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Development of Taksonify Mobile Application for Learning Biological Taxonomy with Gamification and Computer Vision

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Abstract. Taxonomy and scientific names are the most important things that make up the foundation of biology education at the secondary level. But a lot of students have trouble with these subjects because of the old-fashioned way of teaching and all the Latin words. Traditional textbook-based teaching methods make this problem even worse. This study tackles the challenge students encounter in comprehending biological taxonomy by developing Taksonify, a mobile application aimed at enhancing taxonomy education through gamification and computer vision. The ADDIE development model (Analysis, Design, Development, Implementation, Evaluation) was used in the study. Expert validation was performed, and the application was evaluated on 35 tenth-grade students through pre-test and post-test assessments. An expert validation score of 4.73 (media) and 4.44 (content) showed that the evaluation was very likely to work. The average score went up from 16.91 (pre-test) to 20.44 (post-test), with a gain score of 0.69 (moderate). This means that comprehension improved a lot. These results show that Taksonify is a good way to learn about biological taxonomy because it helps students understand the subject much better. The use of Taksonify demonstrates the potential of mobile-based learning tools to improve science education quality, fostering greater interest and understanding of biology among secondary students. This research supports SDG 4 (Quality Education) particularly Targets 4.1 and 4.4, by improving student learning outcomes and strengthening ICT skills. It develops innovative mobile-based, gamified, and computer vision supported learning media to enhance the effectiveness of biology education.

Keywords: Biological taxonomy; learning media; gamification; computer vision; Visual Auditory Kinesthetic (VAK) learning styles.

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INTRODUCTION

Biology is a subject that requires a strong theoretical understanding. One of the topics in biology that demands deep comprehension is Taxonomy and Scientific Nomenclature (Binomial Nomenclature), which serves as the foundation for classifying living organisms into a hierarchical system consisting of Kingdom, Phylum, Class, Order, Family, Genus, and Species. Mastery of this material is essential as it forms the foundation for a comprehensive understanding of biology, particularly at the secondary education level. However, the abundance of scientific terms derived from Latin often poses a significant challenge for students in understanding and memorizing the material (Keeline & Kirby, 2023; Kulamikhina et al., 2022).

In schools, many students struggle to learn the biological classification of living organisms, especially taxonomy, the use of dichotomous keys, and classifying organisms based on observable characteristics. In class, teachers usually teach this material through textbooks and memorization. Because of these methods, students remember facts but don't know why they are true. There is a gap between the expected reasoning skills and what actually happens in the classroom, so we need to come up with more creative and flexible ways to teach (Risti et al., 2024). Textbooks are still the way people learn. But the problem with textbooks is that they make learning boring. This is because textbooks do not match the way students learn best. This is especially true in schools that do not have a lot of access to videos

or other tools that can help students learn (Baskaran Kannan et al., 2021; Lawrence et al., 2020; Levitt & Grubaugh, 2023).

The study suggests a solution to this problem with create a learning app called Taksonify. It is an app that helps teachers teach taxonomy in the classroom. Using gamification and computer vision technology, Taksonify helps teachers make the learning process more fun. Gamification features, like points, challenges, and leaderboards, are designed to keep students interested (Dinata, 2021; Khaldi et al., 2023; Zadeja & Bushati, 2022). Computer vision helps students automatically identify plants and animals in their surroundings, which helps them learn in context and through experience (Iskandar et al., 2023). Mixing gamification and computer vision technology makes Taksonify help people learn in different ways, such as by seeing, hearing, and doing.

The goal of this study is to develop the Taksonify app into an interactive learning tool that teachers can use to teach taxonomy in schools. In addition, the study also hopes to find out how well Taksonify works as a tool for instruction by measuring how much better students understand biological scientific naming, or taxonomy.

The goals of this study are two-fold. Initially, to develop Taksonify as a fun mobile educational app for biology teachers to use in teaching about taxonomy. Second, to assess how much Taksonify is able to improve students' understanding of biological scientific nomenclature, especially through a comparison of educational outcomes before and after using the application through pre and post-test assessments.

This study makes several contributions to the science education field. Taksonify is a powerful instructional resource for educators, reducing the dependency on textbooks and enhancing differentiated instruction for Visual, Auditory, and Kinesthetic (VAK) learning styles. The application enables students to directly interact with species in real environments and improve their understanding of abstract taxonomic concepts. In the wider scope of educational technology, the research provides an operational model to merge gamification and computer vision within a mobile platform for secondary science education. Taksonify tackles educational inequality socially by providing a technology-enhanced learning platform that operates on personal smartphones, increasing access to quality biology education for resource-limited schools.

