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Supplementing biology instruction using the InSci4L app: Its effect on the academic performance and engagement of grade 10 participants

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Abstract

Aim: This study aimed to determine the effectiveness of the InSci4L mobile application in improving the academic performance and engagement of Grade 10 participants in Biology, particularly in learning the Central Dogma of Molecular Biology.

Methodology: The study employed a quasi-experimental pretest-posttest control group design involving 60 Grade 10 participants from Apo Macote National High School during the School Year 2025–2026. Participants were divided into an experimental group exposed to the InSci4L mobile application and a control group taught using conventional instruction. Data were gathered using pretests, posttests, and engagement measures, and were analyzed using ANCOVA to determine the effect of the intervention.

Results: Both groups demonstrated comparable prior knowledge before the intervention. After the instructional period, participants exposed to the InSci4L mobile application obtained significantly higher academic performance compared to those who received conventional instruction. The findings further revealed that the application had a significant positive effect on participants' behavioral, emotional, cognitive, and agentic engagement in Biology learning.

Conclusion: The findings indicate that mobile learning applications with interactive and simulation-based features are effective in improving participants' understanding of complex biological concepts and enhancing engagement in Biology education. The study suggests that integrating mobile-assisted instructional tools into classroom teaching may strengthen academic achievement, learner participation, and technology-enhanced science instruction.

Keywords: *InSci4L mobile application, academic performance, learner engagement, Biology education, Central Dogma of Molecular Biology, mobile-assisted learning*

INTRODUCTION

Science education in the 21st century requires teaching approaches that align with participants' cognitive development and promote active participation. Biology, in particular, presents challenges due to its abstract concepts, making student attitudes and engagement crucial for meaningful learning. As education evolves globally, there is increasing emphasis on inquiry-based and technology-supported instruction to enhance understanding and interest (Manishimwe et al., 2022).

Globally and nationally, digital technologies such as mobile applications and virtual platforms are being integrated into science education to support interactive and personalized learning (Haleem et al., 2022). In the Philippines, initiatives like the K–12 curriculum and Digital Rise Program encourage technology integration; however, student performance in science remains low, as reflected in national and international assessments (Barrot, 2021).

Traditional instruction, which relies heavily on lecture-style teaching and textbook exercises, is often inadequate at meeting students' diverse needs or at making abstract biological concepts more interesting and engaging. Traditional instruction does not always offer opportunities for interaction, visualization, and immediate feedback, which are important for deep cognitive processing and engagement. This is why there is a cycle of poor academic performance and disengagement, as students are less able to connect theoretical knowledge with practical understanding. However, owing to these pedagogical limitations, the use of educational technology has been identified as an effective means of facilitating science education.

In practice, many Filipino participants struggle with Biology, particularly with complex topics like molecular biology, due to limited resources and reliance on traditional lecture-based instruction. These conditions often lead to low engagement, poor conceptual understanding, and weak academic performance (Molinar, 2026; Mohtar et al., 2024). The lack of interactive, visual, and context-based learning experiences further contributes to this persistent issue.

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Although mobile learning applications have shown potential to improve engagement and achievement, many existing platforms remain generic, internet-dependent, and insufficiently aligned with the Philippine science curriculum. Previous mobile learning studies have largely focused on broad science applications without emphasizing localized content, offline accessibility, and curriculum-specific instructional design (Toquero & Talidong, 2021). As a result, these applications may not fully address the contextual learning needs of Filipino students, particularly those in resource-constrained educational settings.

Unlike prior mobile learning studies that focused broadly on generalized science applications, the present study specifically investigates a localized, curriculum-aligned, offline-capable Biology application designed for Filipino Grade 10 participants. The study introduces Integrating Science For Learning (InSci4L), a mobile learning application developed to support the teaching and learning of the Central Dogma of Molecular Biology through interactive simulations, contextualized activities, visual learning supports, and self-paced offline accessibility.

What distinguishes InSci4L from existing Biology learning applications is its pedagogical structure, which integrates localized content, inquiry-based learning strategies, and learner-centered instructional design aligned with the competencies of the K–12 curriculum. The application also provides opportunities for concept visualization, immediate feedback, and active learner engagement, which are often lacking in conventional classroom instruction and existing generalized educational applications.

Furthermore, InSci4L contributes an instructional innovation by offering a context-specific and accessible digital learning environment that can function even in areas with limited internet connectivity. This localized and pedagogically aligned approach addresses gaps in accessibility, curriculum relevance, and instructional effectiveness commonly observed in existing mobile learning platforms.

To address this gap, this study examined the effect of the InSci4L mobile application on Grade 10 participants' engagement and academic performance in Biology. By evaluating a localized, offline-capable, and curriculum-aligned instructional tool, the study aimed to o contribute evidence on how context-sensitive mobile learning applications can improve Biology education in the Philippine setting.

Review of Related Literature and Studies

This chapter presents literature reviews from numerous readings. Key ideas and notions from the reviewed literature are summarized to provide insights, as well as the similarities and differences between the related and existing studies.

Technology Integration in Science

Technology has transformed science education by making learning more interactive and encouraging active student participation. Science teachers are now tasked with engaging participants in authentic inquiry practices, such as formulating questions, designing investigations, analyzing data, and constructing evidence-based explanations (Seland et al., 2023). These practices help develop critical thinking and a deeper understanding.

