required. First, the standardized effect is reconstructed from summary statistics rather than calculated from raw data. The arithmetic is reproducible, but participant-level diagnostics are not possible. Second, the groups were not documented as randomly assigned. Even with similar pre-test achievement, unmeasured differences could contribute to post-test outcomes. Third, the source file does not document whether the same lecturer taught both groups, whether contact time was equal, whether students received equivalent assignments, or whether access to additional materials differed outside the planned intervention.

Fourth, a post-test t-test does not fully exploit a pre-test-post-test design. A well-specified ANCOVA or regression model can increase precision and adjust for individual baseline scores, but such an analysis requires raw records and assumption checking. The present revision deliberately does not simulate that analysis. Fifth, the BPT scale requires clarification because a 30-item instrument is reported alongside means above 30. If scores were converted to percentages, the transformation should be documented; if a different scoring rule was used, that rule should be stated. These issues do not erase the observed group difference, but they narrow the strength of the inference.

Effect-size reporting is nonetheless valuable because a p value alone does not show the magnitude of an observed difference. Lakens (2013) recommends reporting standardized effects in forms that allow future comparison and meta-analysis. By providing Hedges' g and a confidence interval for the raw mean difference, the revised article makes the available evidence more informative while keeping the calculation traceable to the original aggregate data.

4.6 Implications for teaching practice

The findings support a supplementary model of mobile learning. Biology lecturers can use WhatsApp to extend, reinforce, and organize face-to-face teaching, particularly when institutional e-learning infrastructure is limited. The platform is well suited to short concept summaries, annotated diagrams, reminders, discussion prompts, formative questions, peer explanations, and links to stable learning resources. It is less suitable as the sole repository for a complex course because message streams are difficult to archive pedagogically and because access can be interrupted by device or network constraints.

Course design should begin with learning objectives, not application features. For cell biology, for example, a lecturer might use a post-class prompt asking students to distinguish mitosis from meiosis, a labeled image requiring identification of organelles, or a short explanation task connecting protein synthesis to cellular function. These activities can be delivered through WhatsApp, but their educational value comes from alignment with the intended learning outcome and from feedback. Sending large quantities of files without structured tasks can create information overload rather than learning.

Universities should also support lecturers. Mobile learning can create expectations of continuous availability, especially when students interpret a messaging application as an always-open channel. Institutional guidance can define appropriate communication hours, data-protection practices, assessment boundaries, accessibility alternatives, and procedures for students who cannot reliably use a smartphone. Staff development should address instructional design and moderation, not only technical operation.

A minimum design standard can make these recommendations operational. Before a course begins, the lecturer should identify which learning outcomes genuinely benefit from mobile extension and which still require laboratory, face-to-face, or formally assessed activity. During each instructional week, WhatsApp tasks should be limited to a manageable set of functions, such as one concept explanation, one formative prompt, one discussion task, and one administrative reminder. Important resources should have consistent file names and should be archived outside the chat stream when possible. Discussion rules should distinguish academic questions from social messages and should state expected response times. These simple design decisions reduce the probability that useful course information will be buried in conversational traffic.

Assessment should also remain independent enough to test learning rather than platform activity. Message counts, emoji responses, or visible participation can be useful process indicators, but they should not substitute for evidence that students understand Biology. Pimmer et al. (2021) caution that frequency of participation is an imperfect proxy for quality. A student may read carefully without posting frequently, while another may post often without developing accurate conceptual understanding. For this reason, formative activity in WhatsApp should feed into independent quizzes, written explanations, practical tasks, or examinations that directly represent the intended learning outcome.

Equity requires a similar level of design attention. Students can differ in data availability, smartphone quality, storage capacity, electricity access, and the privacy of their home learning environment. A lecturer who assumes uninterrupted connectivity may unintentionally convert a low-cost platform into a barrier. Resource-constrained mobile learning is stronger when materials are compact, deadlines allow for intermittent access, essential content can be downloaded, and students have a way to obtain the same information if they cannot participate synchronously. Okai-Ugbaje et al. (2022) place this contextual fit at the center of sustainable mobile learning. The present study does not measure these equity variables, so they remain implementation priorities for subsequent trials rather than demonstrated features of the intervention.

Finally, the strongest implementation model is likely to be blended rather than platform-exclusive. Biology includes conceptual, visual, quantitative, and practical knowledge. Messaging can reinforce conceptual understanding and maintain communication, but it cannot reproduce every learning experience available in a laboratory or a well-designed face-to-face session. The practical implication of the present result is therefore not to move BIO 205 into WhatsApp. It is to use a familiar mobile channel strategically where it can add access, reinforcement, and interaction to the core course.

4.7 Implications for research

Future research should improve both design rigor and reporting completeness. Randomized assignment may not always be feasible in university courses, but researchers can use intact-class randomization, matched comparison groups, or transparent covariate adjustment when raw data are available. Pre-registration of hypotheses and analysis plans would help distinguish planned analyses from exploratory findings. Participant flow should report recruitment, allocation, attrition, and missing data. Intervention fidelity should record the number and type of instructional posts, assignments, discussion sessions, student access patterns, and lecturer contact time.

