

BioGenAI: Development of an Artificial-Intelligence Generative Module for Senior High School Biology Using Rapid Prototyping Model

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Abstract: *This study aimed to develop and evaluate the BioGenAI mobile application, an artificial intelligence (AI)-generative Biology learning module for Senior High School students, using the Rapid Prototyping model. The study examined students' learning needs, the development and refinement of module prototypes, the level of acceptability, and teachers' evaluation of the instructional material. Findings revealed that while students generally demonstrated strong academic performance and interest in Biology, significant learning gaps existed in complex topics such as genetics, problem-solving, and independent task completion. Students also preferred interactive and technology-supported learning, indicating readiness for AI-integrated instruction. These insights guided the design of the BioGenAI module.*

Three iterative prototypes were developed and progressively improved. Prototype 1 introduced core features such as AI-supported explanations and interactive activities. Prototype 2 enhanced structured practice, guided feedback, and interface design. Prototype 3 integrated supplementary resources, leveled assessments, and improved feedback mechanisms, resulting in a more comprehensive learning tool with progress monitoring and teacher analytics.

The module's acceptability showed consistent improvement across all versions. Prototype 1 received high ratings, while Prototype 2 and Prototype 3 achieved very high levels in engagement, participation, interaction, usability, and classroom appropriateness. These results indicate that iterative refinement effectively enhanced instructional quality. Teachers' evaluations further confirmed the module's effectiveness, describing it as engaging, user-friendly, and supportive of understanding complex Biology concepts. The final evaluation using the LRMDS rating sheet yielded a "Highly Acceptable" rating, validating its instructional and technical quality

Keywords: Generative Artificial Intelligence, Rapid Prototyping, Mobile Applications, General Biology

I. INTRODUCTION

GenAI can create text, images, and other learning materials, making lessons more interactive and personalized for students. In science education, these tools can help explain difficult topics, provide instant feedback, and support students in understanding complex ideas in biology and genetics.

Despite its benefits, the use of GenAI in education also brings challenges. Some concerns include overdependence on technology, academic dishonesty, unequal access to digital tools, and lack of teacher preparation. There is also limited research about how GenAI affects senior high school students' learning, especially in science subjects and in countries like the Philippines.

To address these gaps, this study developed an AI-generated Biology learning module called BioGenAI for Senior High School students using the Rapid Prototyping model. The module was designed to create an engaging and student-centered learning experience that matches educational standards and supports different learner needs. The study also



aims to promote responsible AI use, improve digital literacy, and enhance students' critical thinking and learning outcomes.

II. LITERATURE REVIEW

Recent studies highlight the growing influence of Artificial Intelligence (AI) and Generative Artificial Intelligence (GenAI) in education. AI supports teaching and learning through intelligent tutoring systems, adaptive feedback, automated assessment, and personalized instruction. Generative AI further enhances learning by creating content such as text, simulations, and interactive materials that help students engage more actively in the learning process.

Several studies emphasize that AI-supported learning environments improve learner engagement, autonomy, and conceptual understanding. Personalized learning systems adjust instructional content according to students' prior knowledge, learning pace, and preferences, making instruction more responsive to individual needs. In science education, AI tools help students understand abstract concepts through simulations, interactive explanations, and adaptive exercises.

Research also indicates that AI assists teachers in developing instructional materials and assessments aligned with curriculum standards. These technologies reduce teacher workload while improving instructional consistency and providing immediate feedback to learners. In the Philippine context, AI integration in education continues to expand, although challenges such as limited infrastructure, teacher preparedness, and ethical concerns remain significant considerations.

