Homeohub: Development of Interactive E- Module for Homeostasis and Feedback Mechanisms

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ABSTRACT

The consistently low performance of Filipino learners in both national and international assessments underscores the need to enhance instructional materials and teaching approaches in science education. This study aimed to develop and validate the HomeoHub interactive e-module for teaching homeostasis and feedback mechanisms in Biology. This study employed the first three phases of the ADDIE model—Analysis, Design, and Development—to develop and validate the HomeoHub e-module. A needs assessment was conducted among 47 Grade 11 learners and three in-service Science teachers. Results identified "Coordinated Functions of the Reproductive, Endocrine, and Nervous Systems" as the least mastered topic, particularly concepts related to homeostasis and feedback mechanisms. The HomeoHub interactive e-module was validated by experts in terms of content quality, instructional quality, technical quality, and accuracy and reliability. Pilot testing was conducted among 53 Grade 9 learners from three sections using pre-test and post-test assessments. The findings showed that the e-module obtained "Very Satisfactory" ratings in all evaluation criteria, indicating that it is valid, acceptable, curriculum-aligned, and suitable as a supplemental instructional material. Pilot testing results revealed improvement in learners' mastery levels after using the e-module. However, learners' overall mastery levels remained low. The findings suggest that the multimedia and interactive features of the e-module may support learners' conceptual understanding. Thus, the study concludes that the HomeoHub interactive e-module is a valid, acceptable, and learner-centered instructional resource with potential for classroom use. Future studies may proceed with the Implementation and Evaluation phases of the ADDIE model and employ larger, more diverse samples and experimental research designs to further examine the effectiveness of the e-module.

Keywords: Interactive E-module, Feedback mechanism, Female Reproductive System, Digital Learning Module, Supplementary Material, Multimedia Learning

INTRODUCTION

International and national assessments reveal persistent learning gaps in science education (Mullis et al., 2020; OECD, 2019). Results from the PISA 2022 revealed that the Philippines ranked 77th out of 81 participating countries in science literacy (Magsambol, 2024). Local studies further support these findings. Delos Santos et al. (2021) and Cantere and Nabua (2024) reported that Grade 10 learners demonstrated low mastery in Biology competencies across grade levels, including topics such as cell structure and function, heredity, genetics, ecosystems, and coordinated body systems. These topics require understanding of relationships among structures, processes, and functions, which learners often find difficult due to its abstract nature. One factor that contributes to these learning gaps is the limited variety of instructional materials used in the teaching and learning process (Harahap et al., 2024).

In the digital age, learners are increasingly exposed to technology such as computers, mobile devices, online platforms, and internet-based resources. Because of this, multimedia-based learning has become more accessible and relevant. Multimedia-based learning integrates a variety of elements into the instructional process, including

animations, simulations, instructional videos, interactive exercises and problem-solving activities (Taringan et. al., 2023). One application of multimedia-based learning is the use of digital learning modules or E-modules, a teaching material that presents instructional content in an organized and systematic format that allows learners to study independently or with minimal guidance (Betio, 2025). Interactive digital learning modules have been found to improve student learning outcomes (Betio, 2025; Harahap et al., 2024; Maglinte & Coronica, 2023; Wulansari & Irdawati, 2023; Wijaya & Vidianti, 2019), and creative thinking skill (Wulansari and Irdawati, 2023), and memory retention (Taringan et al., 2023). They serve as alternative instructional materials that support interactive teaching and learning processes by engaging learners through multiple sensory channels, including text, visuals, audio, animation, and interactive tasks (Harahap et al., 2024). These features allow learners to experience more dynamic and meaningful learning experiences compared to traditional instructional approaches.

However, despite these advances, most existing digital learning materials focus on physics or general science topics, leaving gaps in the development of interactive modules for biology concepts such as feedback mechanisms and homeostasis. In relation to this, this study aimed to develop an interactive digital learning module for teaching homeostasis and feedback mechanisms;

METHODOLOGY

Research Design

The study utilized the Analysis, Design, and Development phases of the ADDIE model to develop and validate the HomeoHub e-module. A pilot testing procedure utilizing pretest and posttest assessments was conducted to gather preliminary evidence regarding the usability and potential instructional value of the developed module. Quantitative data were obtained from the needs assessment test and expert evaluation ratings, while qualitative data were gathered from the needs assessment survey and evaluators' comments and suggestions.

Research Participants

Participants were selected using purposive sampling. The participants of this study were composed of both learners and in-service teachers who were involved in the needs assessment and pilot testing phases of the research. For the learners' needs assessment, a total of 47 Grade 11 learners participated in the study. The inclusion criteria were as follows: (a) currently enrolled during S.Y. 2024–2025; (b) have completed or been exposed to the Biology learning competencies from Grades 7 to 10; and (c) have secured parental or guardian consent to participate in the study. These participants were selected to provide insights regarding their learning experiences, difficulties, and needs related to the topic being investigated. Their responses served as the basis for the development and improvement of the instructional material.

For the teachers' needs assessment, three (3) in-service Science teachers participated in the study. The teachers were chosen based on their teaching experience and expertise in handling Science subjects relevant to the study. Their feedback and recommendations contributed to the content validation and enhancement of the developed material. For expert validation of the interactive e-module, two Grade 10 in-service teachers with at least five years of experience in Science, two Master Teachers in Science, and one Information and Communication Technology (ICT) expert were purposely selected. For the pilot testing phase, the developed instructional material was administered to 53 Grade 9 learners. The inclusion criteria were as follows: (a) currently enrolled in S.Y. 2025–2026; (b) had not yet been formally exposed to the selected competency; (c) has secured parental consent; and (d) has access to a mobile device. The pilot participants were selected to evaluate the usability, clarity, and effect of the material prior to its final implementation. Their responses and performance results were utilized to identify areas for revision and improvement.

