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Experimenting with AI-based mobile applications to improve student engagement in ornamental plant learning in rural Indonesian schools

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Abstract: This study aims to optimize student involvement in learning about ornamental plants using technology. Learning experiments were conducted in rural elementary schools in Indonesia. We used an artificial intelligence (AI)-based mobile application to help students recognize ornamental plants via cell cameras and obtain information directly. This study employed a quasi-experimental design with pre-and post-test methods. Ninety-three students in Grades 5 and 6 participated in the study. An application was developed using the MobileNetV2 convolutional neural network model. For one month, students worked in small groups to search for and identify ornamental plants in the surrounding environment. This study demonstrates that AI-based applications can improve student engagement and understanding. The results showed an increase of 35% in comprehension after they used the application. Interviews and observations indicated that the students were more enthusiastic about learning because they received instant feedback and a more interactive learning experience. We identified several obstacles during the experiment, including limited digital literacy and infrastructure readiness. These obstacles can hinder the implementation of AI applications in real learning. We recommend that schools conduct capacity building for teachers and develop adequate infrastructure to further implement this technology.

Keywords: *AI Education, Mobile Learning, MobileNetV2, Ornamental Plants, Student Engagement.*

1. Introduction

Digital transformation in education is growing rapidly and significantly, changing the higher education landscape. This trend is necessary to meet the evolving expectations and needs of students and faculty, particularly during the COVID-19 pandemic [1]. AI technology is significantly changing the way teaching, and learning transpire [2]. The integration of AI in education has been shown to improve learning efficiency, engagement, and outcomes across various educational contexts [3]. AI has great potential for creating intelligent learning systems that are interactive, personalized, and adaptive according to student needs. Several studies conducted in a variety of countries have shown that AI can increase learning effectivenesss Katiyar, et al. [4] as well as enhance student engagement at various educational levels. However, the application of AI in basic education faces several challenges. Several key challenges have been identified, which include technical limitations, difficulty integrating AI with learning methods, and teachers' readiness to use new technology [5]. Integrating AI into basic education presents significant potential but is hindered by obstacles, which include ethical concerns, data privacy issues, and the need for adequate educator training. Addressing these barriers is crucial for the successful implementation of AI in educational settings [5-7]. Which is particularly evident in Indonesia [8].

AI offers promising solutions to educational challenges, particularly through interactive and adaptive learning applications that can recognize student behavioral patterns, provide real-time

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feedback, and enhance personalized learning experiences [9]. AI chatbots can assist students in understanding material and answering questions instantly. A main challenge in primary education is maintaining student engagement in the learning process [10]. Research indicates that elementary school students in Indonesia exhibit shorter attention spans, particularly when influenced by various educational and environmental factors [11]. Other educational studies have indicated that visual and interactive stimulation are crucial for maintaining student engagement. These methods cater to diverse learning styles and enhance cognitive activity, motivation, and retention [12]. Therefore, we sought innovative solutions for creating an engaging technology-based learning environment. AI is crucial in this context, particularly for creating interactive and adaptive learning. The ability to monitor student activities and provide individual feedback facilities is also required. Given these characteristics, the application is attractive to students. In addition, AI applications can significantly enhance educational experiences by providing teachers with tools to facilitate the supervision and assistance of each student, thus ensuring active engagement in learning [13, 14].

This study focuses on utilizing AI-based mobile applications to increase student engagement in learning. We conducted experiments using this application to enable students to learn about different types of ornamental plants. We chose research locations in the rural areas of Indonesia, which contain diverse tropical flora. We introduced students to local ornamental plants such as orchids, bougainvillea, and frangipani. These plants are attractive for learning activities. Through this study, we aim to connect science learning with the local culture. We also believe that students will increase their appreciation of Indonesia's natural wealth.

