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Developing GLOSABIO: A Mobile Learning Application to Enhance Scientific Terminology Mastery

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ABSTRACT
Mastery of biological scientific terms often poses a challenge for students in General Biology courses. This study aimed to develop GLOSABIO, an Android-based learning application designed to improve students' understanding of biological scientific terminology. This research employed the Research and Development (R&D) method using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The research subjects included 33 students from the Science Education Study Program at the University of Bengkulu. Product validation was conducted by material and media experts using validation sheets, while student response questionnaires and a 33-item matching test were used to measure practicality and effectiveness. Data were analyzed using descriptive quantitative analysis, percentage analysis, and N-Gain analysis. The validation results showed that GLOSABIO was highly valid (93%), while practicality testing indicated that the application was very practical (89%). Students' average scores increased from 51.97 in the pretest to 86.41 in the posttest, with an N-Gain score of 0.717 categorized as high/effective. The paired sample t-test showed a significant difference between pretest and posttest scores ($p < .001$), with a very large effect size (Cohen's $d = 2.45$). These findings demonstrate that GLOSABIO is valid, practical, and effective in enhancing students' mastery of biological scientific terminology.

INTRODUCTION

Scientific terminology constitutes as a fundamental component of science education, functioning to define concepts, objects, phenomena, processes, and relationships with precision and clarity within a discipline. In the field of biology, these terms act as a universal language that empowers scientists and students alike to conceptualize and discuss complex scientific ideas accurately (Djumambetova, 2023). Mastery of biological terminology extends beyond the ability to memorize words (Dagnev, 2025); it is an essential foundation for fostering critical thinking, conceptual comprehension, and the effective articulation of scientific concepts (Kotsis, 2025). Without such proficiency, students frequently encounter significant hurdles when engaging with the intricate and rapidly evolving landscape of biological studies.

In the context of higher education, particularly within the Science Education Study Program, the mastery of scientific terminology constitutes a fundamental competence that significantly determines students' success in advanced courses (Lavrentieva et al., 2020). Preliminary observations within the General Biology course at the Faculty of Teacher Training and Education (FKIP) University of Bengkulu, indicate that students' mastery of these terms remains notably low. Evaluative data revealed that only a small fraction of students achieved scores above the B grade (≥75) in key subject areas, including Plant Structure and Function (15%), Animal Structure and Function (24%), Evolution (32%), and Biotechnology (26%). Furthermore, survey results disclosed that only 12% of students felt highly confident in their understanding of scientific terms, while 64% reported a lack of comprehension. This condition highlights the urgent need for innovation in learning media that can assist students in understanding scientific terms more effectively and engagingly.

Survey results also reveal that 94% of students prefer seeking explanations in the internet rather than reading textbooks or engaging in discussions with lecturers. This fact indicates a shift in learning preferences toward digital and mobile learning resources (Noskova et al., 2021). In the digital era, students tend to rely on technology as a primary tool for comprehending course materials. Digital-based learning applications, specifically those Android-based, possess significant potential to enhance accessibility (Huda, 2024) and learning interactivity, as they can be accessed anytime and anywhere (Roza et al., 2024) through personal devices such as smartphones (Wulansari et al., 2022).

Research on the development of digital-based glossary applications has been conducted across various disciplines, such as in Islamic Education (Hidayati, 2020), informatics (Sulistiyarini et al., 2025), and modern physics (Septian & Burhendi, 2022). However, a review of the existing literature reveals a critical gap in terms of functionality and pedagogical depth. The applications developed thus far generally remain limited to presenting content explanations and static reference lists in isolation. There is a notable absence of a reference menu system integrated directly with source citations on advanced platforms for visualization purposes, as well as a lack of adaptive bookmarking features capable of facilitating and tracking individual students' learning paces.

The absence of these integrated features results in low media interactivity, rendering similar applications incapable of shifting the student learning paradigm from mere rote memorization to meaningful conceptual understanding. This fundamental gap explains why the utilization of mobile learning within the domain of biological terminology has not yet yielded optimal results, particularly in addressing students' low comprehension of scientific terms in complex topics. Therefore, a media innovation is urgently required, one that functions not merely as a digital dictionary, but as an adaptive, visual data-driven independent learning instrument.

To address these limitations, the GLOSABIO application was developed, introducing several innovative aspects that significantly distinguish it from similar applications. GLOSABIO integrates a barcode-reference feature that enables students to scan codes to connect instantly with relevant scientific articles or supporting visualizations, along with a bookmark adaptive learning feature designed to track and categorize difficult terms based on students' self-paced learning rhythms. Additionally, the application is equipped with interactive evaluation features directly integrated with Google Forms to provide instant and measurable feedback. The specific scientific contribution of this research lies in the formulation of a glossary-based mobile learning model that empirically bridges the gap between scientific terminology mastery and conceptual understanding, while simultaneously offering a practical media alternative for implementation in science education.