Data Gathering Procedure

In the Analysis phase, a needs assessment test was conducted to Grade 11 learners to identify least learned competencies, followed by an open-ended survey of Biology teachers to determine persistent learning difficulties in the selected competency. During the development phase, the initial version of the interactive e-module was validated by the in-service teachers in terms of content, instructional, and technical quality and revised based on

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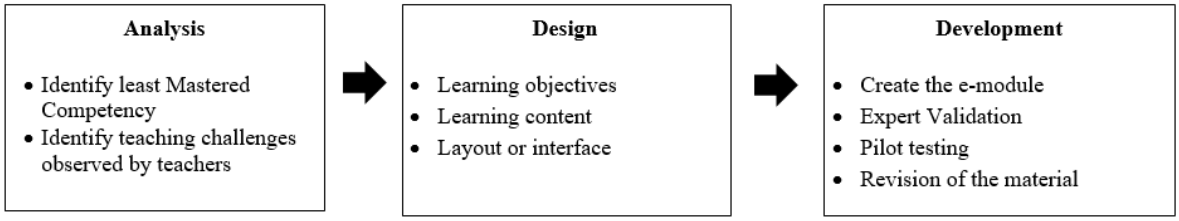
their comments and suggestions. The revised version was then pilot-tested to Grade 9 learners. From the comments of learner participants, the material had undergone another revision. Once the material was finalized, the material was ready for dissemination. Figure 1 shows the flow of the data gathering procedure.

Figure1: Data Gathering Procedure



RESULTS AND DISCUSSIONS

The development followed the ADDIE model, focusing on the Analysis, Design, and Development phases, to ensure that the instructional material is aligned with identified learning needs and curriculum standards.

Selection of Topic

The results of the needs assessment show that the Grade 11 learners have not mastered any of the assessed Biology competencies from Grades 7 to 10, as all mean percentage scores fall below 60%. As shown in Table 1, the top 10 least learned competencies obtained mean percentage scores ranging from 27.03% to 35.14%, all of which were classified as *Not Mastered*. The findings indicate that there are persistent learning gaps in topics requiring conceptual understanding and integration of biological processes. The findings are consistent with the study of Cantere and Nabua (2024) and Delos Santos et al. (2021) who reported that learners demonstrated low mastery across Biology competencies from Grades 7 to 10.

Table1: Least Learned Topics

Topic	Mean Percentage Score	Remarks*	Rank
1.Coordinated Functions of the Reproductive, Endocrine, and Nervous Systems	34.80	Not Mastered	1
2.Heredity: Inheritance and Variation	34.99	Not Mastered	2
3.Biodiversity and Evolution	42.57	Not Mastered	3
4.Respiratory, Circulatory, and Digestive System	42.70	Not Mastered	4
5.Ecosystems	43.24	Not Mastered	5
6.Microscopy and Cell Structure	46.85	Not Mastered	6

Note:* Not mastered (50 % below), Least mastered (51-74%), Nearly Mastered (75-79%), Mastered (80-100%)

Among the identified topics, the “Coordinated Functions of the Reproductive, Endocrine, and Nervous Systems” obtained the lowest MPR of 34.80, interpreted as “Not Mastered,” making it the most difficult competency for learners. Among the identified topics, the content area “Coordinated Functions of the Reproductive, Endocrine, and Nervous Systems” obtained the lowest MPS of 34.80, interpreted as “Not Mastered,” making it the least learned competency among the identified Biology topics. This result indicates that students experience significant difficulty in understanding the interactions and coordination among the three body systems, particularly the complex processes involving hormones, feedback mechanisms, and regulation of body functions. Because of its lowest mastery level, this topic was selected as the focus of the study and the basis for developing the HomeoHub interactive e-module.

The findings are consistent with previous local studies on least mastered competencies in Biology. Cantere and Nabua (2024) reported that competencies related to feedback mechanisms involved in the female reproductive system obtained the lowest mastery level in Grade 10 competencies. Similarly, delos Santos et al. (2021) found that although moving towards mastery, learners have not mastered the concepts of the reproductive system and their functions, role of hormones, feedback mechanisms, protein synthesis, and homeostasis.

Based on the DepEd K–12 curriculum, this content area requires learners to explain how the nervous and endocrine systems coordinate feedback mechanisms to maintain homeostasis and regulate reproductive processes. Due to the abstract and integrative nature of these concepts, students often develop misconceptions and fragmented understanding, as supported by previous studies (Michael et al., 2009; Modell et al., 2015; Cantere & Nabua, 2024; delos Santos et al., 2021).

Because of its low mastery level and conceptual difficulty, the topic was selected as the focus of the study and became the basis for developing the HomeoHub interactive e-module, which specifically emphasized homeostasis and feedback mechanisms in the female reproductive system.

Identification of Learning Gaps

The results from the needs assessment survey of teachers revealed that teachers consistently reported the limited availability of instructional materials as a major challenge. The absence of adequate DepEd-aligned resources forces teachers to rely on alternative materials such as internet sources and self-developed content. This lack of structured and curriculum-aligned resources may lead to inconsistencies in instruction and difficulty in presenting complex concepts effectively. Similar findings have been reported in local studies, where insufficient instructional resources contribute to learners' low mastery of Biology competencies (delos Santos et al., 2021; Cantere & Nabua, 2024). Another major challenge is the conceptual complexity of the topic. Teachers described homeostasis and feedback mechanisms as abstract, involving multiple interacting systems and processes that are not directly observable. The difficulty in creating hands-on activities further limits students' ability to concretize these concepts. This aligns with research indicating that learners struggle with Biology topics requiring systems thinking and integration of multiple concepts (Michael et al., 2009; Modell et al., 2015). The sensitivity of the topic also affects classroom dynamics. Teachers noted that some learners feel shy or hesitant to participate in discussions related to reproductive health due to cultural or religious beliefs. This may reduce student engagement and limit opportunities for clarification of misconceptions, thereby affecting understanding of the topic.

In addition, misconceptions related to reproductive health, such as incorrect beliefs about menstruation, pregnancy, and sexually transmitted diseases, indicate gaps in students' prior knowledge and real-life understanding. At the same time, conceptual misconceptions—such as confusion between positive and negative feedback mechanisms and unfamiliarity with the concept of homeostasis—suggest difficulties in understanding fundamental scientific ideas. These misconceptions are critical because they can hinder new learning if not addressed properly. Research shows that misconceptions often arise in topics involving abstract and invisible processes, particularly when instruction emphasizes memorization rather than conceptual understanding (Coley & Tanner, 2015).