In this study, we explore the integration of artificial intelligence (AI) in education in Indonesia, owing to the rapid advancement in digital transformation. We aimed to answer the following questions: First, how do AI-based mobile applications affect student engagement in learning? Second, to what extent was this application effective in helping students recognize and identify ornamental plants? We integrated AI into elementary school curricula to enhance students' learning experiences. We believe this research provides an overview of the use of AI in creating interactive, interesting, and appropriate learning in student surroundings.

2. Method

In this study, we used a quasi-experimental approach with pre- and post-test designs. Several similar studies have used quasi-experimental methods [15, 16]. The research participants were students in Grades 5 and 6 at an elementary school in rural Indonesia. We chose this school as the research site because access to technology was sufficient, and that the students never used the learning application. Under these conditions, we aimed to determine the impact of using AI-based mobile applications in real learning situations.

2.1. Application Development

We developed an application using a convolutional neural network model with MobileNetV2 architecture. MobileNetV2 can serve as an efficient model by which educational institutions can improve their learning environments and administrative processes [17]. This application helps students to recognize ornamental plants using smartphone cameras and also provides real-time information on plant names, characteristics, and ecological benefits. The application interface was designed for the ease of use for elementary school students. We developed a simple application navigation system with interesting learning features. We collected data for the modeling using flower photography. Strategic collection of flower images around the experimental site reduces errors by ensuring consistent environmental conditions and species availability, which are crucial for accurate modeling and analysis [15]. Figure 1 shows the applications of AI Bases.

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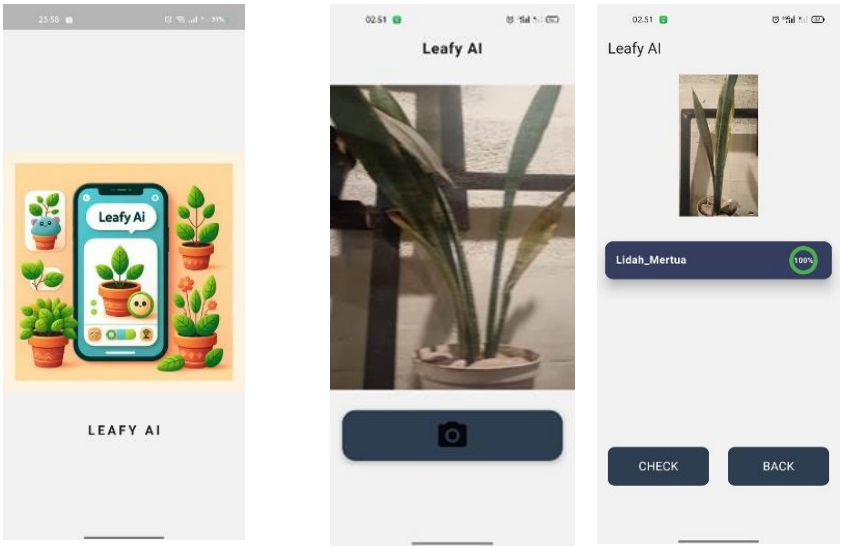

Figure 1.
AI-based ornamental plant recognition application display.

2.2. Learning Model

We applied a group project-based learning model. The students were divided into small groups of three to five. For one month, each group searched for and identified 10 types of ornamental plants in the surrounding environment. Each group member was tasked with searching for 3 types of flowers. They used an application to recognize flowers and matched them using a Google search. Thereafter, each member created a report in the form of a document (.doc) and sent it to the group leader.

The group leader collected member reports and provided a summary that contained a list of ten verified plant names. Upon completion, the group leader sent a summary of the assignment to the teachers via email. Each group created a WhatsApp group to support communication, which included all group members, teachers, and companions. In this group, they discussed, shared information, and obtained directions during the search process. This model is expected to help students learn how to use technology and work in groups. The students learn to search for information independently and work in teams through digital communication.