The integration of technology in schools has expanded significantly in recent years. Technology applications are now widely used for both instruction and organization. Gabriel et al. (2022) noted major investments in technological infrastructure, which increased broadband access for millions of students across thousands of schools, highlighting the growing role of digital tools in education.

Technology tools enhance science learning by enabling simulations, real-time data analysis, and visualization of complex concepts (Yilmaz, 2023). These tools support constructivist learning theories, where knowledge is built through experience and social interaction (Piaget, 1954; Vygotsky, 1978). Technology-rich environments also promote active engagement and inquiry-based learning (Pedapati, 2022).

In Biology, technology is especially valuable for visualizing abstract processes such as cellular and molecular interactions. Studies show that technology-supported instruction improves understanding and academic performance (Sangur et al., 2025; Nurdin et al., 2025).

Recent research highlights the effectiveness of advanced technologies in science education. Artificial Intelligence (AI), augmented reality, and blended learning improve engagement and performance, although challenges such as access, teacher readiness, and implementation persist (Almasri, 2024; Farooq et al., 2024; Ramaila & Molwele, 2022; Yopi, 2024).

Despite research showing that technology-enhanced instruction improves engagement and academic performance in science education, limitations such as unequal access, teacher readiness, and the lack of studies on specific applications remain (Almasri, 2024; Farooq et al., 2024). In particular, few studies have examined the impact of the InSci4L app on both academic performance and student engagement among Grade 10 Biology participants. Thus, the present study contributes to the literature by exploring how InSci4L supports inquiry-based learning, learner participation, and improved Biology learning outcomes.

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Mobile Learning and Educational Applications

Mobile learning refers to education conducted via mobile devices like smartphones and tablets, enabling learning anytime and anywhere across formal and informal contexts. It uses apps and connectivity to support content access, interaction, and just-in-time learning, with educational applications providing instruction, practice, assessment, feedback, and collaboration (Rangel-de Lázaro & Duart, 2023; Rocque, 2022).

Recent research identifies mobile learning as a major educational development, emphasizing flexibility, mobility, and diverse learning contexts rather than the devices themselves. It is viewed as a key component of modern education that supports personalized learning, though it should complement—not replace—traditional instruction and be carefully designed to meet student needs (Criollo et al., 2021; Rangel-de Lázaro & Duart, 2023).

Empirical evidence shows that mobile learning improves academic achievement across subjects and levels (Güler et al., 2021; Yang & Xiang, 2024). Studies report gains in knowledge and skills in medical education (Chandran et al., 2022) and improved language learning through personalized apps. Mobile apps also enhance motivation, cognitive skills, and independence, with gamified tools increasing engagement, grades, and retention, though practical skill development depends on effective integration and access (James et al., 2024; Wu & Jiang, 2025; Partsei et al., 2025).

Students generally have positive attitudes toward mobile learning due to its flexibility and accessibility, and many see apps as effective study tools (Bahador, 2025). It can boost engagement and motivation, especially when interactive and gamified, but challenges include distractions, unequal access, and the need for quality design and institutional support (James et al., 2024; Rangel-de Lázaro & Duart, 2023; Almogren et al., 2024; Criollo et al., 2021; Partsei et al., 2025; Wu & Jiang, 2025).

Despite prior studies showing that mobile learning improves achievement, motivation, and engagement (Güler et al., 2021; Yang & Xiang, 2024), limitations remain, including unequal access, distractions, inconsistent design quality, and limited evidence on long-term, standardized implementation (Criollo et al., 2021; James et al., 2024). These gaps indicate a need for more context-specific applications aligned with curriculum goals. Addressing this, the present study examines the InSci4L app as a structured mobile learning tool for Grade 10 Biology, focusing on its contribution to student engagement and academic performance through inquiry-based learning.

This study is significant because it provides insights into how the InSci4L mobile application can enhance student engagement and academic performance in Biology through technology-enhanced instruction. The findings may help teachers integrate interactive and inquiry-based learning strategies, assist school leaders in supporting mobile learning through training and infrastructure, and guide curriculum developers in designing localized and curriculum-aligned digital instructional approaches for Biology education

Theoretical Framework

This study is grounded in four key educational theories that explain how the InSci4L app enhances biology learning: Constructivist Learning Theory, Cognitive Theory of Multimedia Learning, Mobile Learning Theory, and Engagement Theory. Constructivist Learning Theory (Piaget; Vygotsky) posits that participants actively construct knowledge through experience and social interaction, which supports the use of InSci4L's interactive simulations and learner-centered activities. The Cognitive Theory of Multimedia Learning (Mayer) emphasizes that learning is more effective when information is presented through both visual and verbal formats; this is reflected in the app's integration of animations, narration, diagrams, and quizzes to improve understanding and retention of complex biological concepts.

Mobile Learning Theory of Sharples et al. (2007) highlights the value of accessible, flexible, and personalized learning through mobile devices, aligning with InSci4L's anytime-anywhere accessibility and contextualized content. Engagement Theory (Reeve, 2012) underscores the importance of emotional, cognitive, and behavioral involvement in learning. InSci4L supports this through gamified features, interactive tasks, and immediate feedback, which promote active participation, sustained interest, and deeper learning. Together, these theories provide a strong foundation for examining how the app can improve both academic performance and student engagement.