In terms of instructional practices, teachers reported using a variety of traditional instructional methods, including lectures, textbooks, group discussions, and worksheets. While these approaches provide foundational knowledge, they may not be sufficient for teaching complex and integrative concepts such as feedback mechanisms. Teachers also identified more effective strategies, such as the use of simulations, real-life scenarios, diagrams, concept mapping, and collaborative activities. These approaches support visualization and active learning, which are essential for understanding abstract biological processes. These strategies align with research emphasizing that meaningful learning occurs when learners actively engage with content and construct their own understanding (Chi & Wylie, 2014). However, the limited use of such strategies suggests a gap between recommended practices and actual classroom implementation, possibly due to resource and training constraints.

Moreover, the findings reveal that while teachers recognize the value and effectiveness of interactive e-modules, their implementation is hindered by systemic constraints, including limited training opportunities and inadequate technological infrastructure. Two out of three respondents reported that they have not yet used interactive e-modules. One respondent who had experience using interactive e-modules described them as easy to use and engaging, suggesting that such tools have positive potential in enhancing teaching and learning. However, even this teacher emphasized that the use of interactive materials remains limited due to insufficient technological resources, particularly the lack of computers and necessary equipment in schools. These findings reveal that while teachers recognize the value and effectiveness of interactive e-modules, their implementation is hindered

by constraints, such as the lack of technological equipment. This creates a gap between the potential benefits of interactive learning and its actual use in classroom practice. Addressing these challenges is essential to support the adoption of innovative instructional approaches that can enhance learner engagement and conceptual understanding, particularly in complex topics such as homeostasis and feedback mechanisms.

Overall, the teacher's responses highlight interconnected issues, such as limited instructional resources, conceptual difficulty, learner misconceptions, and constraints in technology integration. These findings strongly support the need for interactive, multimedia-based instructional materials that can address these challenges. The identified need for visualization, guided explanations, and interactive learning experiences justifies the development of the HomeoHub e-module. By incorporating multimedia elements and interactive features, the module aims to enhance learner engagement and support deeper conceptual understanding of homeostasis and feedback mechanisms.

Design and Development Phase

The design and development process followed an iterative approach, where feedback from experts and pilot testing informed continuous revisions of the e-module. During the design phase, the structure, sequence of content, and interactive features of the e-module were planned based on the results of the needs assessment. The HomeoHub e-module was aligned with the Department of Education's Alternative Delivery Mode (ADM) framework, and 5E's lesson with enhancements to incorporate interactivity and multimedia features that support active learning. The module follows a structured sequence: Introduction, What I Know, Let's Explore, What Is It, What's More, What I Can Do, What I Have Learned, and Check Your Understanding.

Each section of the module was intentionally designed to support specific stages of the learning process:

Home Section. This serves as the main navigation interface, providing access to lesson chapters and module components. Its intuitive design enables learners to independently navigate the material, supporting self-directed learning.

Introduction. The Introduction presents an overview of the lesson, including learning objectives and target competencies. This ensures clarity of purpose and alignment with expected learning outcomes.

Let's Get Started. This section of the module serves as the engagement phase. It is designed to capture students' interest, activate their prior knowledge, and prepare them for the new lesson.

Let's Explore. This section includes inquiry-based and real-life contextual activities designed to activate prior knowledge and stimulate curiosity. This section encourages learners to examine real-world scenarios related to homeostasis and feedback mechanisms.

What Is It. This section presents the core instructional content using multimedia elements such as diagrams, animations, and visual representations. This section is critical in explaining abstract biological processes, including hormone regulation and system interactions.

Let Us Practice. This section provides guided practice activities that reinforce understanding and allow learners to apply concepts in structured tasks.

What I Can Do. This section includes performance-based tasks that require learners to apply their knowledge in real-life contexts, promoting transfer of learning.

What I Have Learned. This section encourages reflection and synthesis of key concepts. This section supports metacognitive development and helps learners identify relationships among concepts.

Check Your Understanding. This section involves a summative assessment or post-test to evaluate learners' mastery of competencies and measure learning gains.

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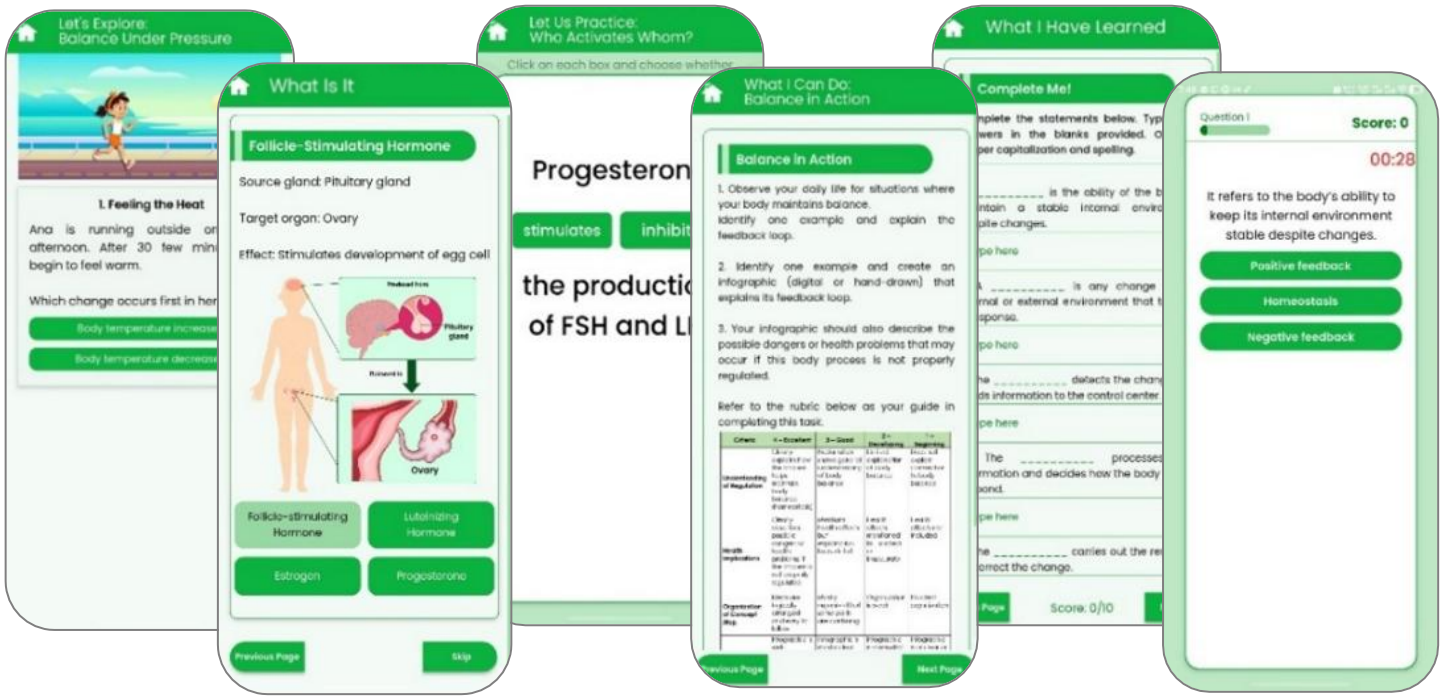
References. This provides a list of sources used in the module to ensure accuracy, credibility, and proper attribution of instructional materials.