2.3. Research Procedures

The research was conducted using the stages as follows:

1. Preparation Stage
   We provided short training sessions for teachers and students on the use of AI-based mobile applications. At this stage, we explained the research objectives and steps that will be carried out. This training aimed to ensure that all the participants understood how the application worked and their respective roles in the research.
2. Pre-test
   We asked students to take an initial test in the form of ornamental plant identification questions without the help of an application. We used this test to measure the students' level of knowledge before participating in learning with applications.
3. Experiments
   After the pre-test, we invited students to participate in project-based learning activities using AI-based mobile applications. This activity occurred outside the classroom, where the students observed, recognized, and identified ornamental plants in the school environment. During this process, the students worked in groups according to the designed learning model.

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4. Post-test
   After the entire series of experiments was completed, we asked the students to take the final test using the same material as in the pre-test. We used pre- and post-tests to measure the increase in students' understanding after participating in learning with the help of the application.
5. Interviews and Observations
   We conducted structured interviews with teachers and students to obtain information on their experiences using the application and group assignments. We also conducted direct observations during the activity to observe students' involvement, cooperation in groups, and their responses to using technology in the learning process.
6. Data Analysis
   We analyzed the data using both quantitative and qualitative approaches. Quantitative data were obtained from the pre- and post-test results, which were analyzed using statistical tests to identify significant differences in students' understanding before and after the application. Qualitative data were obtained from interviews and observations, which were analyzed to understand the aspects of student involvement and their learning experiences in groups using this technology.

3. Result and Discussion

The present study was conducted in a rural area adjacent to an educational city. Although the region is beginning to experience increased access to technology, it still faces educational infrastructure and resource limitations. The rural areas in Indonesia have diverse social and economic conditions, with most people working in the agricultural and other informal sectors. However, the rural areas near educational cities tend to adopt technology more quickly than remote areas as they have better access to educational facilities, Internet networks, and teacher training programs.

We found that geographical factors influence the use of AI-based mobile applications in learning. We conducted this study in the Special Region of Yogyakarta Province in Bantul Regency (Figure 2). This location is close to Yogyakarta—known as a educational city due to its numerous universities and large student population—and is a more developed rural area. Research results in this location can differ from those in more isolated areas. Students at the research location are accustomed to using smartphones. However, they use it more often to play games than study and are not accustomed to using applications to study or work in groups. Although the students were familiar with technological devices, they rarely used them for learning activities. The teachers at this school are used to basic learning technology and often use videoconferencing and Google Classroom for teaching. However, they have never used AI-based applications for teaching activities. This situation becomes challenging when AI-based mobile applications are integrated into the curriculum.