The development of GLOSABIO is not only oriented toward providing new learning media but also plays a role in supporting technology-based active learning (Wang, 2020); (Sitthiworachart et al., 2022). The GLOSABIO application is expected to serve as an innovative solution to the limitations of less interactive conventional methods (Singh et al., 2024), while simultaneously aligning learning with the characteristics of today's digital generation (Chicioreanu & Amza, 2018). The utilization of mobile devices as learning media provides flexibility in time and space (Sirkemaa & Varpelaide, 2019), enhances learning motivation (Lamanauskas et al., 2019), provide efficient and user-friendly availability of learning content (Hidayat et al., 2024), and allows students to review materials independently (Cahya et al., 2020). Beyond contributing to improved learning outcomes, this research is also expected to serve as a developmental model for glossary-based mobile learning that can be adapted for other courses in science and education.

METHOD

This study employed a preliminary development study using a Research and Development (R&D) approach aimed at developing an Android-based learning media named GLOSABIO to enhance students' mastery of scientific terminology in the General Biology course. The development process followed the ADDIE model (Yeh & Tseng, 2019). The research subjects consisted of 33 students from the Science Education Study Program, FKIP Universitas Bengkulu, who had previously completed the General Biology course. Development activities were conducted from July to September 2025, while the implementation and evaluation phases took place from October to November 2025 at the GB IV Building, Universitas Bengkulu.

The research procedures were conducted as follows: 1) analysis, which involved identifying learning needs (Misesani et al., 2020), difficulties in understanding biological terms, and user characteristics to determine application content and features; 2) design, which included designing the user interface, navigation, and core features (Budoya et al., 2019), such as a glossary, visual illustrations, instructional video barcodes, and term bookmarks, as well as developing validation instruments for media and subject matter experts, student response questionnaires, and pretest-posttest instruments; 3) development, which entailed building the application using Android Studio and Flutter (Diansyah & Syafrinal, 2025), followed by validation by subject matter and media experts (Widyastuti & Susiana, 2019); 4) implementation, which involved executing the learning process (Rusdi et al., 2022) using the GLOSABIO media, assessing students' mastery of scientific terminology through pretest and posttest, and collecting student feedback via questionnaires (Sial et al., 2024); and 5) evaluation, which focused on assessing the effectiveness of GLOSABIO by analyzing validation results, practicality scores, and N-Gain scores (Risniawati et al., 2020). The development procedure of GLOSABIO is presented in Figure 1.

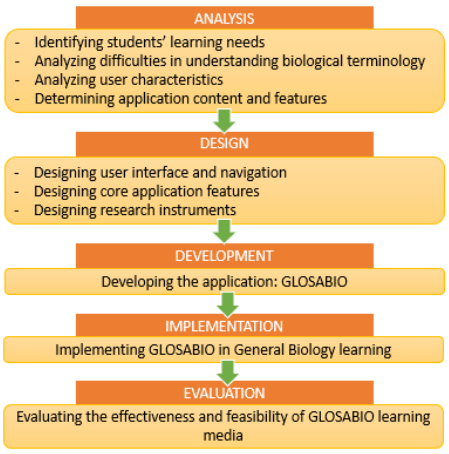


Fig.1. The flowchart of GLOSABIO development using the ADDIE model
(Source: Adeoye et al., 2024)

Research instruments included validation sheets for media and material experts, student response questionnaires, and a 33-item matching test used to assess students' mastery of biological scientific terminology. The validation process involved two expert validators consisting of one material expert in biology education and one media expert specializing in educational technology and digital learning media. Both validators possessed experience in science education research and instructional media development. The validation instruments assessed three major aspects: content validity, application design, and educational benefits. Data analysis was performed using a descriptive quantitative approach, calculating percentages to evaluate the feasibility of the GLOSABIO media based on the following formula:

$$P = \frac{\sum x}{n} \text{ x } 100\% \quad (1)$$

Notes:
P = Percentage
∑x = Total score obtained
n = Maximum possible score
(Source: Sholikha & Subrata, 2024)

The results derived from the product validation and assessment were classified according to the criteria shown in Table 1.

Table 1. Criteria for Expert Validation and Product Testing

Score	Percentage	Validation Category	Description
5	84% – 100%	Highly Valid	No revision needed
4	68% – 83,9%	Valid	Minor revision
3	52% – 67,9%	Moderate Valid	Moderate revision
2	36% – 51,9%	Less Valid	Major revision
1	20% – 35,9%	Highly Invalid	Total revision

(Source: Afifah et al., 2022)

Based on Table 1, the learning media is deemed feasible for use if it achieves a minimum percentage of 68% within the "Valid" category. A higher validation percentage indicates greater feasibility of the media, which subsequently correlates with a reduced need for revisions.