Figure 1 shows some of the section in the e-module.

Figure 1. Sample of the Content of the Interactive E-module

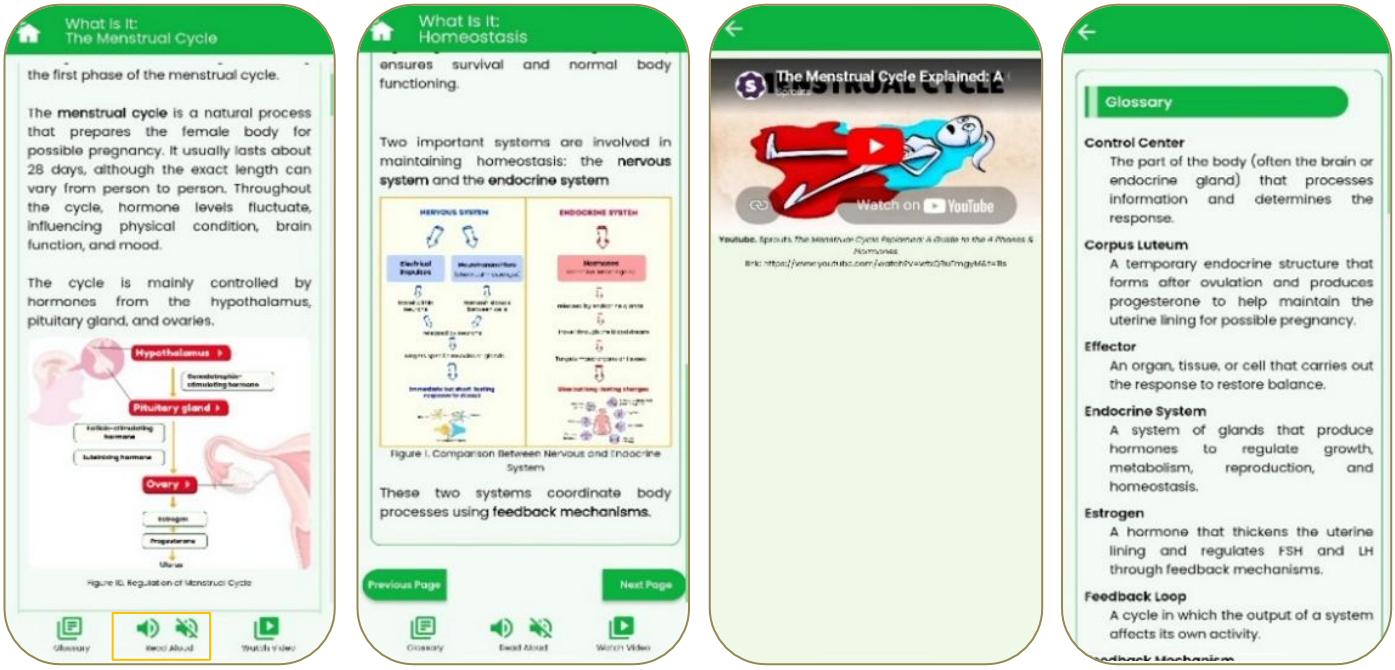


During the development phase, the HomeoHub interactive module was created using *FlutterFlow*, a low-code development platform that enables the creation of interactive and responsive mobile and web applications through a visual interface (FlutterFlow, 2024). The platform allows integration of multimedia such as a read-aloud feature, animations, educational videos, hyperlinks, and interactive quizzes that support active learning and learner engagement. Visual materials such as diagrams, illustrations, icons, and layout designs were developed using *Canva Pro*, a graphic design platform that enables users to create visual content through customizable templates, typography tools, and multimedia elements suitable for educational purposes (Canva, 2024). Additional instructional materials were obtained from Open Educational Resources (OER) and open-licensed educational videos available on YouTube to ensure accessibility, relevance, and compliance with copyright requirements.

One of the strengths of the HomeoHub e-module is that most of its content can be accessed offline, allowing learners to continue studying even with limited internet connectivity. However, embedded video links still require internet access for playback. Despite this limitation, the offline availability of core instructional materials, activities, and assessments increases the accessibility and usability of the module, particularly in areas with unstable internet connection. This feature increases the usability and accessibility of the module, particularly in schools and communities with limited internet connectivity. This is particularly important in the Philippine educational context, where limited internet access and technological resources remain major barriers to digital learning.

The interactive e-module also incorporates multimedia elements. Figure 2 shows some of the multimedia features of the inter-active e-module. Figure 2(a) shows a Read-aloud button that the students can click to enable the audio narration of the reading material. This gives the learner an option to process the information through audio instead of just reading the text. Figure 2(a) and 4(b) also show examples of diagrams and illustrations used in the e-module. Open-licensed educational videos from YouTube, as shown in Figure 2(c), are also embedded in the lesson to provide step-by-step explanations of feedback mechanisms and hormone regulation.

