Jurnal Hurriah: Jurnal Evaluasi Pendidikan dan Penelitian
Hurriah Journal: Journal of Educational Evaluation and Research
Volume 7, No. 2 (2026) PP 362-373

Jurnal Hurriah: Jurnal Evaluasi Pendidikan dan Penelitian
Hurriah Journal: of Educational Evaluation and Research

Journal homepage: https://academicareview.com/index.php/jh
E-ISSN: 2774-8472 I P-ISSN: 2774-8480 I DOI : 10.56806

The Effect of PlantNet Application on Students' Learning Outcomes in Plant Classification: A Quasi-Experimental Study

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ARTICLE INFO

Article history:
Received: April, 2026
Received in revised from: May, 2026
Accepted: June, 2026
Available online: July, 5, 2026

Keywords: PlantNet, learning outcomes, plant classification, biology learning, learning media.

ABSTRACT

This research aims to address the low understanding of students in the material of plant classification which is caused by the learning activity that is primarily theoretical and lacks a direct learning experience. This study aims to analyse the effectiveness of the PlantNet application in improving the learning outcomes of tenth-grade students at MAN 1 Banda Aceh. This is quantitative research with quasi experimental method with the design of one group pretest-posttest design, and the number of samples are 40 students, taken by simple random sampling. The data collection instruments were observation sheets, pretest and posttest instruments and student response questionnaires. The results showed an increase in students' learning outcomes with an average score of 82.3 to 98.1 and an N-Gain score of 0.89 in the high category. The mean difference test showed a statistically significant difference in students' learning outcomes before and after the implementation of the PlantNet application. In addition, the student responses to the use of the application are very good. Results of this study show that the application of PlantNet is effective in improving student learning results on plant classification material and provides meaningful learning supported by technology.

1. Introduction

Biology is a branch of science that examines living organisms and the processes that support such organisms, encompassing the study of biodiversity, including the classification of plants(Astuti et al., 2024). The objective of instructing plant classification is to equip students to categorise plants according to their morphological and anatomical traits(Astuti et al., 2024). In practice, numerous students struggle to grasp these concepts concretely, as the training remains predominantly theoretical and offers little opportunity for actual field experience(Coşkunserçe, 2024).

The educational limits that educators encounter in presenting observational material exacerbate the difficulty(Salsabila & Hidayat, 2025). Specifically, plant classification encompasses a broad and intricate domain that frequently complicates the learning process(Bawingan et al., 2024). The restricted instructional time sometimes compels educators to prioritise basic knowledge over

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https://doi.org/10.56806/ jh.v7i3.443

contextual or experiential learning relevant to the students' immediate environment(Canuto, 2023). This renders the training less interesting and hinders students' ability to cultivate a solid understanding of plant traits.

Moreover, lecture-based instruction continues to be prevalent in biology classes. These strategies often render students' passive consumers of knowledge rather than active participants in the learning process(Salamah et al., 2025). The classification of plants is abstract under these conditions, as pupils mostly rely on teacher explanations and textbook material rather than engaging directly with actual plant specimens(Wahdan Wilsa et al., 2023). These circumstances underscore the necessity for pedagogical innovations that link theory to genuine, real-world applications, a task ideally suited to technology and environment-based learning resources(Iskrenovic-Momcilovic, 2023).

The emergence of digital technology has created potential for the advancement of more interactive and contextualised instruction(Chen & Zhai, 2026). Increasing data suggests that the utilisation of digital learning media might improve students' motivation and academic performance. Research indicates that interactive technology-based media enhances students' performance in plant classification(Halawa, 2024), while digital technologies broadly enhance comprehension and sustain student interest(Aslam et al., 2024). Furthermore, outdoor learning methodologies have been associated with enhanced motivation and outcomes, since they enable students to participate in direct field observation rather than relying solely on abstract instruction(Sitorus et al., 2025). This enhances the significance of learning, since students engage not just with theoretical material but also with actual plant specimens(Diyah et al., 2023).

In the context of the 21st century's shift towards digital learning, smartphone applications, especially plant identification tools such as PlantNet, have been acknowledged as effective educational resources. The use of these applications has demonstrated more practicality and interactivity in biology classes(Diyah et al., 2023) and allows students to recognise and classify plants based on the physical qualities observed directly in their surroundings(Kassa et al., 2024). PlantNet allows users to identify plants by utilising a smartphone camera to recognise them, subsequently providing scientific names, taxonomic families, and further botanical information. Prior research indicates that PlantNet serves as a useful tool for aiding students in comprehending plant classification through visual image-recognition technology(Maulana et al., 2022), while also facilitating swift and precise plant identification through picture analysis (Jatijagad et al., 2025).