RESEARCH METHODS

This study employs a quantitative methodology utilizing the ADDIE model, which is extensively applied in the research and development of educational media (Aprilanti et al., 2023; Rahmandhani & Utami, 2022). The five stages of ADDIE are Analysis, Design, Development, Implementation, and Evaluation (see Figure 1). This method makes sure that the development process is organized, starting with figuring out what users need and ending with testing how well it works (Moses Adeleke Adeoye et al., 2024).

Analysis

The first step in the study is to conduct an analysis. At this point, you need to figure out what the user needs, what the instructional goals are, what the learner is like, and what the problems are with teaching and learning taxonomy. A literature review, direct observation, and interviews with biology teachers are used to gather data about the learning environment and the availability of technology that can help.

The study found that it is difficult for high school students to learn and teach how to classify living things (Fahmi et al., 2021). For teachers, the amount of material is too large for teachers to cover in a short amount of class time without other tools to help students learn (Birzina, 2023). On the other hand, students have a hard time because the material is hard to picture just using textbooks and has a lot of hard Latin words. This makes lessons less interesting and makes it harder to pay attention while learning (Amelia et al., 2025; Sattar et al., 2025).

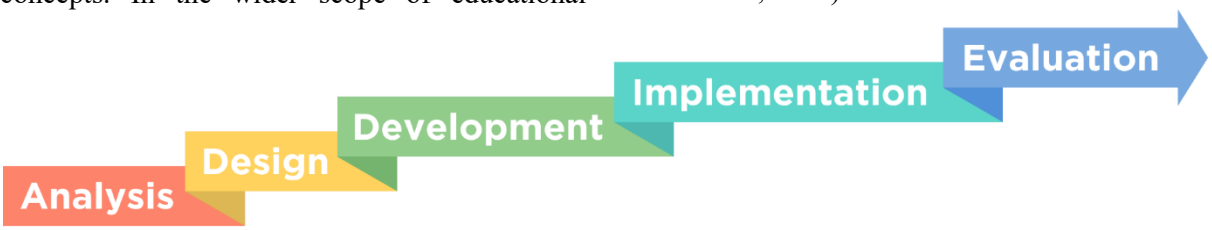

Figure 1. The research stages follow the ADDIE approach.

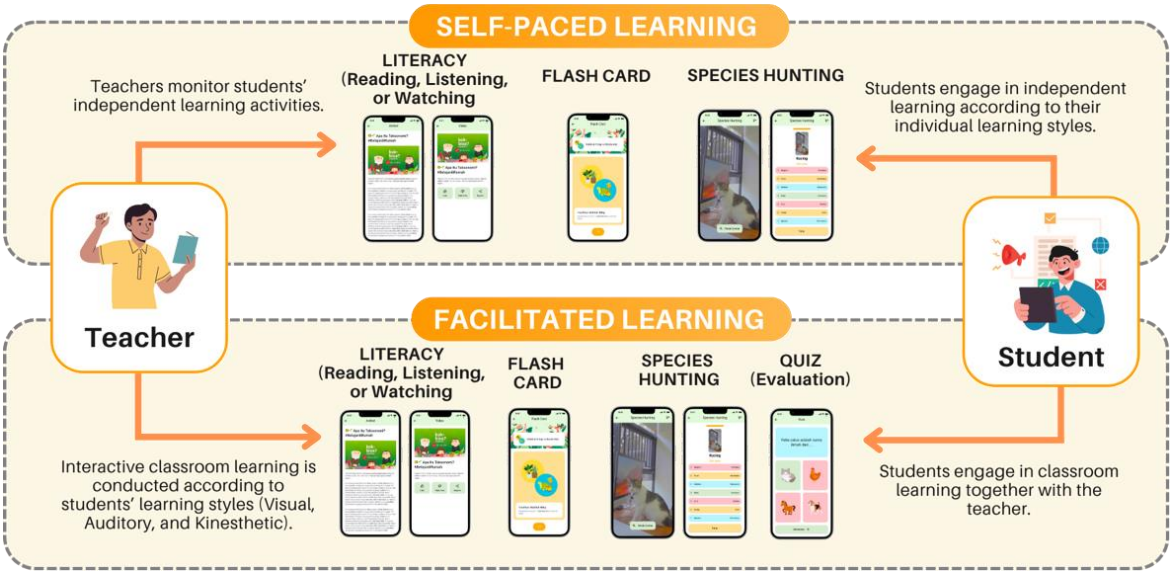

Figure 2. Overview of Taksonify features: learning materials, flashcards, gamified quizzes, and species hunting, from left to right.