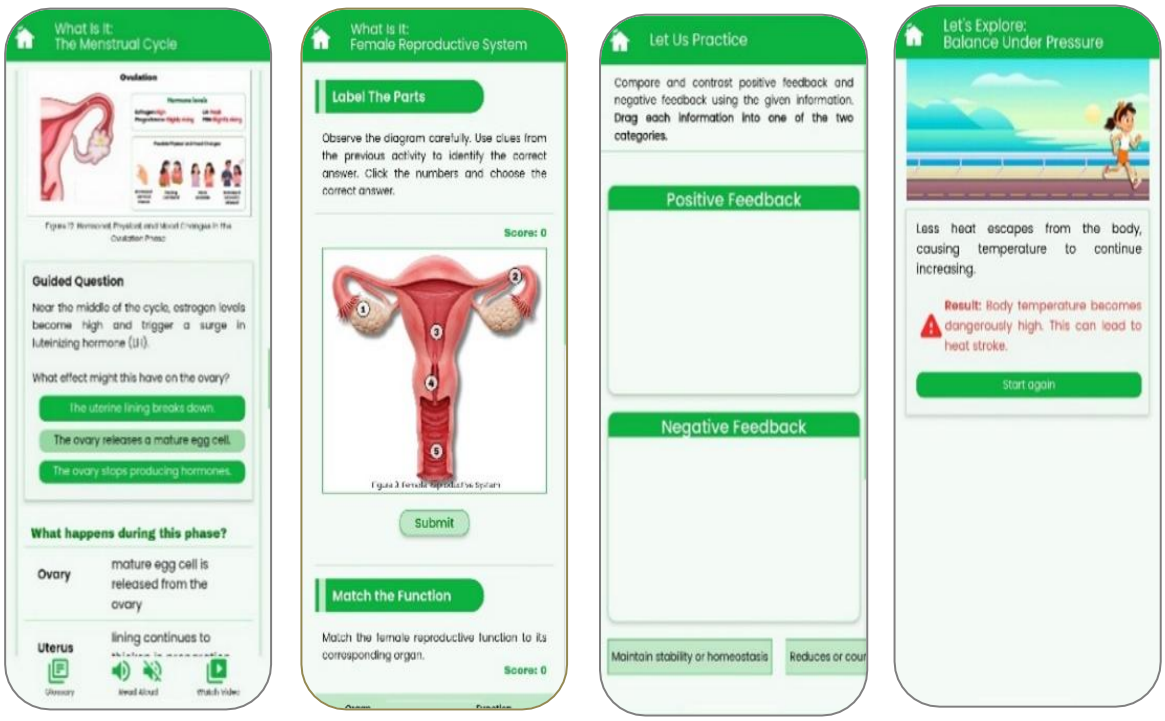
Figure 2. Multimedia Features



(a) Read-aloud (b) Infographics (c) YouTube video (d) Glossary

Figure 3 shows some of the interactive features incorporated in the e-module. Activities such as drag-and-drop, matching-type, branching scenarios, and labeling exercises allow learners to classify feedback mechanisms and identify reproductive structures and functions. Guided questions and immediate feedback with sound effects help learners recognize correct responses, identify misconceptions, and improve understanding throughout the lesson. The e-module also includes branching scenarios based on real-life situations involving body temperature, blood glucose, and hormonal changes, encouraging learners to apply concepts and analyze physiological processes involved in maintaining homeostasis (Bruner, 1961).

Figure 3. Interactive Features



Guided Questions (b) Hotspot image (c) Drag and drop (d) Branching scenario

The initial version of the e-module underwent internal testing to identify technical issues such as bugs, broken links, and interface inconsistencies. Necessary revisions were made, including debugging codes and refining design elements.

Expert Validation

After the initial development of HomeoHub, the prototype underwent expert validation to evaluate the quality of the instructional material in terms of content accuracy, clarity, organization, language, layout, and instructional design. The feedback provided by the validators was carefully analyzed and used as a basis for revising and improving the overall quality and usability of the e-module.

Table 2. Expert's Validation Rating on the Content Quality of the E-module

Statements	Mean	Description*
1. Content is consistent with topics/skills found in the DepED Learning Competencies for the subject and grade/year level it was intended.	4	Very satisfactory
2.Concepts developed contribute to enrichment, reinforcement, or mastery of the identified learning objectives.	4	Very satisfactory
3. Content is accurate.	4	Very satisfactory
4. Content is up-to-date.	4	Very satisfactory
5. Content is logically developed and organized.	4	Very satisfactory
6. Content is free from cultural, gender, racial, or ethnic bias.	3.8	Very satisfactory
7. Content stimulates and promotes critical thinking.	4	Very satisfactory
8. Content is relevant to real-life situations.	4	Very satisfactory
9. Language (including vocabulary) is appropriate to the target user level.	3.8	Very satisfactory
10. Content promotes positive values that support formative growth.	4	Very satisfactory
Mean	**3.96**	**Very satisfactory**

Note: * 1.00-1.75 (not satisfactory); 1.76-2.50 (poor); 2.51-3.25 (satisfactory); 3.26-4.00 (very satisfactory)

In terms of content quality, Table 2 obtained an overall mean of 3.96, interpreted as "Very Satisfactory," indicating high acceptability of the interactive e-module. Experts strongly agreed that the content is aligned with DepEd learning competencies, supports mastery of objectives, and is accurate, updated, and logically organized (all M = 4.00). The e-module was also rated very satisfactory in promoting critical thinking, relating concepts to real-life situations, and promoting positive values (all M = 4.00), showing that it supports meaningful and contextualized learning. These findings support Biggs' (1996) view that effective instructional materials are constructively aligned with learning objectives and assessments.

Meanwhile, the indicators on absence of bias and appropriateness of language obtained slightly lower means (M = 3.80), though still interpreted as "Very Satisfactory." Validators suggested using clearer and simpler language, shortening text passages, and adding a glossary of key terms to improve readability and comprehension. Despite these minor concerns, the results indicate that the e-module is generally suitable, curriculum-aligned, and suitable supporting conceptual understanding and meaningful learning.