Empirical research further corroborates the pedagogical efficacy of PlantNet for biology instruction. The efficacy of Practicum activities utilising PlantNet in enhancing students' comprehension of plant classification has been proven(Nurdin et al., 2025). The program promotes contextual, multisensory learning via image visualisation and field experience. Moreover, its intuitive design and visualised content have been noted to facilitate students' engagement with the curriculum in a more clear and concrete manner(Firdaus et al., 2024).

The initial observations at MAN 1 Banda Aceh indicated that the instruction on plant classification was predominantly theoretical, and the surrounding environment of the school was infrequently utilised as a learning resource, despite its abundant plant diversity, which holds significant potential as a contextual learning medium. The use of the PlantNet program in this context is regarded as a potential approach for direct plant identification, enhancing students' classification skills, and fostering more meaningful learning through genuine experiences.

This study is to examine the efficacy of the PlantNet program in enhancing the comprehension of plant classification among tenth-grade students at MAN 1 Banda Aceh. This project is anticipated to enhance biology instruction through digital technology and offer a more effective, inventive, and contextual alternative learning medium.

2. Methodology

2.1 Research Design

This study utilised a quantitative approach using a quasi-experimental design(Capili & Anastasi, 2024). The selection of quantitative research is predicated on its utilisation of numerical data and statistical analysis to evaluate hypotheses and yield objective results(Cham et al., 2024). This methodology was deemed suitable for the study's objective, which was to quantitatively and statistically assess the enhancement in students' comprehension of plant classification following the implementation of the PlantNet application.

The one-group pretest-posttest design was employed. The researchers lack complete control over all study factors as participants are not randomly allocated individually but are chosen from pre-existing groups, such as established classes. This adhered to the circumstances of the current study, which was conducted utilising an existing class at MAN 1 Banda Aceh without complete subject randomisation. In this study, students had a pretest to ascertain baseline knowledge prior to the intervention, received instruction via the PlantNet program, and subsequently performed a posttest to assess comprehension following the treatment.

2.2 Research Setting and Time

This study was carried out at MAN 1 Banda Aceh, situated in Kuta Alam, Banda Aceh, Aceh Province, during the 2025/2026 academic year. The data collection process spanned around four to five weeks and including preparation, pretesting, deployment of PlantNet-based instruction, posttesting, and data analysis.

2.3 Population and Sample

The population consists of all tenth-grade students at MAN 1 Banda Aceh for the 2025/2026 academic year, representing the totality of research subjects sharing identical characteristics in accordance with the research objectives (Nugroho et al., 2026). We selected the tenth grade due to the inclusion of plant classification in the biology curriculum at this level.
A cohort of 40 students was chosen using simple random sampling. This technique provides each member of the population an equal opportunity for selection, so ensuring that the sample accurately reflects the population's characteristics. Students were required to enrol in the biology course focused on plant classification and own smartphone devices compatible with the PlantNet application, along with basic skill in their operation.

2.4 Data Collection Techniques

Data were obtained using three instruments: observation, tests, and a student response questionnaire.Observation was carried out to determine student activity, engagement, and participation in the learning experience utilising the PlantNet program and a standardised observation sheet built based on student learning activity markers.
Students were tested to assess their understanding of plant classification material. The pretest was used to establish the students' initial understanding before beginning treatment, and the posttest was used to assess their subsequent progress after receiving PlantNet-based education.

Furthermore, a student response questionnaire was issued to assess students' impressions of the learning process. The questionnaire consisted of ten items that assessed students' engagement,

application ease of use, learning motivation, and PlantNet's benefits in aiding plant classification comprehension.

During the intervention, the PlantNet program was utilised to assist students in identifying plants in their classroom environment, making learning more contextual, participatory, and relevant.