Following the validation process, a practicality test was conducted to determine the ease of use of the media within the learning process. The practicality of the media was assessed based on student responses toward the instructional tool, in this case, GLOSABIO. The response data were analyzed using the following formula:

$$\text{Practicality value} = \frac{Total\ score\ obtained}{Maximum\ possible\ score} \text{ x } 100\% \quad (2)$$

The practicality criteria for the learning media were determined based on Table 2. As shown in Table 2, the media is categorized as practical if it achieves a minimum percentage of 61%. A higher practicality score indicates that the learning media is easier for students to use.

Table 2. Practicality Criteria for Learning Media Adapted by Riduwan

Percentage	Practicality Category
0%-20%	Highly Impractical
21%-40%	Not Practical
41%-60%	Sufficiently Practical
61%-80%	Practical
81%-100%	Very Practical

(Source: Arianingsih et al., 2022)

In addition to the practicality test, an effectiveness test was conducted to determine the ability of the developed learning media to improve student learning outcomes, specifically in terms of scientific terminology mastery. The media's effectiveness was assessed by comparing students' pretest and posttest scores, which were then analyzed using the N-Gain score formula:

$$\text{N-Gain score} = \frac{\text{Posttest score} - \text{pretest score}}{\text{Maximum score} - \text{pretest score}} \quad (3)$$

The interpretation of the N-Gain score is classified according to the following criteria.

Table 3. N-Gain Score Criteria

N-Gain score	Classification	Criteria/Interpretation
≥0.7	High	Effective
0.3 - < 0.7	Medium	Moderately Effective
< 0.3	Low	Ineffective

(Source: Guntara, 2021)

Based on Table 3, the learning media is considered effective if the N-Gain score is ≥0.3, falling within the medium to high categories. A high N-Gain score indicates that the media contributes significantly to improving student learning outcomes, specifically in the mastery of scientific terminology within the General Biology course. To strengthen the effectiveness findings obtained from the N-Gain analysis, inferential statistical analysis was also conducted. Prior to hypothesis testing, a normality test using the Shapiro–Wilk test was performed to determine whether the pretest and posttest data were normally distributed. After the data met the normality assumption, a paired sample t-test was conducted to examine whether there was a statistically significant difference between students' pretest and posttest scores following the implementation of GLOSABIO. In addition, effect size analysis using Cohen's d was calculated to determine the magnitude of the instructional effect produced by the application. The statistical analyses were performed using Jamovi software at a significance level of 0.05.

RESULTS AND DISCUSSIONS

Results

This study utilized the ADDIE development model, which consists of several stages: analysis, design, development, implementation, and evaluation. The analysis phase aimed to identify the needs, challenges, and user characteristics that serve as the foundation for application development (Samsudin et al., 2021). This process was conducted through three primary approaches: first, a needs analysis that integrated prior student learning outcomes with perception questionnaires to accurately map difficulties in understanding biological terminology; second, a curriculum and content analysis through document study and mapping terms against Learning Outcomes to ensure content relevance; and third, a user characteristic analysis covering digital literacy, learning preferences, and device specifications. All data were descriptively processed to formulate a list of essential scientific terms and required application features.

The design stage focused on designing the structure and interface (Nowicki et al., 2024) of the GLOSABIO application. The activities included: 1) developing a user interface (UI) that is simple, engaging, and user-friendly; and 2) structuring content and navigation, which featured a collection of scientific terms with accessible definitions, visual illustrations to reinforce comprehension, application icon design using Canva Pro, a Search feature for finding terms by chapter or general keywords, a Reference feature via barcodes that direct users to relevant YouTube videos, and a Bookmarks feature to tag specific terms.

The development phase was executed to transform the design into an operational digital product Ali & Yahaya (2023). The steps included: 1) coding the GLOSABIO application using Android Studio, Flutter, GitHub, and HTML/CSS/JS (web-based) according to technical requirements; 2) internal

testing to ensure all features functioned correctly; and 3) product validation by material and media experts to assess content feasibility, visual design, and technical aspects. The GLOSABIO icon, developed using the Canva platform, is presented in Figure 2 below.

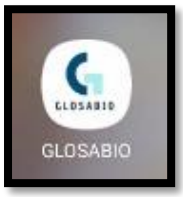
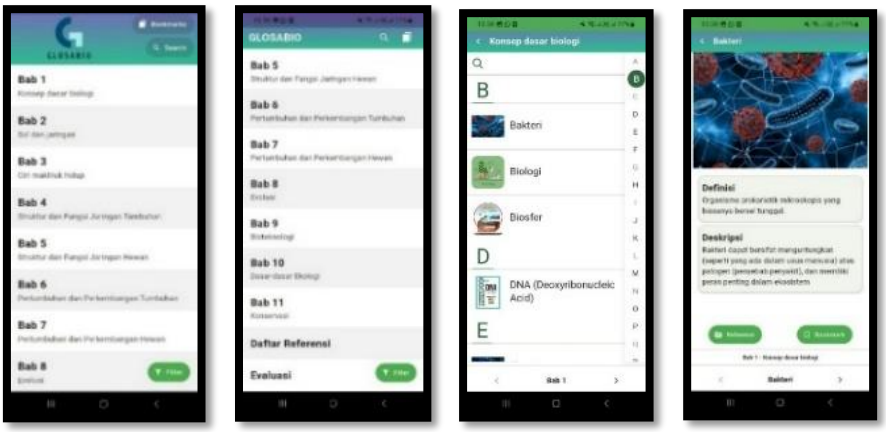