Table 3. Expert's Validation Rating on the Instructional Quality of the E-module

Statements	Mean	Description
1. Purpose of the material is well defined.	4	Very satisfactory
2. Material achieves its defined purpose.	4	Very satisfactory
3. Learning objectives are clearly stated and measurable.	4	Very satisfactory
4. Level of difficulty is appropriate for the intended target user.	3.8	Very satisfactory
5. Graphics / colors / sounds are used for appropriate instructional reasons.	3.8	Very satisfactory
6. Material is enjoyable, stimulating, challenging, and engaging.	3.6	Very satisfactory
7. Material effectively stimulates creativity of target user.	3.8	Very satisfactory
8. Feedback on target user's responses is effectively employed.	4	Very satisfactory

9. Target user can control the rate and sequence of presentation and review.	3.8	Very satisfactory
10. Instruction is integrated with target user's previous experience.	4	Very satisfactory
Mean	**3.88**	**Very satisfactory**

Note: * 1.00-1.75 (not satisfactory); 1.76-2.50 (poor); 2.51-3.25 (satisfactory); 3.26-4.00 (very satisfactory)

The expert validation results in Table 3 showed that the HomeoHub interactive e-module obtained an overall mean of 3.88, interpreted as "Very Satisfactory," indicating high instructional quality and pedagogical soundness. Experts strongly agreed that the material has a well-defined purpose, achieves its intended objectives, and contains clear and measurable learning objectives (all M = 4.00). These findings reflect strong alignment among objectives, content, and learning activities, consistent with Biggs' (1996) principle of constructive alignment. The e-module also received very satisfactory ratings for appropriate difficulty level, effective use of graphics, colors, and sounds, stimulation of creativity (all M = 3.80), and effective use of feedback (M = 4.00). These suggest that multimedia elements were successfully integrated to support engagement and conceptual understanding, consistent with Mayer's (2009) multimedia learning theory. In addition, the material supported learner-centered and self-paced learning through learner control of pacing and integration of prior experiences (M = 3.80–4.00), aligning with constructivist learning theory (Jonassen, 1999). However, the indicator on enjoyment and engagement obtained the lowest mean (M = 3.60), though still "Very Satisfactory," due to comments on lengthy text, unclear statements, small fonts, and inconsistent navigation buttons. These findings suggest that minor improvements in readability and usability may further enhance learner engagement.

The findings indicate that the HomeoHub e-module has high instructional quality and strong potential as a supplemental instructional resource for teaching homeostasis and feedback mechanisms.

Table 4. Expert's Validation Rating on the Technical Quality of the E-module

Statements	Mean	Description
1. Audio enhances understanding of the concept.	3.8	Very satisfactory
2. Speech and narration (correct pacing, intonation, and pronunciation) is clear and can be easily understood.	3.8	Very satisfactory
3. There is complete synchronization of audio with the visuals, if any.	4	Very satisfactory
4. Music and sound effects are appropriate and effective for instructional purposes.	4	Very satisfactory
5. Screen displays (text) are uncluttered, easy to read, and aesthetically pleasing.	3.8	Very satisfactory
6. Visual presentations (non-text) are clear and easy to interpret.	3.8	Very satisfactory
7. Visuals sustain interest and do not distract user's attention.	3.6	Very satisfactory
8. Visuals provide accurate representation of the concept discussed.	3.8	Very satisfactory
9. The user support materials (if any) are effective.	4	Very satisfactory
10. The design allows the target user to navigate freely through the material.	4	Very satisfactory
11. The material can easily and independently be used.	4	Very satisfactory
Mean	**3.9**	**Very satisfactory**

Note: * 1.00-1.75 (not satisfactory); 1.76-2.50 (poor); 2.51-3.25 (satisfactory); 3.26-4.00 (very satisfactory)

Table 4 shows that the HomeoHub interactive e-module obtained an overall mean of 3.90, interpreted as "Very Satisfactory," indicating high acceptability in terms of technical quality. The findings suggest that the e-module is technically functional, user-friendly, and suitable for independent learning. Experts rated the synchronization of audio and visuals, appropriateness of music and sound effects, effectiveness of user support materials, free navigation, and independent usability as very satisfactory (all M = 4.00). These findings indicate that the multimedia and navigation features were effectively integrated to support learner engagement and ease of use, consistent with Mayer's (2009) multimedia learning theory. Indicators related to audio clarity, screen displays, visual presentations, and accuracy of visuals also received very satisfactory ratings (M = 3.80). However, the indicator on visuals sustaining interest and avoiding distraction obtained the lowest mean (M = 3.60), though still "Very Satisfactory," possibly due to comments regarding small font sizes and inconsistent navigation button placement.

Overall, the findings suggest that the e-module has strong technical quality, although minor improvements in readability, visual presentation, and interface consistency may further enhance learner engagement and usability.

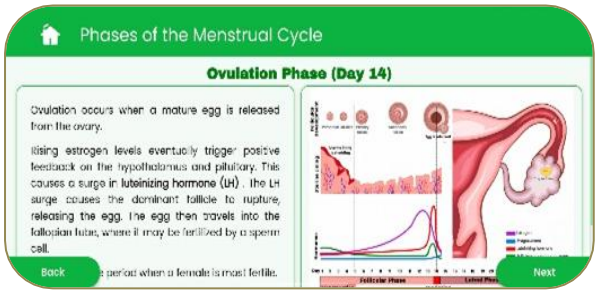
The results in Table 5 indicate that the HomeoHub interactive e-module is generally free from major errors and highly acceptable in terms of accuracy and reliability. All five experts rated the module as "Very Satisfactory" in the absence of conceptual errors, suggesting that the content is scientifically accurate and appropriate for Grade 10 learners. This is important because conceptual accuracy helps prevent misconceptions and supports meaningful learning (Mayer, 2009). Most experts also rated the module as "Very Satisfactory" in factual accuracy, grammatical correctness, and absence of technical or visual errors. However, a few validators noted issues such as unclear statements, lengthy text, inconsistent navigation buttons, small font sizes, and problems with some post-test items and score computation.

Table 5. Expert's Validation Rating on the E-module in Terms of Absence of Error

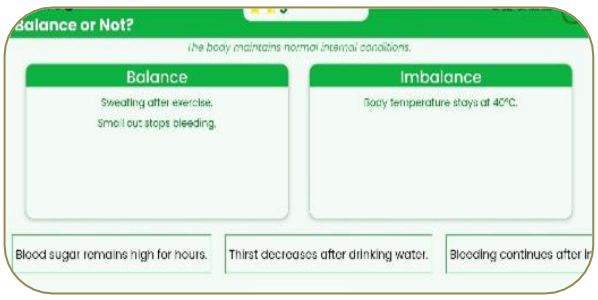
Statements	Very Satisfactory (4)	Satisfactory/Not applicable (3)	Poor 2	Not Satisfactory 1
1. Conceptual errors	5	---	---	---
2. Factual errors	4	---	---	1
3. Grammatical and/or typographical errors	3	1	---	1
4. Other errors (i.e., computational errors, obsolete information, errors in the visuals, etc.).	4	---	1	---

Despite these minor concerns, the findings indicate that the e-module is generally accurate, reliable, and suitable for instructional use. The results also suggest that revisions and technical refinements are necessary to further improve clarity, readability, usability, and overall quality.