Design

A hypothesis was developed subsequent to the analysis phase. For the teacher to be a facilitator and for the learning process to stay student-centered, there needs to be a way for students to learn. This hypothesis prompted the development of a solution in the form of a mobile application named Taksonify. The aim is to enhance the learning process by combining guided instruction with autonomous learning via interactive media. Teachers don't use lectures with this method, and students learn on their own (Figure 2).

The design stage focuses on creating the Taksonify application interface. This includes ideation for key features that support Visual, Auditory, and Kinesthetic (VAK) learning styles. These features include infographic articles (visual), interactive videos (visual-auditory), and gamified quizzes, along with a species hunting feature (kinesthetic). The initial user interface and application flow were developed using design software such as Figma, taking into account educational design principles and mobile accessibility. Figure 3 illustrates the prototype design of several features within the Taksonify application and how it works.

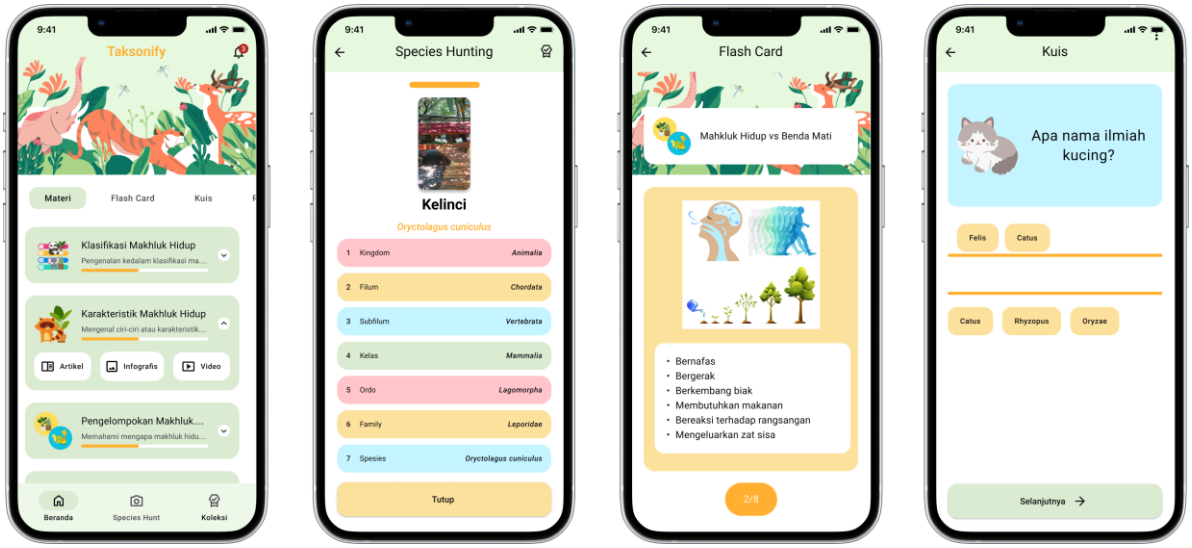

Figure 3. Display of Taksonify application features, including learning materials, species hunting, flashcards, and gamified quizzes (from left to right).