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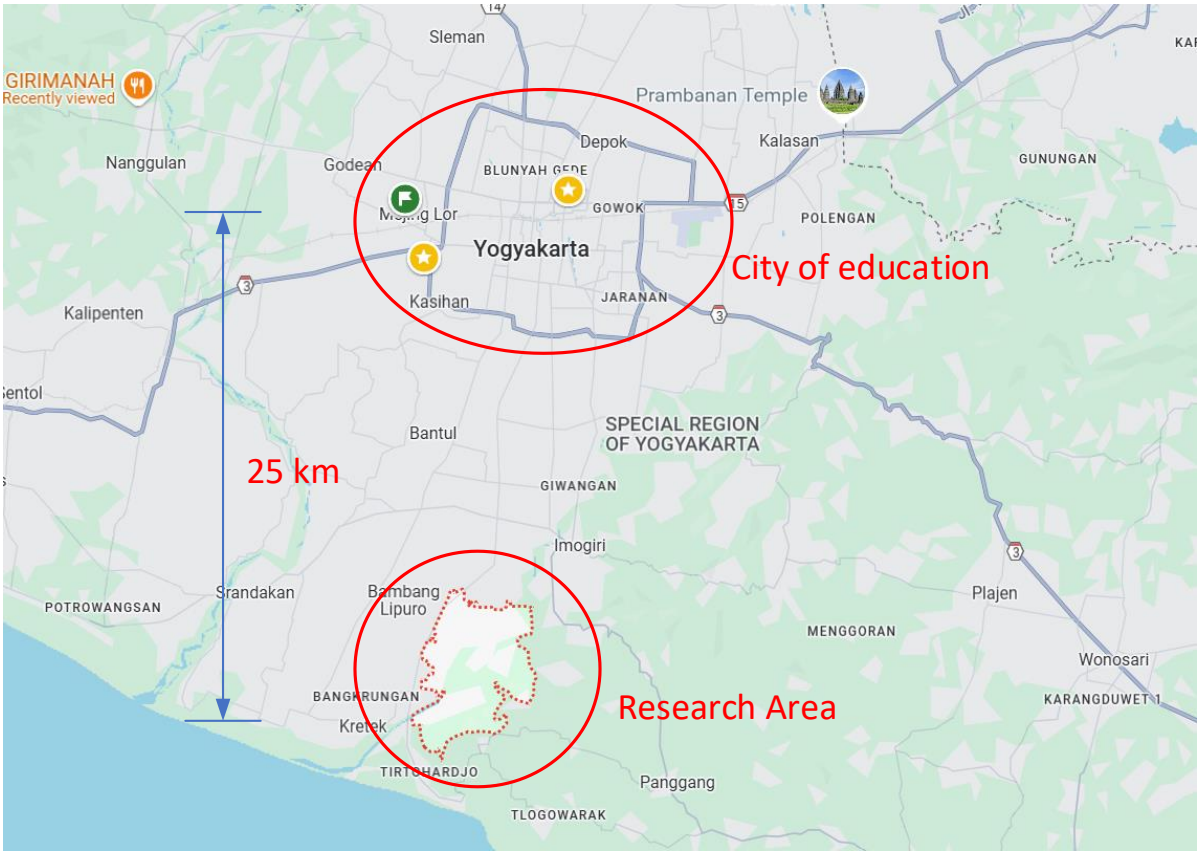

Figure 2.
Google Maps overview of research area.

We analyzed the research results by considering the local socioeconomic conditions. If research is conducted in areas with limited access to technology, additional strategies must be developed. This strategy includes intensive training for teachers and the development of supporting infrastructure.

3.1. Results and Data Analysis

This study involved 93 students in Grades 5 and 6 with four teachers and one companion from the research team. A total of 10 female groups and nine male groups were created. Figure 3 shows the application usage training before the start of the experiment.

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Figure 3.
Activities to introduce the application to all participants.

3.2. Learning Effectiveness

This study shows that AI-based mobile applications can increase students' involvement and understanding in learning of ornamental plants. Based on the pre- and post-test results (Table 1), we found an average increase in students' comprehension scores of 35%. These findings emphasize that the application helps students better recognize and identify various ornamental plants.

Table 1.
Learning effectiveness.

Evaluation Categories	Pre-test (Average Score)	Post-test (Average Score)	Upgrades
Plant Identification	50%	85%	35%
Participation in Discussions	55%	90%	35%
Learning Motivation	60%	88%	28%

Table 1 shows that the students' understanding of ornamental plants increased after using the application. This increase was related to the high level of student activity when using the application. Most students responded positively to the application, especially the real-time feedback features and attractive visual displays. The students felt confident when identifying plants using the application. They obtain instant confirmation of the plant name and additional information that assists in the learning process.

In 1972, Jean Piaget propounded the constructivist theory, which states that students learn more effectively if they actively participate in the learning process. Students build understanding by interacting directly with their environment [18, 19]. This concept demonstrates the importance of experience-based learning. This learning model encourages students to actively build their knowledge. Piaget's theory has been widely used in learning to move from teacher-centered to student-centered models, and hence, we applied this principle to AI-based mobile applications. AI applications can incorporate interactive sensory-rich experiences that encourage the exploration and manipulation of objects [20]. Our application aligns with Piaget's emphasis on learning through physical interaction with the environment. This application helps students learn by allowing them to explore the surrounding environment and obtain real-time feedback. In this experiment, students searched for ten different types of flowers around their houses, used the application to identify the names of the flowers, and then checked the results again using Google. The essence of this learning is for students to develop an understanding of ornamental plants through direct observations. This learning activity allowed students to build active learning experiences supported by technology. Innovative learning tools significantly improve students' understanding and practical skills in plants, fostering a more interactive and engaging learning environment than traditional learning methods [21].