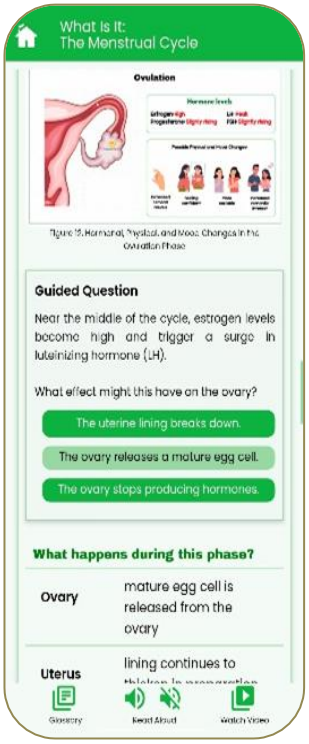
Figure 4. Instructional Revisions Based on Expert Validation



(a) Lengthy text before revision



(b) Confusing activity before revision



(c) Revised discussion

(d) Revised activity

Figure 4 shows some of the revisions made in HomeoHub based on feedback from the expert validation. Ambiguous statements were revised to be more specific, and a glossary of terms was added to define key

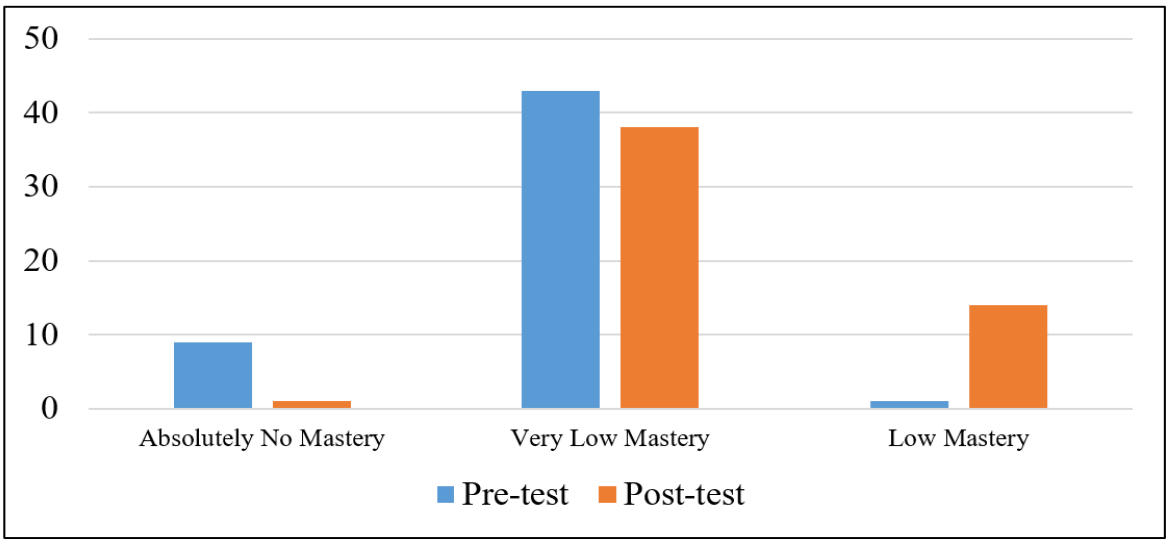
concepts. Additional discussions, including the roles of hormones and the parts of the female reproductive system, were incorporated to strengthen content coverage. Lengthy text passages were simplified and reduced, while some explanations were presented using diagrams, illustrations, infographics, and guide questions with immediate feedback to enhance readability and engagement. Regarding layout, font sizes were adjusted to improve readability and ensure consistency across pages. Navigation buttons were redesigned for uniform appearance and repositioned to enhance usability. Labels were standardized (e.g., "Previous Page" and "Next Page") to ensure clarity and consistency in navigation. Technical issues identified in the post-test, such as unselectable answer choices and incorrect score computation, were corrected to ensure proper functionality of the assessment component.

Pilot Testing

After incorporating revisions based on expert validation, the improved version of the e-module was pilot tested in a public secondary school. The pilot testing aimed to evaluate the clarity of instructions, usability of the interface, appropriateness of interactive activities, and technical functionality of the e-module when used by actual learners.

Figure 5 presents the learners' mastery levels before and after using the HomeoHub interactive e-module. The pilot testing results showed slight improvement in learners' mastery levels after using the e-module. During the pre-test, most learners were classified under "Very Low Mastery" (43 learners) and "Absolutely No Mastery" (9 learners), while only one learner reached "Low Mastery." After implementation, the number of learners under "Absolutely No Mastery" decreased from 9 to 1, while those under "Low Mastery" increased from 1 to 14, indicating improvement in learners' understanding of homeostasis and feedback mechanisms.

Figure 5. Distribution of Learners According to Mastery Level During Pre-test and Post-test



Legend: Absolutely No Mastery (0%-4%), Very Low Mastery (5 % -14 %), Low Mastery (15%-34%), Average Mastery, (65%- 35 %), Moving Towards Mastery (66 %- 85%),Closely Approaching Mastery (86%-95%),Mastered (96 %-100 %)

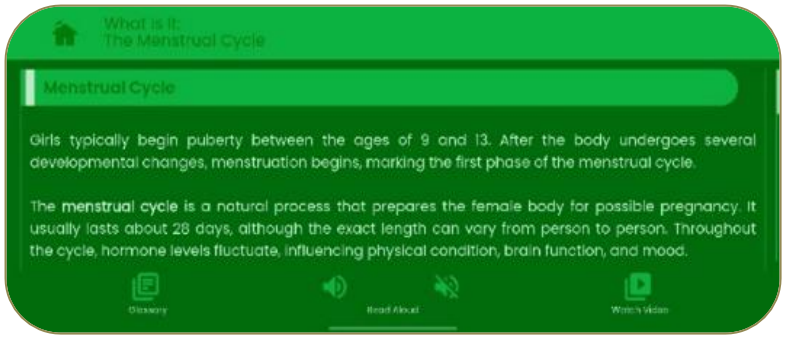
The observed improvement may be associated with the module's multimedia and interactive features, such as visuals, animations, simulations, quizzes, and contextualized examples, which helped learners understand abstract physiological processes. This supports Mayer's (2009) view that multimedia instruction enhances conceptual understanding through visual and verbal representations.