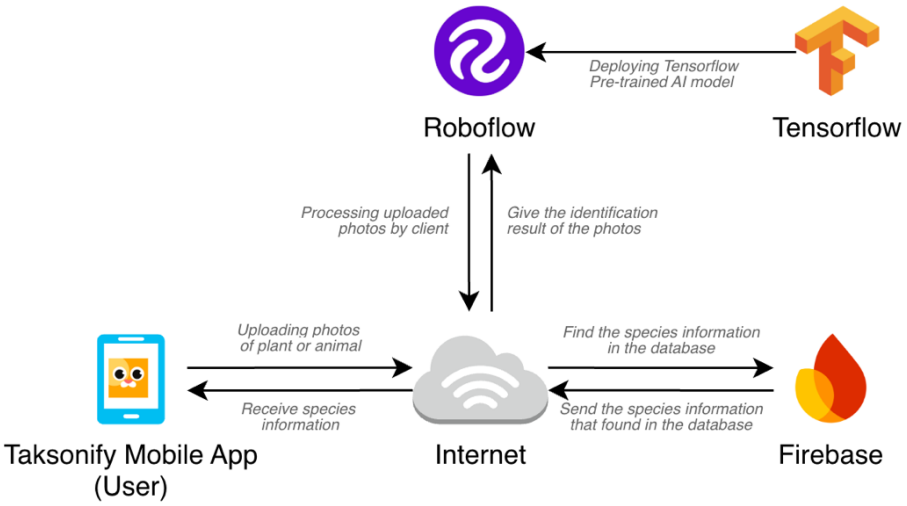

Figure 4. Illustrates the system architecture of the Taksonify mobile app.

Development

After the design stage is completed, the next phase is development, in which the learning media is no longer merely a concept but is transformed into an actual product. Since the intended solution is a mobile application serving as a learning medium, this stage involves the coding and implementation of the Taksonify mobile application. Mobile-based learning innovation is highly relevant, which emphasizes independent, flexible, and technology-oriented learning (Drigas & Angelidakis, 2017; Mohammad Fatkhul Amien & Saptono, 2025).

To ensure that user needs are met, particularly the requirement for cross-platform availability on both Android and iOS, the Flutter framework was selected for developing Taksonify. Platforms such as Flutter enable the development of responsive and interactive cross-platform applications (Jošt & Taneski, 2025).

In addition, Taksonify includes a species-hunting feature powered by computer vision technology. Computer vision is a branch of artificial intelligence (AI) that enables systems to recognize, process, and interpret visual objects such as images or videos (Pandey, 2023; Wang & Wang, 2023). TensorFlow Lite was used to train the model for detecting images of animal and plant species. This model was then deployed using the Roboflow service. All components are integrated in real-time with the support of Firebase as the database. An overview of the Taksonify application architecture is presented in Figure 4.

Implementation

The implementation stage was conducted through a limited trial involving students who were studying taxonomy. During the testing process, the application was used independently by students within a biology learning session facilitated by the teacher. During implementation, the Taksonify application is used based on a predefined scenario. The process starts in class with a pre-test to assess students' prior knowledge. Then, the teacher uses the Taksonify app to teach the students about scientific naming in a way that fits their learning styles. At the end of the session, there is a post-test to see how much the students have learned.

Evaluation

The last step of this study is evaluation. This process analyzes the implementation results to measure the effectiveness of Taksonify as a learning tool for teachers in the classroom and also assesses its impact on improving students' understanding of biological taxonomy in the school. The evaluation uses both formative and summative assessments with a quantitative approach (Zhang et al., 2023). The formative evaluation sought to gather feedback from experts during program implementation. Media and subject matter experts were involved in this phase to complete validation forms containing assessment indicators based on a five-point Likert scale, which included aspects such as content clarity, curriculum alignment, display consistency, navigation, and interaction quality. The average score for each aspect was calculated

using the following formula:

$$Average\ Aspect\ Score = \frac{Total\ Score\ Obtained}{Number\ of\ Indicator} \quad (1)$$

$$Maximum\ Total\ Score = Number\ of\ Indicators \times Highest\ Score \quad (2)$$

The assessment results from media and content experts were used to determine the feasibility category based on the following classification:

4.21 – 5.00 = Very Feasible
3.41 – 4.20 = Feasible
2.61 – 3.40 = Fairly Feasible
1.81 – 2.60 = Less Feasible
1.00 – 1.80 = Not Feasible

Subsequently, the summative evaluation aimed to measure the final competencies or learning objectives achieved through pre-test and post-test instruments consisting of multiple-choice and short-answer questions. The results were used to analyze effectiveness by measuring students' improvement in understanding using the gain score formula (Purwandari et al., 2025). The gain score formula is as follows:

$$Gain\ Score\ (g) = \frac{(Post-test\ Score - Pre-test\ Score)}{(Maximum\ Score - Pre\ test\ Score)} \quad (3)$$

This formula is widely used to assess the effectiveness of learning interventions by comparing pre-test and post-test results. The effectiveness category of students' comprehension improvement based on gain score is classified as follows:

g > 0.7 = High
0.3 < g ≤ 0.7 = Moderate
g ≤ 0.3 = Low

RESULTS AND DISCUSSION

This study resulted in the development of an interactive Android-based learning application called Taksonify, designed to enhance students' understanding of taxonomy and the scientific nomenclature of living organisms. The application integrates various features, including learning articles, educational videos, flashcards, interactive quizzes, and a computer vision-based species hunting feature that allows students to identify species directly from photographs of their surrounding environment. To evaluate the quality of its development and the effectiveness of its implementation, a series of formative and summative tests were conducted involving both experts and students.