TABLE I: SUMMARY OF RELATED LITERATURE AND STUDIES

Refer	Author(s)	Year	Method / Technology	Key Findings	Limitations
[1]	Holmes et al.	2022	AI-supported educational systems	AI enhances personalized learning and adaptive instruction	Ethical and implementation concerns
[2]	Zawacki-Richter et al.	2019	Intelligent tutoring and adaptive systems	AI improves engagement and differentiated instruction	Limited studies in K-12 settings
[3]	Lin et al.	2023	Intelligent Tutoring Systems in Biology	Improved conceptual understanding and adaptive learning	Requires advanced technological support
[4]	Martin et al.	2017	Rapid Prototyping instructional design	Continuous refinement improves instructional quality	Requires repeated testing
[5]	Bond et al.	2020	Personalized digital learning environments	Increased learner engagement and participation	Requires technological readiness
[6]	Dionisio et al.	2025	AI-supported science learning tools in the Philippines	Improved engagement and conceptual understanding	Infrastructure and training challenges

III. PROBLEM STATEMENT

Senior High School students experience difficulties in understanding complex Biology concepts due to learning gaps, misconceptions, and varying levels of prior knowledge. Traditional instructional approaches may not fully address students' diverse learning needs, especially in topics that require visualization, interaction, and higher-order thinking.



skills. Additionally, limited access to engaging and adaptive instructional materials affects students' participation, motivation, and conceptual understanding in Biology.

These challenges highlight the need for an innovative and learner-centered instructional tool that can support personalized and interactive learning experiences. The integration of Artificial Intelligence (AI) in education offers opportunities to provide adaptive feedback, interactive activities, and AI-generated learning support that can enhance engagement and improve understanding of Biology concepts.

Therefore, this study aims to develop an AI-generative Biology learning module (BioGenAI) using the Rapid Prototyping model. The module is intended to support student engagement, conceptual understanding, and interactive learning while ensuring instructional effectiveness, usability, and alignment with curriculum standards.

IV. PROPOSED SYSTEM

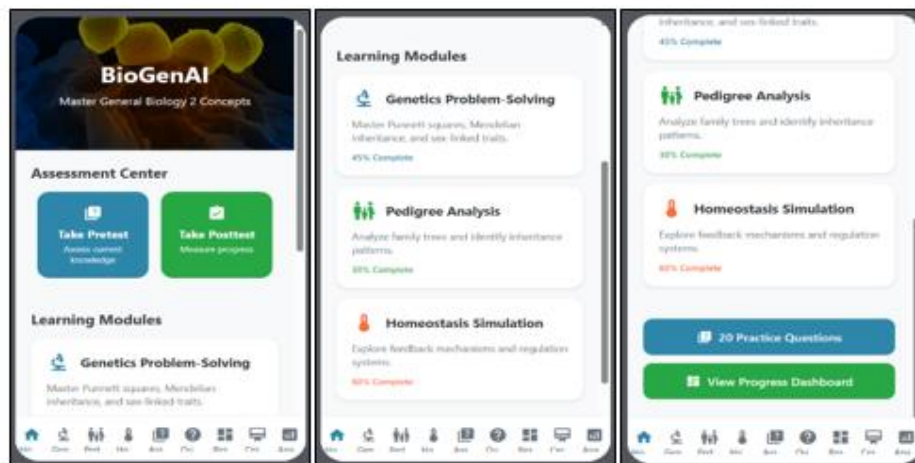
The proposed BioGenAI module is designed to provide Senior High School students with an interactive and adaptive Biology learning experience through a digital learning platform. The module integrates Artificial Intelligence (AI) and Generative AI features to support personalized instruction, improve conceptual understanding, and enhance student engagement in Biology lessons.

The key features of the module include AI-generated explanations, adaptive feedback, interactive quizzes, guided inquiry activities, and multimedia learning resources that help students understand complex Biology concepts. The module also includes simulations and learner-centered activities that encourage active participation, self-paced learning, and critical thinking.

The BioGenAI module is developed using the Rapid Prototyping model, allowing continuous testing, evaluation, and refinement based on feedback from teachers and students. This iterative process ensures that the module remains effective, user-friendly, curriculum-aligned, and appropriate for classroom implementation in Senior High School Biology.