Conceptual Framework

This study is anchored on the premise that mobile learning, particularly through the use of the InSci4L application, influences students' engagement and academic performance in Biology across multiple dimensions. Drawing from theories of student engagement, the framework views engagement as a multidimensional construct consisting of behavioral, agentic, cognitive, and emotional components. The independent variable is the use of the InSci4L mobile application, while the dependent variable is the level of student engagement. The model assumes that integrating interactive, personalized, and accessible mobile learning tools can enhance students' active participation, initiative, deeper thinking, and emotional connection to the subject.

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The framework further posits that the effectiveness of mobile learning in improving engagement is shaped by how well it supports meaningful interaction, self-directed learning, and motivation. It explains that students exposed to the mobile learning intervention are more likely to demonstrate higher levels of engagement compared to those experiencing traditional instruction alone. Thus, the relationship between the intervention and engagement outcomes highlights the role of technology-enhanced learning environments in fostering more active, motivated, and cognitively invested participants in Biology.

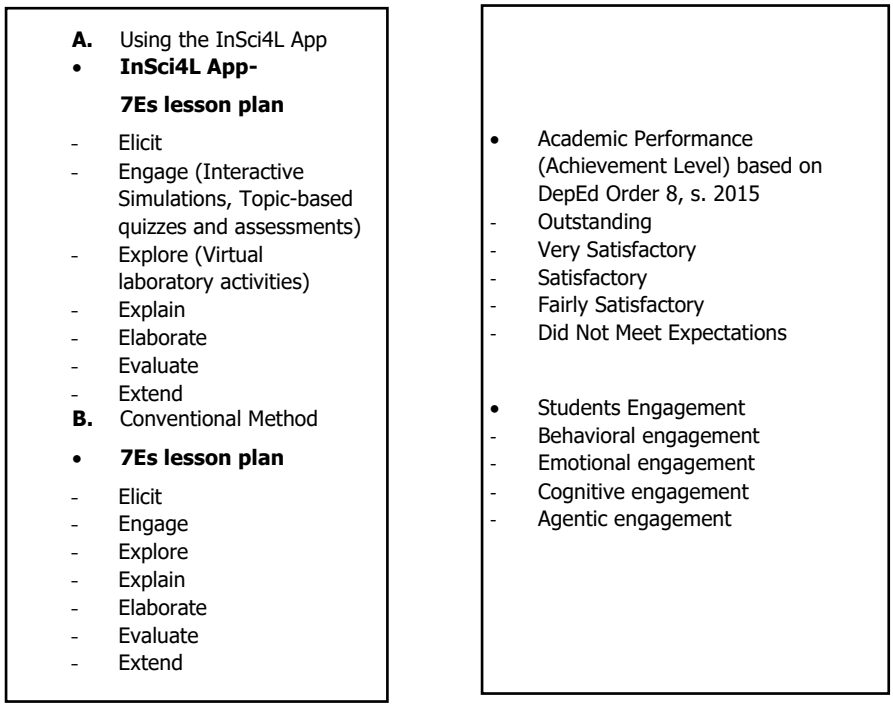

Figure 1. Schematic presentation showing the relationship between the independent and dependent variables of the study

Statement of the Problem

Many Grade 10 participants experience difficulty in learning Biology, particularly concepts that require abstract understanding, critical thinking, and sustained engagement. Traditional lecture-based instruction often limits opportunities for visualization, interaction, and active participation, which may contribute to low academic performance and reduced learner engagement in science classes. As educational institutions increasingly integrate technology-enhanced instruction, mobile learning applications are being explored as supplementary tools to improve teaching and learning processes.

Although educational technologies have demonstrated potential in enhancing learner motivation and academic achievement, there remains limited empirical evidence regarding the effectiveness of localized and curriculum-aligned mobile learning applications in Biology instruction, particularly in the Philippine public-school context. Existing studies also provide limited information on how mobile-assisted instruction influences multiple dimensions of learner engagement, including behavioral, cognitive, emotional, and agentic engagement.

In response to these concerns, this study examined the effects of supplemental instruction using the InSci4L mobile application on the academic performance and engagement of Grade 10 participants in Biology during the School Year 2025–2026. Specifically, the study investigated whether participants exposed to the InSci4L application demonstrated significant differences in academic performance and engagement compared to those who received conventional instruction.

Research Objectives

General Objective

To determine the effects of supplemental instruction using the InSci4L mobile application on the academic performance and engagement of Grade 10 participants in Biology.

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Specific Objectives

Specifically, this study aimed to:

1. determine the academic performance of Grade 10 participants in Biology who were taught using the InSci4L mobile application and those who received conventional instruction;
2. assess the engagement levels of participants in terms of behavioral, emotional, cognitive, and agentic engagement;
3. determine whether there is a significant difference in the academic performance of participants exposed to the InSci4L mobile application and those taught using conventional instruction; and
4. determine whether there is a significant difference in the engagement levels of participants exposed to the InSci4L mobile application and those taught using conventional instruction.

Research Questions

This study sought to determine the effects of supplemental instruction using the InSci4L mobile application on the academic performance and engagement of Grade 10 participants in Biology during the School Year 2025–2026. Specifically, it sought to answer the following questions:

1. What is the academic performance of Grade 10 participants in Biology who are taught using the InSci4L mobile application and those who receive conventional instruction?
2. What are the engagement levels of participants in terms of behavioral, emotional, cognitive, and agentic engagement?
3. Is there a significant difference in the academic performance of participants exposed to the InSci4L mobile application and those taught using conventional instruction?
4. Is there a significant difference in the engagement levels of participants exposed to the InSci4L mobile application and those taught using conventional instruction?