Fig.2. GLOSABIO application logo

The GLOSABIO application features 13 main menus that serve as learning guides and content navigation tools. These menus consist of: (1) Chapter 1: Basic Concepts of Biology, (2) Chapter 2: Cells and Tissues, (3) Chapter 3: Characteristics of Living Things, (4) Chapter 4: Structure and Function of Plant Tissues, (5) Chapter 5: Structure and Function of Animal Tissues, (6) Chapter 6: Plant Growth and Development, (7) Chapter 7: Animal Growth and Development, (8) Chapter 8: Evolution, (9) Chapter 9: Biotechnology, (10) Chapter 10: Fundamentals of Ecology, and (11) Chapter 11: Conservation, which discusses terms related to biodiversity preservation and sustainable natural resource management. Examples of the menu interface for Chapter 1 can be seen in Figures 3 (c) and (d). The overall user interface of the GLOSABIO menu is presented in Figure 3.



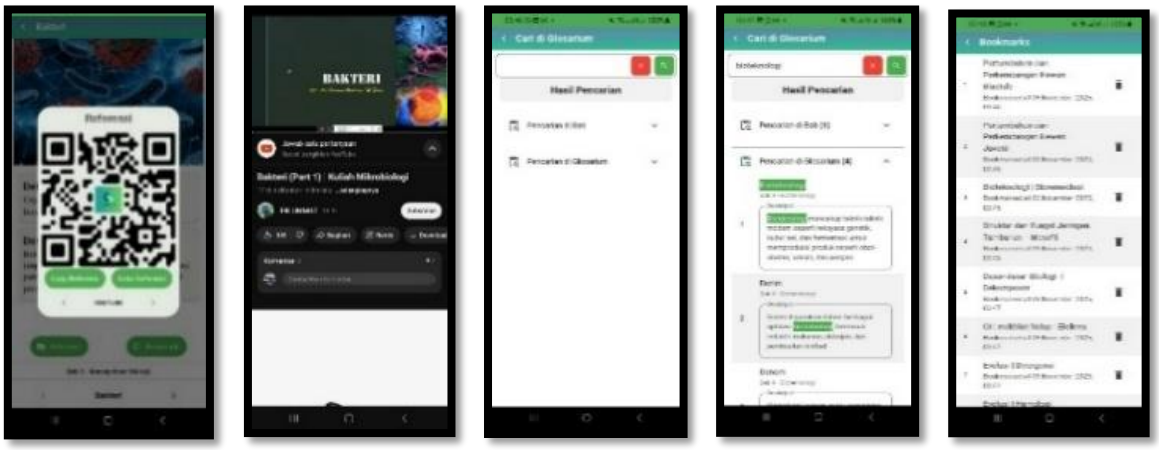
(a) (b) (c) (d)

Fig.3. Main menu interface; a) menu display for Chapters 1-8, b) menu display from Chapter 5 to the Evaluation menu, c) example of the Chapter 1 interface, d) interface of a scientific term consisting of a definition, description, reference, and bookmark.

Chapters 1 through 11 each provide 20 scientific terms relevant to the respective chapter titles. For every term, four sub-menus are available: a) definition, b) description, c) reference, and d) bookmark (examples are shown in Figure 3). The Definition sub-menu provides a precise explanation or meaning of the scientific term. The Description sub-menu offers supplementary information in sentence form that remains relevant to both the term and its definition.

The Reference sub-menu displays barcodes, which are machine-readable visual representations of data consisting of varying vertical lines and spaces for automatic and efficient information identification. In this context, the encoded data refers to direct links to the YouTube platform, accessible via Google Lens as the scanner. Additionally, this sub-menu offers accessibility without a scanner through two advanced features: a) Copy Reference and b) Open Reference. The 'Copy Reference' feature allows users to automatically copy the URL, which can then be pasted into any browser's address bar to access the YouTube content. Meanwhile, the 'Open Reference' feature provides direct and rapid

redirection to the YouTube platform. The interface resulting from the 'Open Reference' feature is illustrated in Figures 4.