Measurement also needs strengthening. The BPT should be reported with a clear scoring range, sample items or a blueprint, item difficulty and discrimination where available, reliability procedures, and evidence of content alignment. If scores are transformed, the formula must be stated. Repeated use of an identical test may introduce practice effects, so parallel forms or item-order procedures should be documented. Longer-term retention tests would show whether mobile support produces durable understanding rather than a short-term post-test advantage.

Future studies should also separate achievement from engagement, interest, collaboration, and self-regulation. The Nigerian studies by Okoli and Ukala (2025) and Ukala and Okoli (2025) illustrate the value of examining multiple outcomes. A platform can improve one dimension and have little effect on another. Mediation analysis could test whether engagement, time-on-task, feedback frequency, or self-regulated learning explains achievement differences. Such analyses require valid measures and participant-level data.

4.8 Limitations

This study has several limitations. The first is the quasi-experimental, non-randomized design. Baseline achievement was similar, but unmeasured group differences remain possible. The second is the absence of participant-level data in the material available for this revision. That restriction prevents ANCOVA, paired change analysis, distributional diagnostics, subgroup analysis, missing-data evaluation, and sensitivity checks.

Third, the submitted source contains unresolved documentation inconsistencies concerning the state named in one sampling sentence and the number of participating universities. The broader manuscript consistently identifies Ekiti State, but the original sampling log should be consulted before publication. Fourth, the BPT is described as a 30-item dichotomous test while the reported means exceed 30. The score transformation was not documented. Fifth, the source material does not provide gender-disaggregated results even though gender interaction appeared in an original objective. No gender conclusion is therefore made.

Sixth, intervention fidelity and dosage were not quantified. The study reports that WhatsApp was used for lectures, notes, assignments, discussions, reminders, and technical support, but it does not report message counts, duration of participation, access frequency, or equality of instructional time. Seventh, the study measures immediate post-treatment performance and does not report delayed retention, transfer, course grades, or laboratory performance. Finally, ethics approval details, consent procedures, funding information, conflict-of-interest declarations, and data-sharing arrangements were not included in the source manuscript and must be completed by the author before publication.

5. Conclusion and Recommendations

The study provides evidence that a structured WhatsApp-supported learning condition was associated with higher post-test Biology performance than conventional instruction among the 200 undergraduates represented in the submitted data. The two groups began with nearly identical pre-test means, but the WhatsApp group showed a larger descriptive increase and finished 7.10 reported score units above the conventional group. The post-test difference was statistically significant, its confidence interval was clearly positive, and the reconstructed standardized effect was substantial.

The finding supports a practical conclusion rather than a technological one. WhatsApp can be useful when it is deliberately integrated with academic content, feedback, discussion, and access to resources. The platform should function as an extension of classroom and laboratory teaching, not as a substitute for the forms of explanation, observation, practical work, and assessment that Biology requires. The value of the intervention depends on instructional design, moderation, student access, and boundaries that protect attention and equitable participation.

Three recommendations follow. First, Biology lecturers who use WhatsApp should organize it around specific learning objectives and concise, retrievable activities. Discussion prompts, diagrams, short formative questions, assignment guidance, and targeted clarification are preferable to unstructured message volume. Second, universities should provide guidance on mobile-learning design, lecturer workload, communication hours, accessibility, data protection, and alternative access for students with connectivity or device constraints. Third, future evaluations should use stronger experimental controls, transparent participant flow, clearly documented assessment scales, intervention-fidelity measures, and participant-level analysis that adjusts for baseline achievement.

Before publication, the author should verify the institutional sampling details, explain the BPT score transformation, provide the missing ethics and consent information, and supply any gender analysis only if the original data support it. These checks are essential because a well-presented result is not sufficient on its own. Reproducible documentation is part of the evidence. With those clarifications, the study can make a useful contribution to the growing literature on mobile-supported science learning in Nigerian higher education.

6. Authors and Ethics Statement

Author identification and contribution. The source DOCX metadata identifies ONIYA TOLUWANI (DR) as the document author and last modifier. The manuscript body, however, does not provide an author byline, institutional affiliation, email address, ORCID, or CRediT contribution statement. This production version therefore uses the provisional byline "Toluwani Oniya" and leaves affiliation and correspondence fields for author confirmation. Formal publication should not proceed until the author verifies the spelling and order of all authors, institutional affiliations, corresponding-author details, and specific contributions.

Ethics approval and participant consent. The study involved university undergraduates and experimental instructional procedures, but the submitted manuscript does not state the name of an ethics committee or institutional review board, an approval/reference number, the date of approval, or the procedure used to obtain informed consent. These details must be supplied from the original study records. No ethics approval number or consent statement has been invented in this revision.

Conflict of interest. No conflict-of-interest declaration was present in the supplied manuscript. The author or authors must provide an explicit declaration before publication.

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Data availability. Participant-level data were not provided for this editorial revision. The statistical reconstruction in this article uses only the aggregate sample sizes, means, and standard deviations reported in the source manuscript. Any public or restricted data-availability statement should be determined by the author in accordance with participant consent, institutional policy, and applicable ethical requirements.

Editorial transparency. The revision reorganized the source study into IMRaD format, corrected language and statistical presentation, added confidence intervals and standardized between-group effects that are mathematically recoverable from the supplied aggregates, and replaced unsupported or unverifiable literature claims with traceable scholarly sources. It did not create missing participant data, institutional identities, gender results, ethics approvals, or intervention records.

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