Hypotheses of the Study

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

H_{01}: There is no significant difference in the academic performance of Grade 10 participants in Biology who are taught using the InSci4L mobile application and those who receive conventional instruction.

H_{02}: There is no significant difference in the engagement levels of Grade 10 participants who are taught using the InSci4L mobile application and those who receive conventional instruction.

METHODS

Research design

This study employed a quasi-experimental research design using a pretest–posttest control-group approach to determine the effectiveness of the InSci4L app on Grade 10 participants' academic performance and engagement in Biology, specifically on the topic of the Central Dogma of Molecular Biology.

Two intact classes were used in the study. The experimental group was exposed to lessons integrated with the InSci4L app, while the control group was taught using conventional instructional methods, such as lectures, textbook-based activities, and teacher-led discussions. Both groups were administered the same pretest before the intervention and the same posttest after the completion of the lesson to measure changes in academic performance.

Population and Sampling

The participants in this study are 60 Grade 10 participants from Apo Macote National High School in Malaybalay City, Bukidnon. To reduce selection bias, two intact class sections with 30 participants each were used, and both groups had similar demographic and academic profiles, as confirmed by school records. Two intact, heterogeneous sections were selected from 3 sections through purposive sampling. These sections were chosen to ensure diversity in learner ability and to reflect a typical classroom composition in a public-school setting. Purposive sampling was chosen to ensure that participants have the specific characteristics needed for the study. These participants are Grade 10 participants taking the Central Dogma of Molecular Biology lesson during the study period. This method keeps the research goals in mind and helps control unrelated variables, such as variations in grade level or subject exposure.

Instruments

This study used two main instruments to gather data: a researcher-developed test of academic performance and a standardized instrument of student engagement. The test of academic performance was composed of 100 multiple-choice items aligned with the Grade 10 Science curriculum, focusing on the Central Dogma of Molecular Biology. The number of

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items was deemed sufficient to cover the topic and provide a reliable measure of participants' knowledge and understanding of the subject. The test was validated for content and face validity by three subject-matter experts in Biology education, instructional materials development, and science pedagogy. An item analysis was performed to ensure the reliability, difficulty level, and appropriateness of the items. A Table of Specifications (TOS) was also developed to ensure alignment between the test items and the learning competencies. The test was pilot-tested with a similar group of students, and its reliability was determined to ensure a stable measure of academic performance.

The student engagement instrument was adapted from Appleton et al. (2006) and contextualized for Grade 10 participants in a public school setting. Item wording was modified for clarity and age-appropriateness while preserving the original constructs of behavioral, emotional, cognitive, and agentic engagement.

Content validity was established through expert review, followed by refinement based on feedback. The revised instrument was then pilot-tested on a sample similar to the target population. Reliability was assessed using Cronbach's alpha, indicating acceptable to excellent internal consistency: Behavioral Engagement ($\alpha = 0.723$), and very high reliability for Agentic ($\alpha = 0.984$), Cognitive ($\alpha = 0.995$), and Emotional Engagement ($\alpha = 0.997$).

Data Collection

The data collection procedure began with institutional approval, followed by informed consent from students and guardians. Participants were oriented on the study's purpose and procedures before data gathering commenced.

A pretest and engagement questionnaire were administered to both the experimental and control groups. The instruments were pilot-tested beforehand to ensure validity and reliability.

During the intervention, the experimental group used the InSci4L app integrated with the 7Es model, while the control group was taught using the 7Es model only, with standardized materials to ensure consistency. Classroom implementation was monitored to maintain instructional fidelity.

After the intervention, a posttest and a second engagement questionnaire were administered to both groups. Observational data were also collected to support the quantitative results. All data were analyzed statistically, ethical protocols were observed throughout, and findings were later shared with the school through a formal report and feedback session.

Treatment of Data

For Problems 1 and 2, descriptive statistics (mean and standard deviation) were used to summarize the academic performance and engagement levels of Grade 10 Biology participants exposed to the conventional method and the InSci4L app.

For Problems 3 and 4, a one-way Analysis of Covariance (ANCOVA) at the 0.05 level of significance was employed to determine whether there were significant differences in academic performance and engagement between the two groups. ANCOVA was selected to control for pre-existing differences in baseline (pretest) scores, thereby providing a more accurate comparison of post-intervention outcomes by adjusting for initial group equivalence.

All analyses were conducted using IBM SPSS Statistics Version 29. In addition to significance testing (p-values), effect sizes (partial eta squared) were reported to indicate the magnitude of the observed effects, supporting a more comprehensive interpretation of the results.

Ethical Considerations

Ethical standards were strictly observed in this study. Formal institutional ethics approval was obtained before the conduct of the research, and official research clearance was secured. In addition, permission to conduct the study was granted by the participating school administration.

Parental consent and student assent were obtained before participation, and involvement was entirely voluntary, with no penalties for withdrawal. Confidentiality was maintained throughout, and all data were securely stored and retained for up to five years before safe disposal. Data from incomplete or ineligible participants were excluded from analysis.