Media Feasibility Validation

The formative evaluation was done by two experts, one in instructional media and the other in biological content. The media expert said that the application got an average score of 4.73 out of 5, which means it is "very feasible" (Table 1). The most important things were how easy it was to use, how well it worked with other media, and how it looked, which people said was both pretty and easy to understand.

The material expert's validation (Table 2) showed an average score of 4.44, which is "very feasible." The highest score was for the learning impact aspect.

Table 1. Recapitulation of media expert validation of the Taksonify mobile app as an interactive biology learning medium.

No.	Statement Item	No. of Indicators	Score	Average (Score/ Indicator)
1.	Ease of Use	3	14	4.70
2.	Visual Appearance	5	24	4.80
3.	Media Integration	4	19	4.75
4.	Media Benefits	3	14	4.70
Total		15	71	4.73 (Very Feasible)

Table 2. Recapitulation of material expert validation of the Taksonify mobile app based on biological taxonomy content appropriateness.

No.	Statement Item	No. of Indicators	Score	Average (Score/ Indicator)
1.	Material Relevance	4	17	4.25
2.	Material Presentation	4	18	4.50
3.	Exercises and Grammar	5	22	4.40
4.	Learning Impact	5	23	4.60
Total		18	80	4.44 (Very Feasible)

These results show that experts consider Taksonify suitable for use as a learning medium in schools. The content aligns with learning objectives and the school curriculum. Validation results also show that the development process follows key principles of digital educational media design. These include clarity of information, ease of navigation, and alignment with student characteristics. These aspects align with prior studies such as Nurjanah et al. (2026) and Wahyudianto et al. (2025), which emphasize content relevance, information accuracy, visual design quality, and interactive navigation in digital learning media.

Overall, the results confirm that each ADDIE stage was implemented effectively. This aligns with findings from Nurrokhmah et al. (2024), where biology learning media developed using the ADDIE model achieved high feasibility ratings from both media and subject matter experts. The relatively low score in the Material Relevance aspect (4.25) in Table 2 indicates a need for improvement in the materials for future development.

Learning Effectiveness

To test the effectiveness of Taksonify and its impact on learning outcomes, a summative assessment was conducted using pre-test and post-test instruments with a total of 35 students in one class. The instrument consisted of 22 multiple-choice and short-answer questions based on the Campbell Biology book. It was designed to measure students' understanding of the classification of living organisms, taxonomic structure, and the application of scientific naming systems. This evaluation method is in line with what is usually done in research on learning media, which uses pre-tests and post-tests to see if digital interventions have helped people learn (Jii Toh & Tasir, 2024).

Table 3 shows the results of the test. The median score before the test was 17, and the average score was 16.91 out of 22. The average score on the post-test went up to 20.44 out of 22, with a median of 22, after an interactive learning session with Taksonify.

Table 3. Recapitulation of Post-test and Pre-test Results.

Number of Correct Answers	Number of Students	
	Pre-test	Post-test
9	1	0
13	6	0
14	1	0
15	4	0
16	4	3
17	6	1
18	3	1
19	1	2
20	2	2
21	2	2
22	5	14
Summary of Correct Answers		
Average	16.91	20.44
Median	17	22

Table 3 shows that there has been a clear improvement in student performance. In the post-test, 14 students got the highest score, while only 5 students did in the pre-test. The fact that so many students got the highest score shows that they have a much better understanding of taxonomy concepts at the mastery level.

Hake's normalized gain formula is used to find out how well learning worked with Taksonify by comparing the scores of the pre-test and post-test. The outcome is as follows:

$$g = \frac{(20.44 - 16.91)}{(22 - 16.91)} = \frac{3.53}{5.09} \approx 0.69 \quad (4)$$

A gain score of 0.69 was reached, which is in the middle range ($0.3 < g \leq 0.7$). This result shows that Taksonify helps students learn about taxonomy a lot.

