

Educational Journal of Artificial Intelligence and Machine Learning

Parabolum Publishing

Vol.2 (1), pp. 34-50, 2026
Doi: 10.58197/nyzkrr75

Available online at http://www.parabolumpublishing.org/

Type of article: Research Article

Exploring the Contribution of AI-Based Plant Identification to Plant Classification Learning and Motivation in Rwandan Secondary Schools

Celine Byukusenge*[1], Henriette Manishimwe[2], David Opanga[3], Devotha Nyirabagenzi[1], & Emmanuel Shyaka[1]

[1]Catholic University of Rwanda
[2]Kibogora Polytechnic
[3]St. John's University of Tanzania

Abstract

Plant classification is a practical component of biology that requires learners to observe, identify and compare plant characteristics. Yet instruction can remain largely theoretical when students have limited opportunities to work with plant specimens. This study examined whether integrating the AI-based Pl@ntNet application into plant classification instruction was associated with improved achievement and motivation among Senior One students in Rwanda. A quantitative, quasi-experimental pre-test–post-test non-equivalent control-group design was used with 370 students in two secondary schools in Rwanda. Intact classes received either Pl@ntNet-supported instruction (n = 185) or traditional instruction (n = 185). Students completed a 30-mark plant-classification achievement test before and after instruction and a four-item, five-point Likert motivation questionnaire after instruction. At baseline, achievement scores were comparable between experimental and control groups in both schools. Following the intervention, the experimental groups' mean achievement scores increased from 14.91 to 21.04 in School A and from 15.62 to 22.96 in School B. Control-group means changed from 14.14 to 14.19 in School A and from 15.36 to 15.79 in School B. Post-test scores were higher in the experimental groups than in the control groups in both schools (School A: 21.04 versus 14.19; School B: 22.96 versus 15.79; both $p < .001$). Post-intervention motivation was also higher among students in the experimental groups (School A: $M = 4.92$, $SD = 0.25$; School B: $M = 4.88$, $SD = 0.27$) than among controls ($M = 3.57$, $SD = 0.82$; and $M = 3.49$, $SD = 0.84$, respectively). The findings suggest that Pl@ntNet-supported instruction may provide a promising way to connect plant-classification concepts with direct observation and inquiry.

Keywords: artificial intelligence; Pl@ntNet; plant identification; plant classification; biology education; student motivation; Rwanda

Article information

Received: 12/05/2026;
Reviewed: 29/05/2026;
Revised: 20/09/2026;
Accepted: 28/09/2026

© 2026 The Author(s). Published by Parabolum Publishing. This is an open access article under the CC BY license (http://creativecommons.org/licenses/bync-nd/4.0/).

*** Corresponding author:** Celine Byukusenge: celinebyukusenge@gmail.com

How to cite this article: Byukusenge, C., Manishimwe, H., Opanga, D., Nyirabagenzi, D., Shyaka, E. (2026) 'Exploring the Contribution of AI-Based Plant Identification to Plant Classification Learning and Motivation in Rwandan Secondary Schools', *Educational Journal of Artificial Intelligence and Machine Learning*, 2(1), pp. 34-50. Available at: https://doi.org/10.58197/nyzkrr75

1. Introduction

Plant classification provides a systematic way of organizing plant diversity and supports scientific communication, biodiversity study, agriculture and conservation (Chase & Reveal, 2009; Godfray & Knapp, 2004). In school biology, learning classification involves more than memorizing taxonomic categories: students need to observe features, compare specimens, recognize similarities and differences, and use evidence to justify groupings. These skills are strengthened when classroom concepts are connected to authentic encounters with plants.

However, opportunities for practical and field-based learning may be constrained by limited access to specimens, instructional resources and time. Where plant taxonomy is taught predominantly through explanations and textbook illustrations, students may have fewer opportunities to develop confidence in identifying plants in their local environment. Digital plant-identification tools offer one possible way to supplement practical biology instruction. The Pl@ntNet application uses image-based recognition to suggest plant identities and provides information that users can explore during field observations (Mäder et al., 2021). Such tools can help connect learners' observations with scientific names and information about plant species.

The educational value of an identification application depends on how it is used. If students simply accept an automated identification, the activity may become a technology demonstration rather than a learning experience. When teachers ask learners to inspect plant features, compare the application's suggestions with their own observations, discuss possible errors and explain classifications, the tool can support inquiry and reflection. This approach is consistent with experiential learning theory, which emphasizes learning through concrete experience, reflective observation, conceptualization and active experimentation (Kolb, 1984). It also reflects the importance of aligning technology, pedagogy and subject content in teaching (Mishra & Koehler, 2006).

Research has considered digital identification tools as resources for biology learning and outdoor organism identification (Finger et al., 2022; Unger et al., 2021). Broader reviews also identify opportunities for artificial intelligence in education while emphasizing the need for appropriate

pedagogical integration (Wang et al., 2024; Zawacki-Richter et al., 2019). In Rwanda, curriculum reforms have emphasized competence-based teaching, while research has continued to identify challenges in translating learner-centred policy into classroom practice (Bizimana et al., 2023; Ndihokubwayo & Habiyaremye, 2018). Yet there is limited locally situated evidence on the use of AI-supported plant-identification applications in lower-secondary biology.