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2.6 Data Analysis Technique

The N-Gain test and paired-sample t-test were employed to evaluate the data. The N-Gain test was employed to assess the extent of enhancement in student learning outcomes following the adoption of PlantNet-based training. N-Gain scores are categorised as low ($g < 0.3$), moderate ($0.3 <= g \leq 0.7$), and high ($g > 0.7$) (Hake, 1999, as referenced in Wahab et al., 2021). A paired-sample t-test was conducted to determine if the difference between the students' pretest and posttest scores was statistically significant.

$$G = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}}$$

The interpretation of the N-Gain value is as follows:

$g > 0.7$	= high category
$0.3 \leq g \leq 0.7$	= medium category
$0 < g < 0.3$	= low category
$g \leq 0$	= fail category

In addition to the N-Gain test, this study also used a paired sample t-test to determine whether there was a significant difference between students' pretest and posttest scores after using the PlantNet application. The t-test was conducted because the data analyzed came from the same group before and after the treatment was administered. Baidowi et al. (2021) explain that the t-test is used to compare the means of two related data sets.

$$t = \frac{Md}{\sqrt{\frac{\sum(d-Md)^2}{n(n-1)}}}$$

Description:

t = Calculated t-test value
Md = Average difference between pretest and posttest scores
d = Difference between posttest and pretest scores for each student
$\sum(d - Md)^2$ = Sum of squares of the deviations
n = Number of research samples

The t-test results were then compared with the t-table value at a significance level of 0.05. If the calculated t-value is greater than the t-table value, then the research hypothesis is accepted. This indicates that the use of the PlantNet application has a significant influence on improving students' understanding of the Plant Classification material in class X MAN 1 Banda Aceh.

3. Results and Discussion

The purpose of this study was to assess whether using the PlantNet application in grade 10 at MAN 1 Banda Aceh improved students' grasp of Plant Classification. The study was carried out with 40 students utilising a One Group Pretest-Posttest Design. Pretests and posttests were used to collect data, as well as observations of student activities and a questionnaire that assessed student responses to the PlantNet application. Before beginning the learning process using the PlantNet application, students were given a pretest to establish their starting proficiency in the Plant Classification subject. Following that, students engaged in an observation-based learning process, identifying various plant types directly using the PlantNet application. At the end of the course, students were given a posttest to see how much their conceptual comprehension had improved since the treatment. Based on the research findings, student pretest and posttest scores were produced, which are shown in Table 1 below.

Table 1. Student Learning Outcomes Before and After Using the PlantNet Application

No	Student Name	*Pretest*	*Posttest*
1	AQ	80	96
2	AS	80	100
3	Al	72	96
4	Al	80	96
5	Am	72	92
6	Ar	80	100
7	As	80	100
8	As	80	100
9	Az	80	100
10	Cu	76	100
11	Em	80	100
12	Fa	80	96
13	Fi	92	100
14	Ha	80	92

15	Hu	80	100
16	In	92	100
17	Ji	92	100
18	ilK	92	100
19	Kh	92	100
20	Me	92	100
21	Mo	92	100
22	Mt	96	100
23	Mu	72	96
24	M Z	80	96
25	M	92	100
26	M	92	100
27	Na	72	96
28	Az	96	100
29	Na	96	100
30	Nu	72	96
31	Ra	72	96
32	Ki	92	100
33	Ri	72	96
34	Sy	80	100
35	Sy	80	100
36	fa	72	96
37	T.	96	100
38	Wu	72	92
39	Zh	72	100
40	Da	72	92
Average		**3.292**	**3.924**
Amount		**82,3**	**98,1**

Table 1 illustrates the students' academic performance prior to and after to the integration of the PlantNet application in Plant Classification education. The mean pretest score was 82.3, whereas the mean posttest score rose to 98.1. The findings demonstrate that pupils attained elevated scores subsequent to utilising the PlantNet program. The majority of students demonstrated an increase in their posttest scores, indicating that the program facilitated an enhancement in their comprehension of Plant Classification concepts.

Table 2. Descriptive Statistics of Students' Learning Outcomes

Descriptive Statistics of Students' Learning Outcomes				
	N	**Minimum**	**Maximum**	**Mean**
Pretest	40	72	96	82,3
Posttest	40	92	100	98,1
N-Gain	40	0,60	1,00	0,92

Source: Research data analysis results (2026)

Based on Table 2, the average pretest score of students before the implementation of the PlantNet application was 82.3, with a minimum score of 72 and a maximum score of 96. After the learning process using the PlantNet application, the average posttest score increased to 98.1, with a minimum score of 92 and a maximum score of 100. This increase indicates that the use of the

PlantNet application contributed positively to improving students' understanding of plant classification concepts.

Furthermore, the N-Gain analysis showed an average score of 0.92, with a minimum value of 0.60 and a maximum value of 1.00. According to the N-Gain criteria, this value falls into the high category. These findings demonstrate that the use of the PlantNet application was highly effective in enhancing students' learning outcomes in plant classification material.