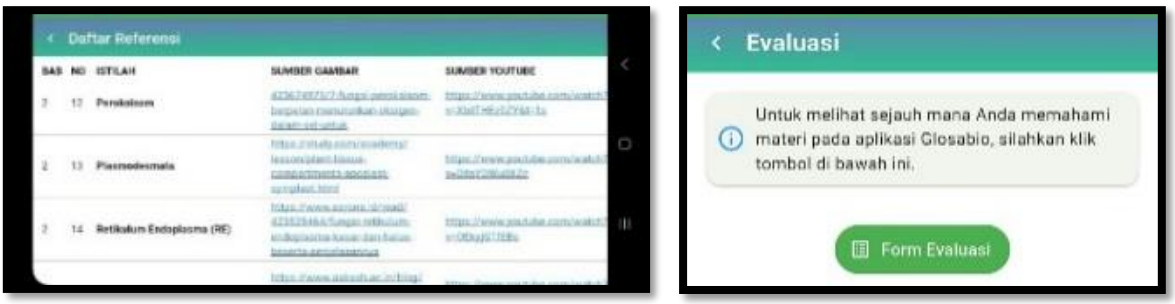


(a) (b) (c) (d) (e)

Fig.4. Interface of supporting features; a) barcode for a scientific term reference, b) example of the "Open Reference" feature interface, c) Search feature before a keyword is entered, d) Search menu interface after entering a keyword, e) Bookmark feature interface.

GLOSABIO is also equipped with several key interactive features: 1) Search Feature: This allows users to locate specific terms using keywords, chapters, or particular categories. The interface of the Search feature before and after keyword entry is presented in Figures 4 (c) and (d), 2) Bookmarks Feature: This functions to tag essential terms for rapid re-access. When a user selects a scientific term and clicks the bookmark icon, the term is automatically added to the Bookmark menu located on the main page, specifically within the Title Bar next to the GLOSABIO icon at the top. This term will be grouped with other bookmarked items. To remove a tag, the user simply clicks the bin (trash) icon, which automatically deletes the term from the Bookmark menu, as illustrated in Figure 4 (e).

The GLOSABIO application also provides additional menus, namely the Reference List menu, shown in Figure 5 (a), which contains photo sources and external links (from the YouTube platform), and the Evaluation menu, shown in Figure 5 (b). The latter provides practice questions based on biological terminology to measure the user's level of conceptual understanding. These evaluation questions are provided via a link connected to an assessment compiled using the Google Forms platform. This integration ensures that students and other learners can access the evaluation at any time without time constraints.



(a) (b)

Fig.5. GLOSABIO supporting menus; a) Reference List menu, b) Evaluation menu.

GLOSABIO provides a simplified navigation system, ensuring that users with varying levels of digital literacy can operate the application with ease. Each chapter can be accessed freely without a predetermined sequence, allowing for a flexible and needs-based learning experience. Through a combination of validated scientific content, an engaging interface, and adaptive functionality, the

GLOSABIO application serves not only as a digital dictionary for biological terminology but also as an interactive learning medium that supports the enhancement of scientific literacy, independent learning skills, and academic readiness for students in the field of biology.

Following the development phase, GLOSABIO underwent validation regarding its content and media aspects by two expert validators. During this validation stage, several revisions were made based on the experts' feedback, including the following Table 4.

Table 4. Expert Validation Feedback

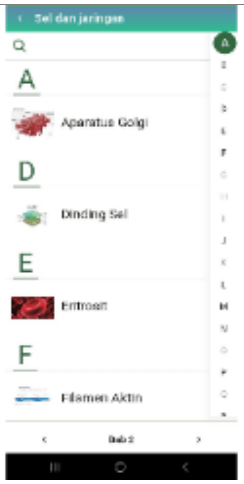
Validator	Feedback	Before Revision	After Revision
Content Expert	Definition writing must strictly adhere to proper sentence structure (Subject, Predicate, Object).		
Media Expert	Careful attention should be given to typography, especially capitalization and lowercase usage.		

Table 4 presents the feedback from validators regarding the media and content aspects that required refinement for product improvement. The content expert suggested that the definitions of terms must strictly adhere to proper sentence structure (subject, predicate, and object). Meanwhile, the media expert recommended paying close attention to typography, specifically the correct use of capitalization. Both sets of feedback were addressed to enhance the GLOSABIO application. Following these revisions, the validation results are presented in Table 5.

Table 5. GLOSABIO Application Validation Results by Content and Media Experts

No	Assessment Aspect	Evaluation Indicators	Validity Percentage	Validity Category
1	Content Validity	Content accuracy, definition precision, clarity of material, and alignment with learning objectives	97.5%	Highly Valid
2	Application Design	Ease of navigation, layout consistency, visual interface, and application accessibility	85%	Highly Valid
3	Educational Benefit	Learning motivation, comprehension effectiveness, independent learning, and suitability as a learning tool	95%	Highly Valid
Average			**93%**	**Highly Valid**

The validation results conducted by two expert validators show that the GLOSABIO application achieved an average score of 93%, placing it in the "Highly Valid" category. This value indicates that the developed application has met the feasibility standards for learning media in terms of content, design, and educational benefits. Generally, these results demonstrate that GLOSABIO is a feasible medium for use in General Biology courses, both in terms of scientific content accuracy and practical usability. This high validity score reflects a systematic development process that adheres to instructional design principles aligned with the ADDIE model, involving needs analysis, goal-oriented design, and continuous evaluation.