Role as an Interactive Instructional Medium

The results of the improvements that occurred show that Taksonify helps teachers a lot so that students learn well. Students are more motivated when they can choose how they want to learn; they can learn through experiences. They can play games like quizzes with points, challenges, and interactive feedback. This is consistent with studies by Furkan Kurnaz & Koçtürk (2025) and Ratinho & Martins (2023) that show gamification enhances engagement and motivation; it captures students' interest.

Students can learn about living things in their environment by taking pictures using a species search feature that uses computer vision. This changes the way we learn about species from memorizing to actually experiencing it. All these features work together to support learning styles, like visual, auditory, and kinesthetic styles, in one place. This is what makes Taksonify different from learning apps and what makes it a full learning ecosystem that fits with the curriculum.

Taksonify is also helpful for schools that do not have a lot of teaching tools or can not go on field trips. The problem of not having devices is no longer a problem because students now have personal smartphones and teachers can use these smartphones in interactive teaching and learning processes (Yadav & Chakraborty, 2024).

Taksonify is a unique mix that has not been seen in previous mobile learning apps for secondary biology teaching. Previous research has used either gamification or computer vision, but in this case Taksonify combines both. The species hunting functionality allows students to recognise real species from pictures taken in their environment, linking the taxonomy lessons in the class to a direct exploration in the field. By identifying real-world aspects, this turns taxonomy from a rote memorisation task into an experiential learning experience. To the best of our knowledge, no previous work in secondary biology education has reported a mobile app that combines gamified assessment, computer vision species identification, and multi-modal content delivery, all in a single platform, and with alignment to national curriculum standards.

This research has a number of benefits for science education and the wider community. It provides empirical evidence that a gamified mobile application with the help of computer vision leads to a moderate but significant increase in students' understanding of biological taxonomy with a gain score of 0.69. This adds to a growing body of research supporting the use of technology-enhanced approaches in secondary natural science education.

Taksonify is a structured, curriculum-based resource for biology teachers that reduces preparation efforts and increases students' engagement in taxonomy instruction. The app provides students the opportunity to build content knowledge and online literacy abilities through engaging, self-directed learning. The research promotes equal access to quality science education through a mobile solution that can be used on personal devices, without the need for expensive lab equipment or field trips. This actively contributes to the achievement of SDG 4 (Quality Education), especially Targets 4.1 and 4.4, by improving learning outcomes and reinforcing students' ICT abilities via accessible digital resources.

CONCLUSION

This study successfully created a learning app called Taksonify to help students learn about taxonomy in secondary school. Experts said it was ready to use and gave it high scores for media and content. The scores were 4.73 and 4.44, which means the app is very useful. The students who used Taksonify got better scores. At first, their average score was 16.91 and increased after using Taksonify to 20.44. This shows that Taksonify really helped students understand taxonomy and scientific names. The improvement was moderate, with a gain score of 0.69. This also shows that using games and computer vision in learning can be a way to support quality education, which is in line with the goals of SDGs Targets 4.1 and 4.4.

There are some things that this study didn't look at which can be done in the future. First, the app should be tested in large areas to see if it works everywhere. Second, the experts said the app's materials are still limited, with a score of 4.25, so the materials needs to be adjusted. Last, this study didn't see if students still remembered knowledge after a long time. A long-term study that follows students over time would make the evidence for gamification-based learning in this subject stronger.

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AUTHOR CONTRIBUTION STATEMENT

All authors contributed significantly to the work reported in this manuscript. MHA was responsible for drafting and developing the overall manuscript. AAG provided supervision, guidance, and critical review of the manuscript. RND contributed to proofreading and reviewing the final English manuscript. All authors read and approved the final manuscript and agreed to be accountable for all aspects of the work.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest regarding the publication of this paper.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies. However, limited portions of the manuscript were refined using an AI-based tool to check for inconsistencies in writing and to assist with translation into English. All AI-assisted content was carefully reviewed, edited, and validated by the authors, who take full responsibility for the final version of the manuscript.