The study complied with relevant data protection regulations and ensured that student information was not used for commercial purposes. No monetary incentives were provided; only optional tokens, such as snacks and certificates, were given as appreciation. The research had no conflict of interest, and the InSci4L application was used strictly for instructional and research purposes.

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RESULTS and DISCUSSION

Level of Participants' Academic Performance in Biology who are taught using the InSci4L app, and of the participants who are not taught using the InSci4L app

The mean scores from the pretest and posttest results of the groups, the experimental and control groups, were analyzed and presented in Table 1.

Table 1
Mean and Standard Deviation of the Students' Academic Performance in Biology

Groups	N	Pretest			Posttest		
		Mean	SD	Descriptive Level	Mean	SD	Descriptive Level
Control	30	14.23	4.446	Did not meet Expectations	32.97	5.720	Did not meet Expectations
Experimental	30	15.67	5.554	Did not meet Expectations	38.87	4.988	Fairly Satisfactory

Legend: Outstanding 46-50 | Very Satisfactory 43-45 | Satisfactory 40-42 | Fairly Satisfactory 38-39 | Did Not Meet Expectations Below 37

The mean scores and standard deviations indicate that both groups initially demonstrated low Biology performance. The control group obtained a pretest mean of 14.23 (SD = 4.446), while the experimental group recorded 15.67 (SD = 5.554), with both classified as "Did Not Meet Expectations." This suggests that learners in both groups began with limited prior knowledge and weak conceptual understanding of Biology concepts.

Following the intervention, both groups showed improvement. The control group reached a posttest mean of 32.97 (SD = 5.720), still at the "Did Not Meet Expectations" level, indicating progress but continued difficulty in meeting competency standards. The experimental group, however, obtained a posttest mean of 38.87 (SD = 4.988), classified as "Fairly Satisfactory," reflecting attainment of minimum competency with some need for guided support.

In terms of gain scores, the control group improved by 18.74 points, while the experimental group increased by 23.20 points. This greater improvement suggests that the InSci4L mobile learning intervention more effectively enhanced students' academic performance compared to the conventional approach. Mobile learning applications such as InSci4L may support curriculum implementation by delivering structured, curriculum-aligned content in interactive formats, ensuring that learning competencies are systematically addressed. They also promote differentiated instruction by allowing learners to engage with content at their own pace and according to their individual needs, which is particularly important in mixed-ability classrooms.

Overall, while both groups improved, only the experimental group reached the minimum proficiency level. This indicates that the InSci4L intervention better supported competency-based science education by helping learners demonstrate required skills and knowledge aligned with curriculum standards.

These results align with recent research demonstrating that mobile-assisted and technology-based learning environments have a significant positive effect on participants' academic achievement in science courses (Almogren et al., 2024). Moreover, in the field of Biology learning, simulations and multimedia-based learning have been shown to positively affect understanding of abstract scientific concepts through visualization and self-paced learning, leading to higher levels of achievement (Kassa et al., 2024). The better achievements recorded in the experimental group also align with a constructivist approach, as reflected in participants' achievements in learner-centered learning environments rather than traditional teaching methods (Do et al., 2023).

Level of Participants' Engagement in Biology of the Grade 10 participants taught using InSci4L and of the participants who are not taught using InSci4L

Before the InSci4L application was used in the biology class, the Grade 10 participants' baseline levels of involvement are shown in Table 2. Behavioral, emotional, cognitive, and agentic engagement were the four variables used to quantify engagement. The findings indicate that before the InSci4L learning application was integrated, participants' initial levels of participation in the biology lesson were moderate. The InSci4L app's interactive simulations, virtual lab exercises, and gamified tests, intended to increase student engagement and motivation in learning biology, had not yet been used by the participants.

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Table 2

Engagement Level in Biology of the Grade 10 Participants (Pretest)

	Control Group			Experimental Group		
	Mean	SD	Descriptive Level	Mean	SD	Descriptive Level
Behavioral Engagement	2.85	0.422	Moderate Engagement (ME)	3.95	0.580	High Engagement (HE)
Agentic Engagement	2.64	0.522	Moderate Engagement (ME)	3.63	0.508	High Engagement (HE)
Cognitive Engagement	2.58	0.610	Low Engagement (LE)	3.43	0.610	High Engagement (HE)
Emotional Engagement	2.82	0.442	Moderate Engagement (ME)	3.55	0.695	High Engagement (HE)
Grand Mean	2.72	0.496	Moderate Engagement (ME)	3.65	0.619	High Engagement (HE)

**Reversed Coding*

Legend: 1-1.80 - Very Low Engagement (VLE), 1.81-2.60 - Low Engagement (LE), 2.61-3.40 - Moderate Engagement (ME) 3.41-4.20 - High Engagement (HE), 4.21-5.00 – Very High Engagement (VHE)

The pretest results show clear differences in Biology engagement between the control and experimental groups. The control group had a grand mean of 2.72 (Moderate Engagement), while the experimental group scored higher at 3.65 (High Engagement), indicating stronger initial engagement among experimental group participants.

In behavioral engagement, the control group scored 2.85 (ME), reflecting moderate participation, while the experimental group scored 3.95 (HE), showing greater attentiveness and active involvement. For agentic engagement, the control group's mean of 2.64 (ME) suggests moderate initiative, whereas the experimental group's 3.63 (HE) indicates stronger learner participation and influence in the learning process.