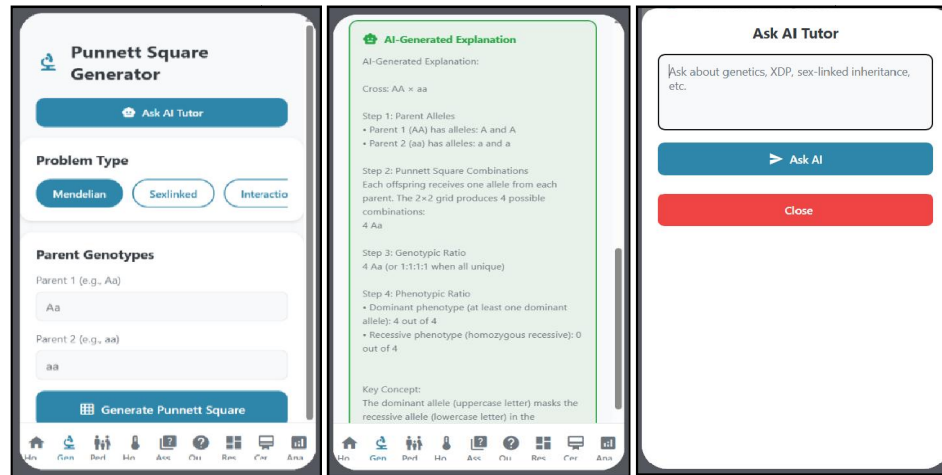
1. BioGenAI Home Screen Page

The BioGenAI Home Screen Page serves as the main interface of the application, providing students with easy access to assessments, learning modules, and progress monitoring features. It includes interactive Biology activities such as Genetics Problem-Solving, Pedigree Analysis, and Homeostasis Simulation, which are designed to improve conceptual understanding and engagement. The interface also allows learners to track their progress through pretests, post-tests, practice questions, and a performance dashboard.



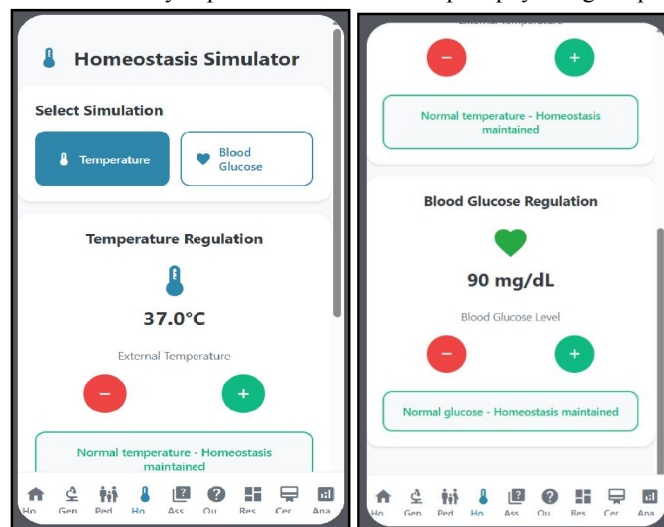
2. Punnett Square Generator and AI Tutor Feature

The Punnett Square Generator and AI Tutor Feature allows students to solve genetics problems interactively by generating Punnett squares based on selected inheritance patterns and parent genotypes. The feature also provides AI-generated explanations that guide learners through the steps of solving genetic crosses, helping improve conceptual understanding. Additionally, the AI Tutor enables students to ask questions related to genetics and receive instant learning support and explanations.



3. Homeostasis Simulator Feature

The Homeostasis Simulator Feature provides students with an interactive learning environment for understanding body regulation mechanisms such as temperature control and blood glucose regulation. Through simulations and adjustable controls, learners can observe how changes in conditions affect homeostasis and how the body responds to maintain balance. This feature enhances conceptual understanding by allowing students to actively explore and visualize complex physiological processes.