Table 3. Frequency Distribution of Pretest Scores

Frequency Distribution of Pre-test Scores		
Score Interval	**Frequency**	**Percentage**
70–75	10	25%
76–81	14	35%
82–87	0	0%
88–93	11	27,5%
94–100	5	12,5%
Jumlah	**40**	**100%**

Source: Research data analysis results (2026)

Based on Table 3, the distribution of pretest scores shows that the majority of students were in the score interval of 76–81, accounting for 14 students (35.0%). In addition, 11 students (27.5%) achieved scores in the interval of 88–93, while 10 students (25.0%) obtained scores in the interval of 70–75. Only 5 students (12.5%) were in the highest interval of 94–100, and no students were found in the interval of 82–87.

These findings indicate that students' initial understanding of plant classification before using the PlantNet application was relatively varied. Although some students had already achieved high scores, the overall distribution suggests that students still required more effective and contextual learning experiences to strengthen their conceptual understanding.

Table 4. Frequency Distribution of Posttest Scores

Score Interval	**Frequency**	**Percentage**
90–92	3	7,5%
93–95	0	0%
96–98	11	27,5%
99–100	26	65%
Jumlah	**40**	**100%**

Source: Research data analysis results (2026)

Based on Table 4, the posttest score distribution indicates that most students achieved scores in the interval of 99–100, totaling 26 students (65.0%). Furthermore, 11 students (27.5%) obtained scores in the interval of 96–98, while 3 students (7.5%) achieved scores in the interval of 90–92. No students were found in the interval of 93–95. The concentration of scores in the highest interval demonstrates a substantial improvement in students' learning outcomes following the implementation of the PlantNet application. These results suggest that the application successfully facilitated students' understanding of plant classification through direct observation and identification activities.

Table 5. Frequency Distribution of N-Gain Scores

Frequency Distribution of N-Gain Scores			
N-Gain Category	**Interval**	**Frequency**	**Percentage**
Low	$g < 0.30$	0	0.0%
Moderate	$0.30 \leq g < 0.70$	1	2.5%
High	$g \geq 0.70$	39	97.5%
Total	**40**		**100%**

Source: Research data analysis results (2026)

Based on Table 5, the N-Gain analysis revealed that 39 students (97.5%) were categorized in the high N-Gain category, while only 1 student (2.5%) was classified in the moderate category. No students were included in the low category. These findings indicate that almost all students experienced a substantial improvement in their learning outcomes after the use of the PlantNet application. The dominance of the high N-Gain category confirms that the application was highly effective in improving students' understanding of plant classification concepts. Through direct plant identification activities, students were able to connect theoretical knowledge with real-world observations, resulting in more meaningful and effective learning experiences.

Based on the data, it can be seen that the average student score increased after using the PlantNet application in the learning process. The average pretest score of 82.3 increased to 98.1 in the posttest. This increase indicates that the use of the PlantNet application has a positive influence on students' conceptual understanding of the material on Plant Classification. To clarify the increase in average student scores before and after the treatment, can be seen in Graph 1 below.

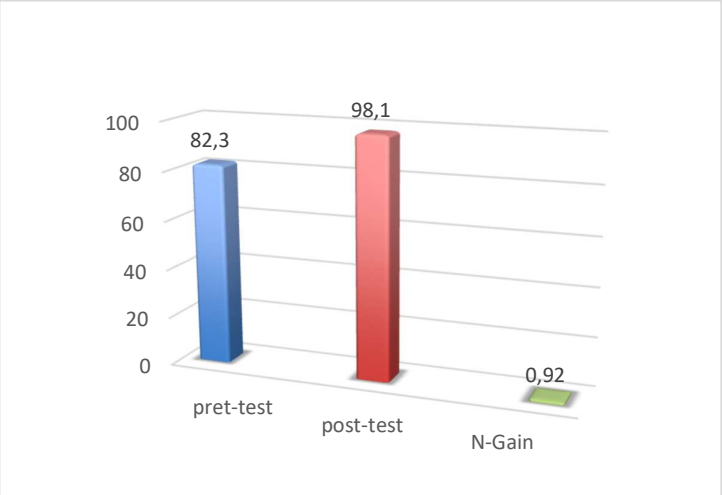

Fig.1. Average Value Difference Data

Based on Graph 1, there is a significant increase between the average pretest and posttest scores after using the PlantNet application in learning Plant Classification.