Regarding content validity, an average percentage of 97.5% was obtained (as shown in Table 5) across four indicators: content accuracy, precision of definitions and terms, clarity and readability, and alignment with learning objectives. These results indicate that the biological glossary content in GLOSABIO is consistent with scientific concepts and the General Biology curriculum. The validators noted that biological terms are presented concisely yet remain conceptually accurate, thereby facilitating student understanding. High editorial clarity and readability further strengthen the effectiveness of this media as a self-directed learning tool (Himmah et al., 2024). Overall, the content validity aspect earned an average score of 4.9, categorized as "Highly Valid."

In the application design aspect, indicators such as ease of navigation, interface consistency, visual appearance, and accessibility achieved an average validity percentage of 85%. This indicates that GLOSABIO was designed with an engaging interface, consistent layout, and a navigation structure that is easy for users to comprehend. The simple yet informative interface design is deemed to help students browse biological terms without operational confusion. This finding aligns with Mayer's multimedia design theory (Putra et al., 2025), which suggests that effective digital learning media should be user-friendly, visually appealing, and minimize cognitive load to optimize the information processing. Overall, the application design aspect received an average score of 4.25, categorized as "Highly Valid."

Meanwhile, the educational benefit aspect, with indicators covering learning motivation, effectiveness in enhancing comprehension, support for independent learning, and suitability as a learning tool, obtained an average validity percentage of 95%. This indicates that GLOSABIO is not only technically feasible but also pedagogically capable of supporting meaningful learning. Students can engage in independent learning (Adriani et al., 2020) using GLOSABIO anytime and anywhere, making the learning process more flexible and student-centered (Ridho et al., 2025) This finding is consistent with research by Setianawati et al., (2023), which suggests that student motivation and independence emerge from interactive learning experiences tailored to the digital generation's learning styles. Overall, the educational benefit aspect earned an average score of 4.75, categorized as "Highly Valid."

In conclusion, the overall average validation result of 93% indicates that GLOSABIO fulfills the principles of effective learning media development: content validity, visual appeal, and educational utility (Brawijaya et al., 2026) This success is attributed to the systematic application of the ADDIE model, where each phase (Analysis, Design, Development, Implementation, and Evaluation) was conducted sequentially and reflectively (Donkor et al., 2021). Thus, these validation results provide a

solid foundation for proceeding to the implementation phase to test the practicality and effectiveness of GLOSABIO in General Biology courses.

The implementation phase aimed to deploy the Android-based digital learning medium, GLOSABIO, to enhance students' mastery of scientific terminology in General Biology. The activities included: 1) introducing the application to students and providing a brief training session on its use; 2) utilizing GLOSABIO within the instructional process of the General Biology course; and 3) conducting a small-scale trial consisting of 33 students who utilized GLOSABIO as their learning tool.

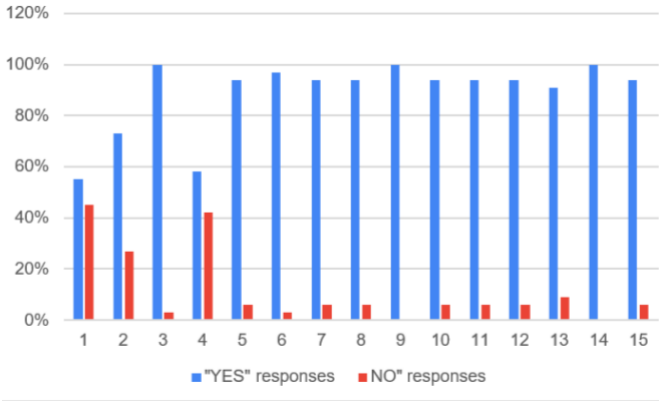


Fig.6. Practicality test results

The implementation results indicate that the use of the Android-based learning medium, GLOSABIO, was highly functional and well-received by students. This is evident in Figure 5 regarding the practicality test results. Based on the Practicality Test, 33 students responded to 15 questionnaire items, resulting in 89% "YES" responses and 11% "NO" responses. According to the practicality criteria, these student responses fall into the "VERY PRACTICAL" category. This high level of practicality is supported by the features available in GLOSABIO, which facilitate learning specifically within the General Biology course.

The evaluation phase was conducted following the instructional implementation of the Android-based learning medium, GLOSABIO, to assess the improvement in students' mastery of biological scientific terminology and ensure its effective use in learning. The effectiveness test results for learning with GLOSABIO are presented in Table 6 below.