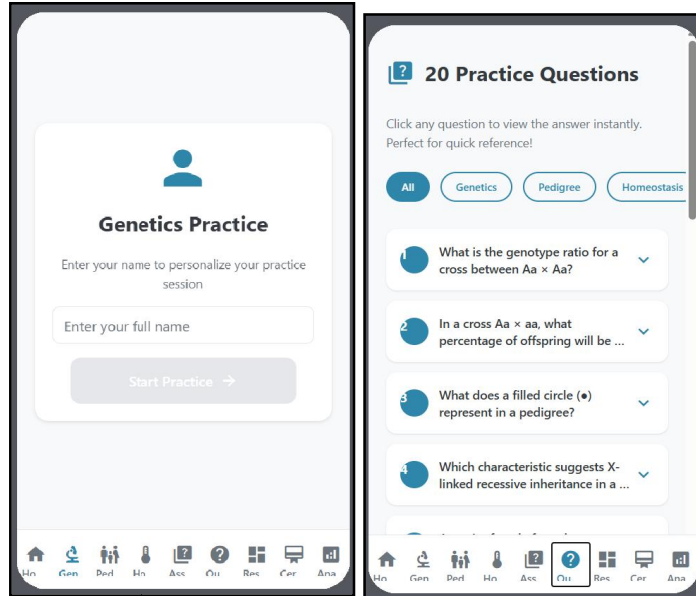


4. Personalized Practice Interface

The Personalized Practice Interface allows students to engage in customized Biology practice activities based on their learning needs and interests. It provides categorized practice questions in topics such as Genetics,

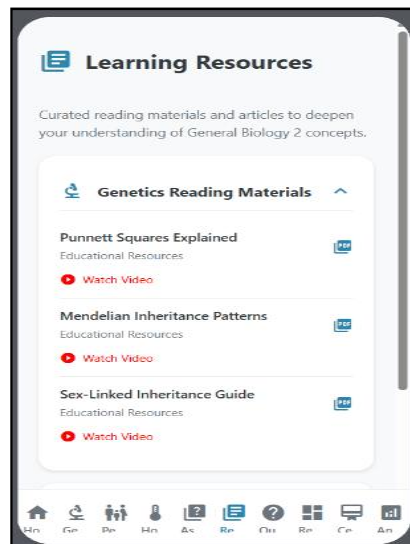


Pedigree Analysis, and Homeostasis, enabling learners to review concepts and receive immediate answers for self-assessment. This feature promotes independent learning, active participation, and improved mastery of Biology concepts through interactive practice sessions.



5. Additional Learning Resources

The Additional Learning Resources feature provides students with supplementary educational materials that support deeper understanding of General Biology concepts. It includes reading materials, videos, and interactive resources related to topics such as Punnett squares, Mendelian inheritance, and sex-linked traits. This feature enhances independent learning by giving students accessible references for review, enrichment, and concept reinforcement.



V. SYSTEM ARCHITECTURE

The BioGenAI module consists of several integrated components that work together to provide an adaptive and interactive Biology learning experience for Senior High School students. The user interface allows students and teachers to access the module through digital devices such as computers, tablets, or mobile phones. The system is designed to support easy navigation, interactive learning activities, and learner-centered instruction.

The AI-generative component processes learner input and provides adaptive feedback, AI-generated explanations, guided inquiry prompts, and personalized learning support based on students' responses and performance. Interactive simulations, quizzes, and multimedia resources are integrated into the module to help students understand complex Biology concepts and improve conceptual understanding.

The module also includes a database and monitoring component that stores learner progress, assessment results, and interaction data while maintaining privacy and security. An evaluation and feedback component gathers responses from students and teachers to support continuous improvement and refinement of the BioGenAI module through the Rapid Prototyping process.

VI. METHODOLOGY

This study employed a design-based research approach using the Rapid Prototyping Model (RP) to develop the BioGenAI, an AI-generative learning module for Senior High School Biology. The methodology involved iterative cycles of prototype design, testing, refinement, and evaluation to ensure that the module is learner-centered, pedagogically sound, and aligned with curriculum standards.

The process began with the collection of data from Senior High School students and teachers to identify learning needs, prior knowledge in Biology, learning gaps and misconceptions, experiences with digital and interactive instruction, and perceptions toward AI-based learning. This information served as the foundation for the development of the BioGenAI module.