Hypothesis Test Results (t-Test)

A hypothesis test was conducted to determine whether the use of the PlantNet application improved students' understanding of Plant Classification. The test used a paired sample t-test based on student pretest and posttest data. The analysis showed that the average posttest score was higher than the average pretest score. The calculated t-value was greater than the t-table at a

significance level of 5%. Therefore, the alternative hypothesis (Ha) was accepted and the null hypothesis (Ho) was rejected.

Table 6. Pretest and Posttest t-Test Results

NO.	Component	Score
1.	Total Sample	40
2.	Pretest Average	82.3
3.	Posttest Average	98.1
4.	Average Difference	15.8
5.	Significance Level	0.05
	Test Results:	**Ha was accepted**

These results indicate that the use of the PlantNet application significantly improved students' understanding of plant classification in grade 10 of MAN 1 Banda Aceh.

3.1 Student Responses to the Use of the PlantNet Application

In addition to learning outcomes, this study also measured student responses to the use of the PlantNet application in biology lessons. Data were obtained through a student response questionnaire covering aspects of interest, learning motivation, ease of use of the application, and understanding of the Plant Classification material. The questionnaire was administered to 40 students after the learning process was completed. Based on the results, the majority of students responded positively to the use of the PlantNet application in their learning.

Students felt that learning became more interesting, interactive, and enjoyable because they were able to directly observe plants in the school environment. Furthermore, the use of the PlantNet application also helped students recognize plant scientific names, understand plant morphological characteristics, and facilitate the systematic process of plant classification. The percentage of student responses to the use of the PlantNet application can be seen in Table 4 below.

Table 7. Percentage Results of Student Questionnaire Responses to the Use of the PlantNet Application

No.	SS	S	TS	STS	Total Score	Percentage
1	25	15	0	0	145	90,6%
2	20	18	2	0	138	86,3%
3	28	12	0	0	148	92,5%
4	30	10	0	0	150	93,8%
5	24	14	2	0	142	88,8%
6	22	16	2	0	140	87,5%
7	26	14	0	0	146	91,3%
8	21	17	2	0	139	86,9%
9	27	13	0	0	147	91,9%
10	29	11	0	0	149	93,1%
		Average			**1444**	**90,25%**

Source: Research data analysis results (2026)

Table 4 shows that all indicators received a "Very Good" rating, with an average score of 90.25%. The highest score was for the fourth statement, at 93.8%, while the lowest score was for the second statement, at 86.3%. Nevertheless, all indicators remained in the "Very Good" rating. These results indicate that the use of the PlantNet application has received a positive response from students in the biology learning process. Students found the learning more engaging, interactive, and enjoyable because they were able to directly observe plants in the school environment.

The use of the PlantNet application also helped students understand the Plant Classification material more easily through hands-on plant identification activities. Furthermore, the PlantNet application helped students recognize plant scientific names, understand plant morphological characteristics, and facilitate the systematic process of Plant Classification. During the learning process, students appeared more active in discussions, worked collaboratively in groups, and were enthusiastic about observing plants using the PlantNet application. This demonstrates that digital technology-based learning can increase student motivation and engagement in the learning process.

Overall, the results of the questionnaire show that the PlantNet application can be used as an effective and innovative digital learning media in biology learning because it is able to increase students' interest in learning, motivation, and understanding of plant classification material.

4. Conclusions

The results of the study indicate that the use of the PlantNet application can improve students' understanding of Plant Classification in grade 10 of MAN 1 Banda Aceh. This is evident in the increase in the average pretest score from 82.3 to 98.1 in the posttest. Furthermore, the average N-Gain score of 0.92 is considered high, and the t-test results indicate a significant effect. The improvement in learning outcomes occurred because the PlantNet application helps students observe and identify plants directly, making learning more concrete and understandable. Students were also more active in the learning process because they were directly involved in plant identification activities using digital technology. The questionnaire results showed that the majority of students responded positively to the use of the PlantNet application. Students found the application easy to use, engaging, and helped them better understand the Plant Classification material.

Acknowledgement

The authors would like to express their sincere gratitude to the Principal of MAN 1 Banda Aceh, the Biology teacher, and all students of class X who participated in this research. Their support, cooperation, and active participation greatly contributed to the successful completion of this study. The authors also thank the Faculty of Teacher Training and Education, Universitas Serambi Mekkah, for the support provided during the research process. This research was not funded by any grant.

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