For cognitive engagement, the control group scored 2.58 (Low Engagement), indicating limited strategy use, while the experimental group scored 3.43 (HE), reflecting deeper thinking. Emotional engagement was 2.82 (ME) for the control group, compared to 3.55 (HE) for the experimental group, showing higher enjoyment and interest in Biology. Overall, the pretest findings establish that while both groups exhibited engagement in Biology, the experimental group consistently demonstrated higher engagement across all dimensions. These baseline differences highlight the importance of controlling for initial engagement levels when analyzing posttest outcomes and provide a clear reference point for evaluating the effectiveness of the InSci4L app in enhancing participants' engagement in Biology.

Several studies support these findings, indicating a beneficial association between mobile applications and student engagement. Aldalur and Perez (2023) discovered that science applications with simulations and gamified features greatly increased student motivation and cognitive engagement.

Similarly, Anuyahong and Pucharoen (2023) found that localized mobile learning resources increased student classroom involvement and sustained attention, especially in heterogeneous learning situations. Furthermore, Hamid et al. (2024) discovered that participants who used mobile learning platforms showed more interest and self-directed learning practices in scientific classes. These studies support the current findings, indicating that mobile applications such as InSci4L have an important role in increasing student involvement across behavioral, emotional, and cognitive dimensions.

Table 3 presents the mean scores and standard deviations of the control and experimental groups on the posttest engagement measure in Biology, organized according to the four dimensions of engagement, behavioral, agentic, cognitive, and emotional, with each indicator interpreted using the study's descriptive levels. The table shows how participants in both groups manifested engagement after the instructional period, and the pattern of means across dimensions provides a clear picture of how engagement differed between those who received conventional instruction and those who received supplemental instruction through InSci4L.

Table 3

Engagement Level in Biology of the Grade 10 Participants (Posttest)

Engagement	Control Group			Experimental Group		
	Mean	SD	Descriptive Level	Mean	SD	Descriptive Level
Behavioral Engagement	3.07	0.610	Moderate Engagement (ME)	4.58	0.503	Very High Engagement (VHE)
Agentic Engagement	2.70	0.567	Moderate Engagement (ME)	4.05	0.374	High Engagement (HE)
Cognitive Engagement	2.60	0.610	Low Engagement (LE)	4.08	0.610	High Engagement (HE)
Emotional Engagement	3.08	0.558	Moderate Engagement (ME)	4.60	0.491	Very High Engagement (VHE)
Over all	2.85	0.608	Moderate Engagement (ME)	4.31	0.516	Very High Engagement (VHE)

**Reversed Coding*

Legend: 1-1.80 - Very Low Engagement (VLE), 1.81-2.60 - Low Engagement (LE), 2.61-3.40 - Moderate Engagement (ME) 3.41-4.20 - High Engagement (HE), 4.21-5.00 – Very High Engagement (VHE)

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The posttest results show a clear difference in Biology engagement between groups after the intervention. The control group had a grand mean of 2.85 (Moderate Engagement), while the experimental group reached 4.31 (Very High Engagement), indicating the intervention was more effective in enhancing overall engagement. For behavioral engagement, the control group scored 3.07 (ME), reflecting moderate participation, while the experimental group scored 4.58 (VHE), showing very high attention and involvement, likely due to the app's interactive features.

In agentic engagement, the control group posted 2.70 (ME), indicating moderate initiative, whereas the experimental group scored 4.05 (HE), suggesting greater learner autonomy. Similarly, cognitive engagement was low in the control group (2.60, LE) but high in the experimental group (4.08, HE), reflecting deeper thinking supported by app features like simulations and virtual labs. For emotional engagement, the control group achieved 3.08 (ME), while the experimental group reached 4.60 (VHE), indicating higher enjoyment and interest, possibly driven by gamification and immediate feedback.

The findings reveal that the experimental group consistently outperformed the control group across all dimensions of engagement—behavioral, agentic, cognitive, and emotional—ultimately achieving a Very High Engagement level. This pattern aligns with existing research highlighting the effectiveness of mobile-assisted learning environments in fostering active student participation and deeper learning (Pedraza & Canoy, 2025). The integration of the InSci4L app appears to have provided interactive, learner-centered opportunities that encouraged participants not only to participate actively but also to take initiative in their learning processes, a hallmark of agentic engagement (Sadiqzade, 2025).

Moreover, the observed increase in cognitive and emotional engagement supports prior findings that technology-enhanced instruction can promote meaningful learning by making content more accessible, relevant, and motivating (Sailer et al., 2024). Taken together, these results provide compelling evidence that the use of the InSci4L app significantly enriched participants' engagement in Biology, reinforcing the premise that mobile-assisted instruction can create more dynamic, immersive, and effective learning experiences.

Difference in the academic performance of Grade 10 Biology participants who are taught using InSci4L and those participants who are not taught using InSci4L?

Table 4 presents the one-way analysis of covariance (ANCOVA) results assessing whether Grade 10 participants in the control and experimental groups differed significantly in posttest Biology academic performance after statistically controlling for pretest (Pre-Exam) scores. This analysis is well-suited to the study's quasi-experimental design because it adjusts for baseline differences in prior knowledge and provides an estimate of the treatment effect (use of InSci4L versus conventional instruction) on posttest achievement while holding initial performance constant.