This study therefore investigated the integration of Pl@ntNet into Senior One plant-classification instruction in two secondary schools in Rwamagana District. It addressed three questions: (1) What were students' baseline levels of plant-classification achievement before the intervention? (2) How did achievement change following Pl@ntNet-supported instruction compared with traditional instruction? (3) Did post-intervention achievement and motivation differ between the two instructional groups?

2. Literature Review

2.1 Plant Classification and Its Importance in Biology Education

Plant classification is a fundamental component of biology education because it enables learners to understand plant diversity, recognize relationships among organisms, and organize living organisms according to shared characteristics. Classification involves observing morphological features, identifying similarities and differences, grouping organisms, and applying scientific criteria to distinguish plant groups and species (Chase & Reveal, 2009). Beyond memorizing taxonomic categories, meaningful learning of plant classification requires students to develop observation, comparison, identification, and analytical skills.

Despite its importance, plant identification and classification can be challenging for secondary school learners. Students are often required to distinguish plants using characteristics such as leaf arrangement, leaf shape, flower structure, stem characteristics, and reproductive features. When these concepts are taught predominantly through textbooks, illustrations, and teacher explanations, learners may have limited opportunities to interact directly with plant specimens and develop practical identification skills.

The limited attention given to plants in educational settings has also been discussed through the concept of plant blindness, which refers to the tendency to overlook plants and underestimate their

ecological importance (Wandersee & Schussler, 2001). More recently, Parsley (2020) proposed the term plant awareness disparity to describe this phenomenon and emphasize the importance of strengthening people's awareness of plants and their significance. Stagg et al. (2025) reviewed literature on plant awareness in education and identified the importance of meaningful first-hand encounters, identification activities, and positive learning experiences in promoting students' awareness of plants.

These observations suggest that effective plant classification instruction should provide learners with opportunities to engage directly with plant specimens, investigate their characteristics, and connect classroom knowledge with biodiversity in their immediate environment.

2.2 Artificial Intelligence and Digital Technologies in Biology Education

The integration of artificial intelligence (AI) into education has created opportunities for developing interactive, personalized, and technology-supported learning experiences. AI applications can support learning through image recognition, automated feedback, adaptive learning activities, and intelligent information retrieval. In biology education, these technologies offer particular potential for supporting activities that require observation, identification, comparison, and interpretation of biological information. Wang et al. (2024), in a systematic review of artificial intelligence in education, identified opportunities for AI to support teaching and learning while emphasizing the importance of appropriate pedagogical integration. Similarly, Zawacki-Richter et al. (2019) highlighted the growing application of AI in education and the need for greater consideration of pedagogical and educational perspectives.

In biology, image-recognition technologies can assist learners in recognizing organisms from photographs and accessing relevant biological information. These applications can provide additional learning resources, particularly when students have limited access to specialized scientific equipment or extensive collections of biological specimens. However, the educational contribution of AI depends on how it is incorporated into classroom activities. Technology should not replace students' observation, reasoning, or scientific judgment. Instead, it should support learners in examining biological characteristics, generating explanations, evaluating information, and developing scientific understanding.

2.3 AI-Powered Plant Identification Applications and Biology Learning

Mobile plant identification applications represent an important development in the use of AI for biodiversity education. These applications employ image-recognition technologies to suggest plant identities based on photographs submitted by users. They can provide learners with opportunities to investigate plant diversity, access species information, and connect theoretical concepts with observations of plants in their surroundings.

Pl@ntNet is an example of an AI-supported plant identification platform that enables users to photograph plants and receive suggested species identifications. Its development is associated with participatory biodiversity observation and image-based plant recognition (Joly et al., 2016). The platform combines automated image analysis with contributions from users who submit and annotate plant observations.

More recent research by Lefort et al. (2025) explains how Pl@ntNet combines artificial intelligence and human contributions to improve the quality of plant identification data. The study demonstrates the importance of combining machine-generated predictions with human knowledge and validation. This feature is particularly relevant to biology education because it reinforces the idea that AI-generated identifications should be critically examined rather than automatically accepted.

Research examining the accuracy of automated plant identification applications has also demonstrated their potential usefulness while identifying limitations. Hart et al. (2023), using 857 professionally identified plant images representing 277 species, found that identification accuracy varied across applications and plant types. Their findings indicate that automated identification tools can provide useful suggestions, although accuracy depends partly on the characteristics of the plant and the quality of the images submitted. For educational purposes, this means that students should be encouraged to compare application-generated suggestions with observable plant characteristics and, where possible, consult teachers, scientific references, and other reliable identification resources.

2.4 Mobile Plant Identification Applications and Students' Learning Achievement

The use of mobile plant identification applications has increasingly been investigated as a means of improving practical learning and biodiversity awareness.