Despite the improvement, overall mastery levels remained low, as no learners reached "Average Mastery" or higher in the post-test. This may be due to the complex and abstract nature of the topic, which requires understanding interconnected biological systems and feedback mechanisms (Michael et al., 2009; Modell et al., 2015). In addition, usability issues identified during pilot testing, such as unclear instructions, confusing assessment items, navigation difficulties, and small font sizes, may have affected learner performance.

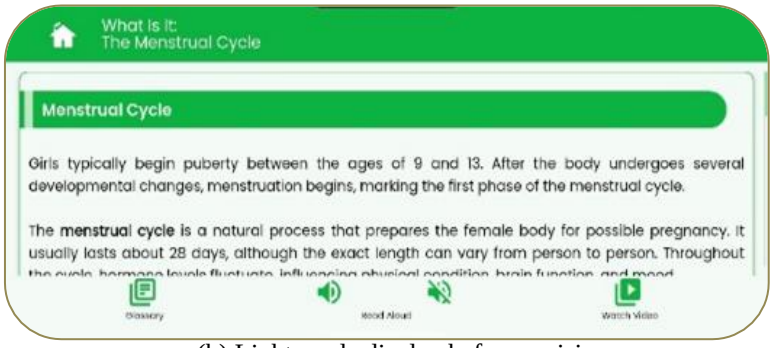
Consequently, revisions were made to improve the clarity, readability, and usability of the e-module before final implementation.

Figure 6 shows some of the revisions made from the issues identified during the pilot testing. Feedback gathered during pilot testing provided valuable insights into learners' interaction with the e-module and was used to further refine the design, layout, navigation, and functionality of HomeoHub to improve overall user experience and accessibility.

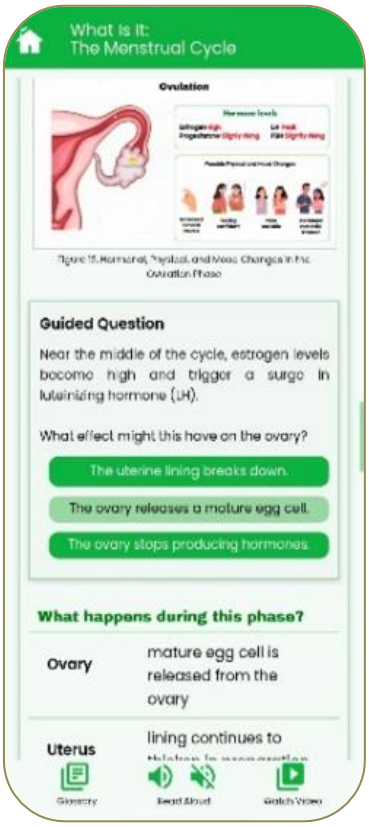
Figure 6. Revisions in Interface Layout and Responsiveness Based on Pilot Testing



(a) Dark mode display before revision



(b) Light mode display before revision



(c) After revision

Several issues were identified during pilot testing, particularly related to interface appearance, layout responsiveness, navigation usability, screen orientation, instructional clarity, and assessment items. Thus, the digital learning module was revised to ensure readability in both light and dark modes, improve responsiveness across different mobile screen sizes, and enhance visibility of navigation buttons. The e-module was also redesigned to function effectively in both portrait and landscape orientations to provide flexibility and ease of use for learners.

CONCLUSION AND RECOMMENDATIONS

The findings of the study revealed that Grade 11 learners demonstrated low mastery in several Biology competencies, particularly in the topic "Coordinated Functions of the Reproductive, Endocrine, and Nervous Systems," indicating difficulty in understanding homeostasis and feedback mechanisms due to the abstract and integrative nature of the concepts. Based on the identified learning needs, the HomeoHub interactive e-module was successfully developed and aligned with the DepEd learning competencies and curriculum standards. Expert validation results showed that the e-module obtained "Very Satisfactory" ratings in terms of content quality, instructional quality, technical quality, and accuracy and reliability, indicating that it is valid, acceptable, and suitable as a supplemental instructional material for Grade 10 Biology. Pilot testing results also revealed improvement in learners' mastery levels after using the e-module, suggesting that the multimedia and interactive features may support learners' conceptual understanding. However, despite the observed improvement, learners'

overall mastery levels remained low, indicating that the topic remains challenging and may still require additional instructional support and further refinement of the material. Overall, the findings suggest that the HomeoHub interactive e-module is a valid, engaging, and learner-centered instructional resource with potential for classroom implementation.

This study was limited to the Analysis, Design, and Development phases of the ADDIE model. Although pilot testing was conducted to gather feedback and preliminary evidence regarding the usability of the HomeoHub e-module, the Implementation and Evaluation phases were not formally carried out. Therefore, the effectiveness of the e-module in improving student learning outcomes cannot be conclusively established based on the findings of the present study.

Thus, the researchers recommend that future studies involve larger and more diverse samples from multiple schools to enhance the generalizability of the findings. Future researchers may also employ experimental or quasi-experimental research designs with control groups to determine the effectiveness of the HomeoHub e-module in improving students' Biology learning outcomes. Since the present study focused on the Analysis, Design, and Development phases of the ADDIE model, future research may proceed with the Implementation and Evaluation phases to assess the usability, effectiveness, and long-term educational impact of the HomeoHub e-module in actual classroom settings.

Ethical Considerations

This study adhered to the ethical guidelines of the Research Integrity and Compliance Office (RICO). Ethical clearance was obtained prior to data collection, and informed consent was secured from all participants and their parents or guardians. Participation was voluntary, and participants were informed of their right to withdraw at any time without penalty. To ensure confidentiality, all data were anonymized and stored securely, with access limited to the researcher. Data were used solely for research purposes and will be securely disposed of following the prescribed retention period. The researcher declares no conflicts of interest, and all research procedures were conducted with integrity, transparency, and respect for participant welfare.

Conflict Of Interest

The author(s) declare that there are no known financial, personal, professional, or institutional conflicts of interest that could have influenced the design, conduct, analysis, interpretation, or reporting of this study.

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