Table 4
One-Way ANCOVA Summary of the Participants' Academic Performance in Biology by Group Controlling for Pretest Scores

Source	SS (Type III)	Df	MS	F	P	Partial Eta Square
Model	2675.04	2	1337.521	98.051	<.001	0.775
Pre-Exam	892.893	1	892.893	65.456	<.001	0.535
Group	1405.849	1	1405.849	103.06	<.001	0.644
Error	777.541	57	13.641			
Total	51903	60				

*Significant at p<0.05 alpha level. R Squared=.775 (Adjusted R Squared=.767)

The results of the study clearly demonstrate significant differences in participants' academic engagement between classes that used the InSci4L app and those that did not use the app. Participants who were taught using conventional methods without the InSci4L app consistently exhibited moderate to low levels of engagement across behavioral, agentic, cognitive, and emotional dimensions. This suggests that traditional instruction alone may limit opportunities for active participation, learner agency, deep cognitive processing, and sustained emotional interest, especially when teaching abstract Biology concepts.

In contrast, participants exposed to the InSci4L app demonstrated high to very high engagement levels in all engagement dimensions. The app's interactive simulations, virtual laboratory activities, gamified assessments, and real-time feedback promoted active participation, encouraged participants to ask questions and share ideas, enhanced critical thinking, and

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increased enjoyment and motivation. These features transformed participants from passive recipients of information into active participants in the learning process.

Overall, the difference highlights that using the InSci4L app created a more learner-centered, interactive, and engaging learning environment, while not using the app resulted in a more teacher-centered and less dynamic instructional experience. This supports the conclusion that mobile-assisted instruction, when intentionally designed and aligned with pedagogical frameworks, significantly enhances learner engagement in Biology.

Correspondingly, posttest engagement scores showed that the experimental group achieved high to very high levels of behavioral, agentic, cognitive, and emotional engagement. In contrast, the control group remained at moderate to low levels. The interactive features of the InSci4L app—including gamified quizzes, simulations, virtual laboratory activities, and real-time feedback—promoted active participation, self-directed learning, critical thinking, and motivation. These elements fostered meaningful connections between abstract Biology concepts and real-life applications, which likely contributed to the higher academic achievement.

In general, the findings highlight that mobile-assisted, interactive learning not only increases student engagement but also leads to improved learning outcomes, supporting the integration of technology into student-centered instructional practices.

Interpreted through the lens of the study's theoretical framework, the significant group effect supports the instructional value of InSci4L in enhancing Biology achievement beyond what can be attributed to initial differences in prior knowledge. From a constructivist learning perspective, the app's interactive simulations, virtual laboratory activities, and self-paced exploration likely facilitated active knowledge construction, enabling participants to develop a deeper conceptual understanding of abstract topics such as transcription and translation within the central dogma of biology.

In line with Mayer's Cognitive Theory of Multimedia Learning, InSci4L's integration of animations, diagrams, narration, and embedded quizzes may have supported dual-channel processing and reduced unnecessary cognitive load, thereby strengthening comprehension and retention and contributing to higher posttest performance.

Furthermore, Mobile Learning Theory helps explain how the app's flexible, anytime-anywhere access, especially with offline functionality and localized content, may have increased participants' opportunities for continuous practice and review beyond classroom limitations, a feature particularly relevant in resource-constrained public-school contexts. Finally, consistent with Engagement Theory, the app's gamification elements, immediate feedback, and interactive tasks likely promoted sustained behavioral and cognitive engagement, which can translate into greater effort, persistence, and ultimately improved academic outcomes.

Overall, the ANCOVA findings provide strong evidence that, when baseline performance is held constant, participants exposed to InSci4L achieved significantly higher Biology posttest performance than those taught through conventional methods, supporting the study's theoretical proposition that mobile, multimedia, and constructivist-aligned learning experiences enhance both learning processes and achievement.

Despite the control for initial differences, the experimental group showed a stronger performance in the posttest relative to the control group with a Huge effect size. This result is in consonance with many meta-analyses that showed a higher efficacy of mobile learning interventions to positively influence the science performance of participants (Nurdin et al., 2025). These results validate the Cognitive Theory of Multimedia Learning by Mayer(2002) that visuals in multimedia learning can effectively improve the learning outcome by reducing the extraneous cognitive loads (Bahador, 2025).

The application of the ANCOVA complies with current recommendations in the field of advancing causal inferences in quasi-experiments by statistically controlling for differences that exist before the study (Rangel-de Lazaro & Duart, 2023). Therefore, the results demonstrate strong causal evidence that InSci4L positively enhanced participants' performance in Biology above the level of prior knowledge.

Difference between the engagement level in Biology of the Grade 10 participants who are taught using InSci4L and of the participants who are not taught using InSci4L?

Table 5 presents the results of the one-way ANCOVA examining the effect of the InSci4L educational application on the academic engagement of Grade 10 participants in Biology, controlling for pretest engagement scores. The overall model was statistically significant ($F(2, 57) = 489.265$, $p < .001$, $R^2 = 0.945$), indicating that group membership and baseline engagement together explained a substantial portion of the variance in posttest engagement. The pretest engagement scores significantly influenced posttest outcomes ($F(1, 57) = 43.173$, $p < .001$, partial eta squared = 0.431), confirming that participants' initial engagement levels contributed to their overall engagement, yet the intervention effect remained substantial.