REFERENCES

Amelia, R., Ermayanti, & Meilinda. (2025). Need Assessment of Teaching Material for Classification Living Things at Junior High School. *Jurnal Penelitian Pendidikan IPA*, *11*(11), 898–908. https://doi.org/10.29303/jppipa.v11i11.12834

Aprilanti, H., Rahayu, E. S., & Hadiyanti, L. N. (2023). Development of Pteridophyte Taxonomic Learning Resource to Foster Cognitive and Psychomotor Learning Outcomes. *Biosaintifika: Journal of Biology & Biology Education*, *14*(3), 444–453. https://doi.org/10.15294/biosaintifika.v14i3.42919

Baskaran Kannan, Ganesan Shanmugavelu, Santhiran Arumugam, Shobanah Menon Baskaran, & Balakrishnan Parasuraman. (2021). Students' Learning Styles in the Classroom and Its Importance to Educators in the Teaching and Learning Process: An Overview. *EPRA International Journal of Multidisciplinary Research (IJMR)*, (8), 64–70. https://doi.org/10.36713/epra8045

Birzina, R. (2023). Some Issues Concerning the Use of Didactics of Biology. *Journal of Baltic Science Education*, *22*(3), 376–380. https://doi.org/10.33225/jbse/23.22.376

Dinata, H. (2021). Gamification in Education Context: The Intention, The Design and The Result. *Inform : Jurnal Ilmiah Bidang Teknologi Informasi Dan Komunikasi*, *6*(2), 75–80. https://doi.org/10.25139/inform.v6i2.4035

Drigas, A., & Angelidakis, P. (2017). Mobile Applications within Education: An Overview of Application Paradigms in Specific Categories. *International Journal of Interactive Mobile Technologies (IJIM)*, *11*(4), 17. https://doi.org/10.3991/ijim.v11i4. 6589

Fahmi, F., Fajeriadi, H., & Irhasyuarna, Y. (2021). Feasibility of the Prototype of Teaching Materials on the Topic of Classification of Living Things Based on the Advantage of Local Wetland. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, *3*(2), 113. https://doi.org/10.20527/bino.v3i2.10322

Furkan Kurnaz, M., & Koçtürk, N. (2025). A Meta-Analysis of Gamification's Impact on Student Motivation in K-12 Education. *Psychology in the Schools*, *62*(12), 4997–5009. https://doi.org/10.1002/pits.70056

Iskandar, A., Unggul, A. P., Musyarrafah, S., Kurdi, S., Fitra, D., Sri, N., Fati, H., Riska, M., & Muqarramah, T. A. (2023). *Transformasi Digital Dalam Pembelajaran* (A. Ashari, Ed.). PT. Literasi Nusantara Abadi Grup.

Jii Toh, T., & Tasir, Z. (2024). The Impact of a Mobile Learning Application on Students' Cognitive Load and Learning Performance in Biology. *Journal of Information Technology Education: Research*, *23*, 026. https://doi.org/10.28945/5380

Jošt, G., & Taneski, V. (2025). State-of-the-Art Cross-Platform Mobile Application Development Frameworks: A Comparative Study of Market and Developer Trends. *Informatics*, *12*(2), 45. https://doi.org/10.3390/informatics12020045

Keeline, T., & Kirby, T. (2023). Latin Vocabulary and Reading Latin: Challenges and Opportunities. *TAPA, 153*(2), 531–559.

https://doi.org/10.1353/apa.2023.a913472

Khaldi, A., Bouzidi, R., & Nader, F. (2023). Gamification of e-learning in higher education: a systematic literature review. *Smart Learning Environments*, *10*(1), 10. https://doi.org/10.1186/s40561-023-00227-z

Kulamikhina, I., Abrosimova, E., Esmurzaeva, Z., & Taglianti, J. V. (2022). Building terminological competence in ecology students through creation of glossaries. *SHS Web of Conferences*, *134*, 00146. https://doi.org/10.1051/shsconf/202213400146

Lawrence, B. C., Yaman Ntelioglou, B., & Milford, T. (2020). It is complicated: Learning and teaching is not about "learning styles." *Frontiers for Young Minds*. https://doi.org/10.3389/frym.2020.00110

Levitt, G., & Grubaugh, S. (2023). Teacher-centered or Student-centered Teaching Methods and Student Outcomes in Secondary Schools: Lecture/Discussion and Pro-ject-based Learning/Inquiry Pros and Cons. *EIKI Journal of Effective Teaching Methods*, *1*(2). https://doi.org/10.59652/jetm.v1i2.16