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The results of this experiment support Vygotsky's theory of the zone of proximal development. According to this theory, learning is more effective when students receive support from technology, teachers, or peers [22, 23]. We observed that the AI applications helped students understand the material. However, the interview results showed that students still needed social interactions to support their learning processes.

This finding was corroborated by the results of the interviews with teachers. One teacher stated that the application provided a more contextual learning experience. However, because students were not familiar with learning applications, some had difficulty understanding how applications worked. Individual study habits caused some students to be less active in group discussions when using the application. Teachers also revealed that they rarely use technology in learning; therefore, further training and support are crucial to effectively integrate technology into teaching activities.

In interviews, several teachers stated that they were still considering implementing technology-based learning methods. One challenge is developing content that complies with the curriculum and regulations. In addition, they are more likely to choose methods, such as video conferencing, if they must use technology in learning. The teacher stated that a gap still remains in understanding how AI applications can be optimally implemented in learning environments. One of the four teachers interviewed was a school principal who stated, "We really need a model like this, but we need more detailed information." This statement indicates that although teachers are interested, they need more detailed explanations. Teachers need training to apply this learning model effectively in learning. One teacher said, "It seems that most students are more enthusiastic about learning because." "Children can immediately observe the results of plant identification without having to ask the teacher." However, the teachers also highlighted the need for additional tutoring sessions to ensure that students could use the application to its full potential.

3.3. Group Work

Each group was tasked with collecting flower names and reporting them to the teacher. The group leader is responsible for collecting and summarizing member reports as a final report. Upon completion, each participant filled in their opinions on the group work. Table 2 shows the results of the survey used to measure the group performance on assignments.

Based on Table 2, the group work for collecting flower plant names was classified as Highly Effective, with an average effectiveness of 83.32%. Cooperation among members went well, particularly in cooperation, communication, and respect for friends' opinions. However, from Table 2, the assertiveness of group members and the ability to make decisions when differences arise in opinion must still be improved to optimize the effectiveness of group work in the future. Group discussions and active learning promote critical thinking [24].

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Table 2.
Results of the group work survey.

No	Statement	Total Score	Percentage (%)	Category
1	I like to work in groups	314	84.41%	Highly Effective
2	My group mates worked well	299	80.38%	Effective
3	Providing info via WAG	284	76.34%	Effective
4	Collaborate to find plants	314	84.41%	Highly Effective
5	The chairman works well	303	81.45%	Highly Effective
6	The chairman gave information	306	82.26%	Highly Effective
7	Chairman mediates disputes	299	80.38%	Effective
8	Respect your friend's opinion	320	86.02%	Highly Effective
9	Teaming up with friends	321	86.29%	Highly Effective
10	Helping a friend in need	301	80.91%	Effective
11	Be assertive in a group	269	72.31%	Effective
12	Participate in groups	309	83.06%	Highly Effective
13	Making decisions when disagreeing	285	76.61%	Effective
14	Prioritizing group discussions	314	84.41%	Highly Effective
15	Maintaining speaking ethics	297	79.84%	Effective

3.4. Research Finding

The findings of this study show a difference between the survey results on the effectiveness of group work and the quality of the collected reports. Although the survey results generally showed that all groups worked together effectively, the female student groups tended to produce more neat, complete, and structured reports compared with the male student groups.