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Table 5

One-Way ANCOVA Summary of the Participants' Academic Engagement in Biology by Group, Controlling for Pretest Scores

Source	SS (Type III)	Df	MS	F	p	Partial Eta Square
Model	33.50	2	16.75	489.265	<.001	0.945
Pre-Exam (Covariate)	1.478	1	1.478	43.173	<.001	0.431
Group	1.993	1	1.993	58.199	<.001	0.505
Error	1.951	57	0.034			
Total	803.243	60				

*Significant at p<0.05 alpha level. R Squared=.945 (Adjusted R Squared=.943)

The group effect was significant ($F(1, 57) = 58.199$, $p < .001$, partial eta squared = 0.505), indicating that participants who used the InSci4L app exhibited significantly higher engagement than the control group. Specifically, the experimental group demonstrated very high levels of behavioral engagement (mean = 4.58), high agentic engagement (mean = 4.05), high cognitive engagement (mean = 4.08), and very high emotional engagement (mean = 4.60), while the control group remained in the moderate to low engagement range across all dimensions.

These findings suggest that the interactive features of the InSci4L app—including gamified quizzes, real-time feedback, simulations, and virtual laboratory activities—effectively enhanced participants' attention, motivation, critical thinking, participation, and emotional involvement in learning. The results support the conclusion that mobile-assisted, student-centered instructional tools can foster comprehensive engagement in complex scientific topics, providing an effective alternative to traditional teaching methods.

Viewed through the lens of the study's theoretical framework, the significant group effect on engagement provides strong support for InSci4L's capacity to foster participants' involvement in Biology learning beyond what can be explained by their initial engagement levels. From Mobile Learning Theory, the app's portability and anytime-anywhere access likely enabled sustained interaction with Biology content beyond classroom constraints, encouraging continued participation and learning continuity. Through Constructivist Learning Theory, the app's simulations and interactive activities may have increased participants' sense of active involvement and ownership of learning as they explored biological processes and constructed understanding through meaningful experiences. In relation to Mayer's Cognitive Theory of Multimedia Learning, the integration of visuals, narration, and structured quizzes likely supported comprehension and reduced confusion, thereby enhancing participants' confidence and willingness to participate—strengthening engagement.

Finally, consistent with Engagement Theory, the app's feedback mechanisms, interactive tasks, and gamified features likely supported behavioral engagement (active participation and persistence), cognitive engagement (deep processing and strategy use), emotional engagement (enjoyment and interest), and agentic engagement (learner input and initiative).

Overall, the ANCOVA results indicate that, after controlling for baseline engagement, participants exposed to InSci4L demonstrated significantly higher posttest academic engagement in Biology compared with those taught through conventional instruction, reinforcing the framework's proposition that technology-supported, interactive, and learner-centered environments can meaningfully elevate student engagement. This finding lends credence to recent literature regarding how learning environments that are improved by technology and mobile learning have been shown to have a positive effect on overall engagement levels of participants, from a behavioral, cognitive, emotional, and agentic point of view (Gu, 2025; Hamid et al., 2024)

In theoretical terms, the results are consistent with Engagement Theory and self-determination studies, as they highlight autonomy, interactivity, and task significance as critical elements for maintaining engagement with learning activities and pursuits (Yang et al., 2025). Findings from this study show that InSci4L was relatively effective in improving engagement in learning Biology.

Conclusion

The findings of the study demonstrate that integrating the InSci4L educational application significantly improved the academic performance and engagement of Grade 10 participants in Biology. Participants exposed to the mobile-assisted instructional intervention achieved higher posttest scores and demonstrated stronger behavioral, cognitive, emotional, and agentic engagement compared to those who received conventional instruction.

The results further highlight the instructional value of interactive simulations, gamified activities, real-time feedback, and multimedia-supported learning experiences in enhancing participants' understanding of complex biological concepts. The findings support the effectiveness of learner-centered and technology-enhanced pedagogical approaches in promoting meaningful learning and active classroom participation.

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Moreover, the study contributes to educational research by providing evidence that localized and curriculum-aligned mobile learning applications can strengthen science instruction in secondary education. The findings also underscore the importance of integrating digital learning innovations into classroom practice, curriculum implementation, and teacher professional development to improve learning outcomes in Biology education.

Recommendations

1. Biology teachers may integrate the InSci4L educational application as a supplementary instructional tool to enhance participants' understanding of abstract biological concepts and increase classroom engagement through interactive and learner-centered activities.
2. School administrators may strengthen support for technology-enhanced instruction by providing adequate digital resources, internet connectivity, device accessibility, and professional development opportunities related to mobile-assisted learning.
3. Curriculum planners and education policymakers may consider integrating localized and curriculum-aligned mobile learning applications into science education programs to support competency-based and technology-enhanced teaching practices.
4. Teacher education institutions may incorporate training on mobile-assisted instruction, gamification, and digital pedagogy into pre-service and in-service teacher development programs to strengthen teachers' technological and pedagogical competencies.
5. Participants may use educational mobile applications responsibly to reinforce lessons, promote self-paced learning, and develop greater independence and engagement in Biology learning.
6. Future researchers may conduct further studies examining the long-term effects of InSci4L across different grade levels, subject areas, and educational contexts using varied research designs and broader participant populations.

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