Mohammad Fatkhul Amien, & Saptono, S. (2025). Development of Android-Based Mobile Learning Media on Cell Material to Improve Students' Learning Outcomes. *Journal of Biology Education*, *14*(2), 177–187. https://doi.org/10.15294/ujbe.v14i2.32768

Moses Adeleke Adeoye, Kadek Adrian Surya Indra Wirawan, Made Shania Satya Pradnyani, & Nyoman Intan Septiarini. (2024). Revolutionizing Education: Unleashing the Power of the ADDIE Model for Effective Teaching and Learning. *JPI (Jurnal Pendidikan Indonesia)*, *13*(1), 202–209. https://doi.org/10.23887/jpiundiksha.v13i1.68624

Nurjanah, N., Istiq'faroh, N., & Subrata, H. (2026). Development of Digital Learning Media on the Icons of the Nusantara Capital City to Enhance Critical Literacy of Fifth-Grade Elementary Students. *International Journal of Social Science and Human Research, 09*(01). https://doi.org/10.47191/ijsshr/v9-i1-24

Nurrokhmah, S., Mursid, R., & Ampera, D. (2024). Development of a Biology Learning Media-Flipped Classroom Model Using Edpuzzle. *Randwick International of Education and Linguistics Science Journal*, *5*(2), 552–566. https://doi.org/10.47175/rielsj.v5i2.990

Pandey, Mrs. A. (2023). Computer Vision. *International Journal for Research in Applied Science and Engineering Technology*, *11*(7), 510–514. https://doi.org/10.22214/ijraset.2023.54701

Purwandari, P., Huriawati, F., & Dewi, S. K. (2025). The Effectiveness of PBL-Based Multimedia Articulate Storyline and Phet Simulation on Student Learning Outcomes. *EDUKASIA Jurnal Pendidikan Dan Pembelajaran*, *6*(2), 1211–1222. https://doi.org/10.62775/edukasia.v6i2.1689

Rahmandhani, H. N., & Utami, E. (2022). Comparative Analysis of ADDIE and ASSURE Models in Designing Learning Media Applications. *Jurnal Educative: Journal of Educational Studies*, *7*(2), 123. https://doi.org/10.30983/educative.v7i2.6005

Ratinho, E., & Martins, C. (2023). The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review. *In Heliyon* (Vol. 9, Number 8). Elsevier Ltd. https://doi.org/10.1016/j.heliyon.2023.e19033

Risti, I. S., Rahardjanto, A., & Hindun, I. (2024). The Urgency of Metaverse-Based Science Learning for Biological Classification in Junior High School: Rationale, Design Framework, and Classroom Implementation. *Journal of Frontiers in Multidisciplinary Research*, *5*(2), 127–135. https://doi.org/10.54660/.IJFMR.2024.5.2.127-135

Sattar, M. A., Maqbool, M. U., Zakir, F., & Billah, M. (2025). Enhancing student engagement through augmented reality in secondary biology education. *Frontiers in Education*, *10*. https://doi.org/10.3389/feduc.2025.1628004

Wahyudianto, J., Ilmiyati Rahmy Jasril, García, J. L. C., & Argyrakou, C. C. (2025). Empowering Vocational Learners: Development and Validation of Android-Based Interactive Media for Electronics Education. *Journal of Hypermedia & Technology-Enhanced Learning*, *3*(3), 202–222. https://doi.org/10.58536/j-hytel.195

Wang, C., & Wang, L. (2023). Artificial Neural Network and Its Application in Image Recognition. *Journal of Engineering Research and Reports*, 50–57. https://doi.org/10.9734/jerr/2023/v24i2802

Yadav, S., & Chakraborty, P. (2024). Reinforcing biology education in schools using smartphones: a post-COVID pandemic study. *Education and Information Technologies*, 29(3), 3615–3635. https://doi.org/10.1007/s10639-023-11987-z

Zadeja, I., & Bushati, J. (2022). Gamification and serious games methodologies in education. *Proceedings - The Eleventh International*

Symposium GRID 2022, 599–605. https://doi.org/10.24867/GRID-2022-p66

Zhang, Y., Wu, X., Zhu, C., & Zhou, J. (2023). Classroom Quantitative Evaluation: A Method of Both Formative and Summative Evaluation. *Sustainability (Switzerland)*, *15*(3). https://doi.org/10.3390/su15031783