Table 6. Results of Effectiveness and Inferential Statistical Analysis

Variable	Mean	SD	N-Gain	T	P	Cohen's d	Interpretation
Pretest	51.97	12.22					
Posttest	86.41	7.58	0.717	14.1	< .001	2.45	Effective

Based on Table 6, the pretest results for students' mastery of biological scientific terminology showed an average score of 51.97 (out of a maximum of 100), which increased significantly to 86.41 in the posttest. The N-Gain analysis yielded a score of 0.717, falling into the "Effective" category. This N-Gain score demonstrates that the use of the GLOSABIO learning medium is effective in enhancing students' understanding of scientific terminology in the General Biology course.

To strengthen the effectiveness findings obtained from the N-Gain analysis, inferential statistical testing was conducted using a paired sample t-test and effect size analysis. Prior to hypothesis testing, a normality test using the Shapiro–Wilk method was performed. The result showed a significance value of 0.492 ($p > 0.05$), indicating that the data were normally distributed. The paired sample t-test results revealed a statistically significant difference between pretest and posttest scores after the implementation of GLOSABIO ($t = 14.1$; $p < .001$). The descriptive statistics showed that the mean score increased from 51.97 (SD = 12.22) in the pretest to 86.41 (SD = 7.58) in the posttest. Furthermore, the effect size analysis using Cohen's d yielded a value of 2.45, indicating a very large effect size. These results strengthen the findings that GLOSABIO effectively improved students' understanding of biological scientific terminology.

Discussion

The results of the study showed that the Android-based learning media GLOSABIO was effective in improving students' understanding of biological scientific terms in the General Biology course. This was indicated by the increase in the average pretest score from 51.97 to 86.41 in the posttest, with an N-Gain score of 0.717, which falls into the high/effective category. These findings indicate that students experienced a significant improvement in conceptual understanding after using GLOSABIO in the learning process. The high N-Gain score demonstrates that the developed media not only helped students acquire new information but also facilitated deeper knowledge construction processes.

The improvement in understanding biological scientific terms in this study indicates that students need learning media capable of bridging abstract biological concepts into forms that are more concrete and easier to understand. Biological scientific terms are often complex because they use specialized terminology, Latin language, and possess high interconnections among concepts. When students experience difficulty understanding basic terminology, their comprehension of broader biological concepts is also disrupted. Therefore, the improvement in learning outcomes in this study indicates that GLOSABIO successfully assisted students in building conceptual understanding in a more systematic and structured manner.

Theoretically, the effectiveness of GLOSABIO can be explained through Mayer's multimedia learning theory. This theory states that learning becomes more effective when information is presented through an integrated combination of visual and verbal elements, thereby helping learners process information optimally within working memory (Galimova et al., 2025; Stanič & Špernjak, 2025). In the GLOSABIO application, scientific terms are not only presented in the form of textual definitions but are also complemented with additional descriptions, visual illustrations, and audiovisual references that support concept elaboration processes. Such diverse information presentation helps students connect scientific terms with more realistic biological contexts, making the process of understanding concepts easier and more meaningful.

In addition, the effectiveness of GLOSABIO can also be explained through the constructivist approach in learning. This approach emphasizes that knowledge is actively constructed by learners through independent learning experiences and interactions with learning resources. The use of GLOSABIO allows students to access materials flexibly, study terms according to their needs, and review materials anytime through Android devices. This flexibility supports self-regulated learning processes because students have greater control over their own learning. Research on mobile learning in science education shows that mobile device-based learning can improve cognitive engagement, higher-order thinking skills, and scientific communication because it supports more active and flexible learning processes (Galimova et al., 2025; Sangur & Zubaidah, 2025).

The findings of this study are also consistent with previous studies showing that Android-based learning media effectively improve learning outcomes and understanding of biological concepts. Research by Nofitasari et al. (2021) showed that Android-based biology learning applications could improve students' conceptual understanding because they provide flexible, engaging, and easily accessible learning experiences. Another study by Raistanto et al. (2023) also demonstrated that Android applications in biology learning improved students' learning outcomes and reading literacy through more interactive learning experiences. Furthermore, research by Amien & Saptono (2025) found that Android-based mobile learning media on cell materials achieved an N-Gain score of 0.78, categorized as effective in improving students' cognitive learning outcomes. These findings strengthen the results of the present study that the integration of mobile technology in biology learning contributes positively to improving learning quality.

Nevertheless, this study has a different focus compared to previous studies. Most prior studies focused on improving learning outcomes in biological concepts generally, whereas this study specifically emphasized students' understanding of biological scientific terms. This focus is important because scientific terminology forms the foundation of academic communication in biology. Understanding scientific terms not only helps students comprehend lecture materials but also supports their ability to read scientific literature, understand research journals, and communicate academically

in the field of science. Therefore, the effectiveness of GLOSABIO indicates that Android-based digital learning media can be used as a tool to strengthen students' scientific literacy.