Some of the factors that can cause this difference include:

1. Differences in Gender Characteristics in Attitudes Toward Tasks
   A previous study has shown that female students tend to have greater neatness, rigor, and responsibility in completing academic assignments [25]. These results directly affect the quality of their reports, particularly in terms of document preparation, data presentation, and complementary group administration.
2. Perception of Academic Obligations
   Female students often have strong intrinsic motivation to maintain the quality of their work results, including reports [26-28]. This can encourage them to be more serious about ensuring that the report follows the teacher's instructions, particularly regarding data completeness and presentation aesthetics.
3. Division of Roles in Groups
   The differences in group work between elementary school girls and boys are diverse [29]. Factors influencing these differences include subject matter and group composition. Research has shown that their academic performance may be the same, but different work patterns emerge in certain situations, especially when learning collaboratively [30, 31].
4. Impact of Using AI-Based Applications
   Although AI-based applications help all groups access the required information, the processing and presentation of information in the form of reports is still significantly influenced by each group's work habits. The female group tended to utilize the information from the application in more detail and process it systematically in the report. Simultaneously, the male group focused more on the results of the information search than on packaging the final report. This is in line with the results of Arcand's research, which stated that women use more relational processing and comprehension efforts, supporting the selectivity model of gendered cognitive styles. This research showed that girls engage in technology through collaboration, whereas boys explore it independently, with gender norms shaping their learning and information processing.
5. Emotional and Aesthetic Engagement

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Female students were generally more concerned about the aesthetic aspects and visual preparation of reports, resulting in more attractive and structured documents. This contrast is an added value in assessing the quality of the report, even though the level of effectiveness of the group work—according to the survey—did not differ significantly between the groups. According to Nasab and Motlagh [32] female students tended to produce reports that were more coherent and expressive than their male counterparts.

3.5. Research Limitation

The main limitation of this study is that the research was insufficient sample size. We conducted in only one elementary school. Therefore, the findings cannot be generalized to other schools. Indonesia is a vast country with diverse geographic, socioeconomic, cultural, and technological conditions. This causes each school to have a different level of infrastructure and student digital literacy [33]. Another limitation is that only short training sessions were provided to teachers and students as we assumed that they were familiar with smartphone applications commonly used in post-COVID-19 education. This assumption does not hold in any context, especially in schools with small digital literacy gaps. Providing more comprehensive training can help reduce technical obstacles. The difficulty of using the application affects the research results. Students tended to give negative feedback if they found it difficult to use the application. In addition, the relatively short duration of this research implies that teachers could not fully understand the long-term benefits and impacts of implementing this application. Teachers' understanding of technology forms different attitudes toward modern learning tools. Therefore, research with longer observation periods in many different locations can provide teachers with better insights into the impact of integrating current technology into learning.

4. Conclusions

The system used in this experiment helped students learn according to a particular subject. Research has shown that AI-based mobile applications can effectively increase student engagement and understanding when learning about ornamental plants, particularly in rural areas adjacent to educational cities. Through a quasi-experimental design with pre- and post-tests, the research results showed a significant increase in students' understanding of plant identification and their involvement in learning. Research has also shown that AI can increase student engagement at various educational levels.

However, the application of AI to basic education faces certain challenges. The results reveal that although AI provides great benefits, its successful implementation is highly dependent on the readiness of the infrastructure and the digital literacy of students and teachers. Additionally, social interaction in learning remains an important aspect that technology cannot completely replace.

Based on these findings, we recommend increased support for teachers in adopting AI-based learning technologies and further development of application features to improve ease of use for students. Further research is needed to investigate the long-term effects of this technology, increase the sample size, and refine its implementation for use in diverse educational environments with varying socioeconomic backgrounds.

Institutional Review Board Statement

This study was conducted as part of a formal collaboration between the Research and Innovation Centre of Universitas Muhammadiyah Yogyakarta and the participating schools in 2024. The research activities were carried out with the school's approval. The cooperation agreement was documented in the research proposal, and all procedures involving human participants adhered to the ethical guidelines and institutional regulations.

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Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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