Using the Rapid Prototyping framework, the study underwent continuous and cyclical stages of module development. Prototype 1 focused on the initial development of the AI-generative module. After classroom implementation and evaluation, Prototype 2 was created by revising the module based on teacher feedback. Prototype 3 further improved the module by incorporating additional refinements in instructional design, usability, engagement, and AI-supported features.

Teacher-administered module evaluation questionnaires were utilized throughout the iterative process to assess the effectiveness and acceptability of each prototype. Feedback gathered from evaluations guided the refinement of the module to improve content quality, instructional effectiveness, interaction, and learner engagement.

The finalized BioGenAI module was evaluated using the Learning Resource Management and Development System (LRMDS) rating sheet. The evaluation focused on content quality, instructional quality, technical quality, presentation and organization, interoperability, and identification of conceptual, factual, and grammatical errors.

Through this iterative and evaluation-driven methodology, the study ensured that the final BioGenAI module is adaptive, effective, curriculum-aligned, and responsive to the learning needs of Senior High School students in Biology.



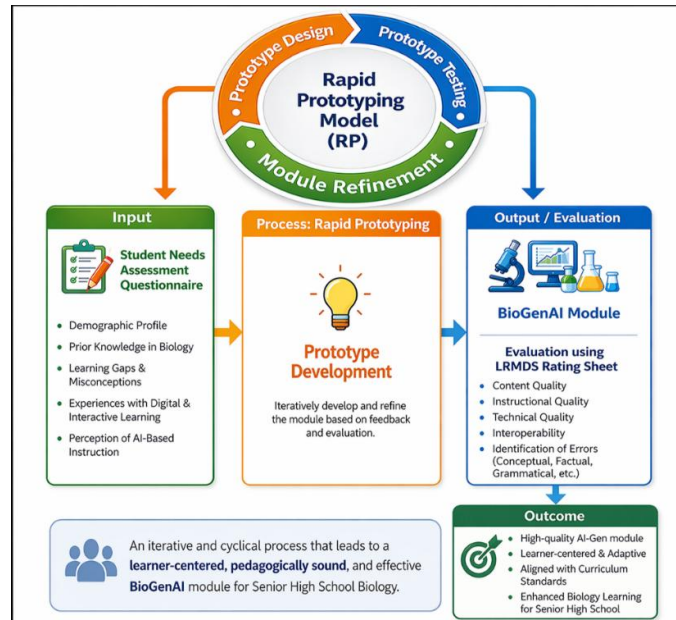


Fig1: Framework for the Development of the BioGenAI Module

VII. FUTURE SCOPE

Future improvements in artificial intelligence and educational technologies can further enhance the capabilities of the BioGenAI module. More advanced AI features may provide highly personalized learning experiences, improved adaptive feedback, and more interactive simulations that can help students better understand complex Biology concepts. Integration with emerging educational technologies may also improve accessibility, learner engagement, and real-time performance monitoring.

Educational institutions may further integrate AI-generative learning modules into science instruction to support learner-centered and technology-enhanced education. Future developments may also include additional multimedia resources, advanced assessment tools, and expanded Biology topics to strengthen conceptual understanding, critical thinking, and independent learning among Senior High School students.

VIII. CONCLUSION

The study successfully developed and evaluated the BioGenAI mobile application, an AI-generative Biology learning module for Senior High School students, using the Rapid Prototyping model. The findings showed that identifying students' learning gaps, prior knowledge, and perceptions toward AI-based learning helped in creating a relevant and effective instructional tool. The integration of AI-supported features addressed students' difficulties in complex Biology topics and supported interactive and learner-centered learning experiences.

The iterative refinement of the three prototypes improved the module's quality, usability, engagement, and instructional effectiveness. Teachers evaluated the BioGenAI application as engaging, user-friendly, curriculum-aligned, and highly acceptable for classroom use. The study concluded that BioGenAI effectively enhances student engagement, conceptual understanding, and learner autonomy, while the Rapid Prototyping model proved effective in developing and improving AI-supported educational materials.



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