From a pedagogical perspective, the effectiveness of GLOSABIO is influenced by the characteristics of student-centered learning. The application enables students to independently determine which terms they want to study, access additional references autonomously, and review materials according to their individual needs. Student-centered learning is known to enhance intrinsic motivation, curiosity, and active engagement in the learning process. Moreover, the use of mobile devices, which are closely integrated into students' daily lives, makes the learning process more contextual and relevant to the characteristics of today's digital generation. Recent systematic review studies also show that mobile learning in biology education can improve learning motivation, critical thinking skills, and student engagement by providing more interactive and flexible learning experiences (Sangur & Zubaidah, 2025; Jazuri et al., 2026).

The implications of this study for biology education are quite significant. The findings indicate that Android-based learning media can serve as an innovative alternative to address students' low understanding of scientific terminology. In the context of higher education, mastery of scientific terms is essential because it relates to students' ability to understand concepts, read scientific references, and develop scientific literacy. Therefore, the integration of digital learning media such as GLOSABIO can support the transformation of biology learning to become more adaptive to technological developments and the needs of the digital generation. In addition, the findings also indicate that biology learning should no longer focus solely on information transfer but should instead be directed toward developing active, independent, and technology-based learning experiences (Ubben et al., 2023; Wijaya et al., 2025).

The inferential statistical analysis further strengthens the effectiveness of GLOSABIO in improving students' understanding of biological scientific terminology. The paired sample t-test results revealed a statistically significant difference between students' pretest and posttest scores after the implementation of GLOSABIO ($t = 14.1$; $p < .001$). These findings indicate that the increase in students' understanding was not merely incidental but resulted from the use of the Android-based learning application during the instructional process. The substantial increase in the average score from 52.0 in the pretest to 86.4 in the posttest demonstrates that students experienced meaningful improvement in mastering biological scientific terminology after engaging with GLOSABIO.

In addition, the effect size analysis yielded a Cohen's d value of 2.45, which falls into the category of a very large effect size. This result indicates that GLOSABIO not only produced statistically significant learning improvements but also had a strong practical impact on students' conceptual understanding. A very large effect size suggests that the intervention contributed substantially to learning outcomes and provided meaningful educational benefits. These findings strengthen the previous N-Gain analysis and confirm that GLOSABIO effectively supports students in understanding complex biological terminology.

Overall, the results of the study indicate that GLOSABIO is effective in improving students' understanding of biological scientific terms because it supports knowledge construction processes, reduces cognitive load, increases learning engagement, and facilitates independent learning. These findings reinforce the importance of developing Android-based digital learning media in biology education, particularly to support scientific terminology literacy and strengthen students' conceptual understanding more deeply.

CONCLUSION AND SUGGESTION

This preliminary Research and Development (R&D) study successfully developed an Android-based learning application, GLOSABIO, using the ADDIE model to support students' mastery of biological scientific terminology in General Biology courses. The findings demonstrated that GLOSABIO is valid, practical, and effective as a digital learning medium. The validation results obtained from material and media experts showed an average score of 93%, categorized as "Highly Valid," indicating that the application meets the feasibility standards in terms of content accuracy, application design, and educational benefits. In addition, the practicality test revealed a positive student

response rate of 89%, categorized as "Very Practical," suggesting that GLOSABIO is easy to use and supports flexible learning processes.

The effectiveness test further demonstrated that GLOSABIO significantly improved students' understanding of biological scientific terminology. Students' average scores increased from 51.97 in the pretest to 86.41 in the posttest, with an N-Gain score of 0.717 categorized as "High/Effective." Furthermore, inferential statistical analysis using a paired sample t-test showed a statistically significant difference between pretest and posttest scores ($t = 14.1$; $p < .001$). The effect size analysis also produced a Cohen's d value of 2.45, indicating a very large effect size. These findings confirm that GLOSABIO not only provides statistically significant improvements but also has substantial practical impact on students' conceptual understanding of biological scientific terminology.

In addition, future development of GLOSABIO may integrate more advanced features such as adaptive learning analytics, artificial intelligence-based recommendations, gamification elements, and interactive simulations to further enhance students' engagement and conceptual understanding. Further studies are also encouraged to investigate the long-term impact of glossary-based mobile learning on scientific literacy, critical thinking skills, and retention of biological concepts in science education.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, A.P.A.; methodology, A.P.A.; formal analysis, A.P.A.; investigation, A.P.A.; writing—original draft preparation, A.P.A.; writing—review and editing, A.P.A., D.P., S.S., A.E.L., N., A.U., and Z.F.R. All authors have read and agreed to the published version of the manuscript.

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DECLARATION OF GENERATIVE AI SOURCES

During the preparation of this manuscript, the authors used Gemini (Google) for language improvement and grammar checking. All generated content was carefully reviewed, revised, and verified by the authors, who take full responsibility for the final content of the manuscript.

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