Coşkunserçe (2024) examined the use of the Pl@ntNet mobile application combined with out-of-school learning activities among fifth-grade students. The study found that students were able to

identify and record more plant species following the activities. It also reported improvements in biodiversity-related behaviours. These findings suggest that mobile plant identification applications, when combined with direct environmental observation, can contribute to students' knowledge of local plant diversity.

Similarly, research in biology education has examined the educational value of digital identification tools in comparison with conventional identification methods. Finger et al. (2022) discussed the possibilities offered by modern plant identification keys for biology lessons, highlighting the potential of digital resources to support species identification and practical biology instruction.

Unger et al. (2021) also examined iNaturalist as an engaging resource for identifying organisms during outdoor learning activities. Their work illustrates the potential of digital identification resources to connect learners with biological diversity beyond the classroom.

Nevertheless, identifying a plant correctly does not necessarily mean that a learner understands the scientific principles underlying its classification. Educational activities should therefore require students to explain the characteristics used to identify plants, compare different species, and relate their observations to the relevant biological classification concepts.

2.5 AI-Based Plant Identification and Student Motivation

Student motivation is an important factor influencing participation, persistence, and engagement in learning activities. In biology education, practical and interactive activities can create opportunities for students to develop curiosity and interest in scientific concepts.

Mobile technologies may contribute to motivation by allowing students to participate actively in learning, receive immediate feedback, and investigate questions arising from their observations. Jeno et al. (2017) investigated the effects of a mobile application on biology students' motivation and achievement in species identification. Their findings indicated that mobile application-supported learning could enhance intrinsic motivation, perceived competence, and achievement.

Further evidence is provided by research on digital and conventional plant identification methods. The study by Finger et al. (2023), examining digital and paper-based plant identification tools, found that both approaches could positively influence students' intrinsic motivation, although their effects on enjoyment, perceived competence, and autonomy differed.

These findings are particularly relevant to the present study because Pl@ntNet-supported learning provides opportunities for students to independently investigate plants, examine identification suggestions, and participate in practical classification activities. Such experiences may increase students' enjoyment, confidence, and willingness to engage with biology.

However, the motivational benefits of technology should not be assumed to arise automatically from its availability. Teachers need to design activities that encourage meaningful participation, provide appropriate guidance, and allow students to make decisions and reflect on their learning.

2.6 Plant Classification Education in the Rwandan Context and Research Gap

In Rwanda, the competence-based curriculum emphasizes the development of knowledge, skills, attitudes, and practical competencies through learner-centred approaches. Biology education therefore requires teaching strategies that enable students to apply scientific concepts to real-life situations and their surrounding environment. Research by Ndihokubwayo and Habiyaremye (2018) discussed Rwanda's transition from a knowledge-based to a competence-based curriculum and the implications for teaching and learning. Similarly, Bizimana et al. (2023) examined biology teachers' attitudes and instructional practices in the context of competence-based education, highlighting the importance of translating curriculum expectations into classroom practice.

Plant classification offers opportunities to implement these educational expectations through observation, investigation, identification, and comparison of local plant species. However, conventional classroom approaches may not always provide sufficient opportunities for students to engage with the biodiversity around them. Although international studies have investigated digital plant identification and outdoor biodiversity learning, there remains a need for context-specific evidence concerning the integration of AI-supported plant identification into lower-secondary biology instruction in Rwanda. In particular, further investigation is needed into whether integrating applications such as Pl@ntNet into classroom and field-based activities is associated with improvements in students' plant classification achievement and motivation.

The present study addresses this gap by examining the contribution of Pl@ntNet-supported instruction to plant classification achievement and learning motivation among Senior One students in two secondary schools in Rwamagana District, Rwanda.

3. Theoretical Framework

The study is informed by three complementary theoretical perspectives: Experiential Learning Theory, Technological Pedagogical Content Knowledge (TPACK), and Self-Determination Theory. Together, these perspectives explain how AI-supported plant identification can facilitate practical learning, how teachers can integrate technology effectively into biology instruction, and how interactive learning experiences may influence students' motivation.

3.1 Experiential Learning Theory

Experiential Learning Theory, developed by Kolb (1984), provides the primary theoretical foundation for this study. The theory emphasizes that learning occurs through the transformation of experience into knowledge. According to Kolb, effective learning involves four interconnected stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. In the context of plant classification, Pl@ntNet can facilitate concrete learning experiences by enabling students to observe and photograph plants in their school environment or surrounding communities. Through these activities, learners encounter actual plant specimens rather than relying exclusively on textbook illustrations.

Reflective observation occurs when students examine the characteristics of the plants they have photographed and compare their observations with the identification suggestions generated by the application. Students can reflect on differences in leaf shapes, flower structures, stems, and other visible characteristics. During abstract conceptualization, learners connect their observations with biological concepts and develop an understanding of the principles used in plant identification and classification. Teachers can guide students in relating observable plant characteristics to scientific classification categories. Finally, active experimentation occurs when students apply their acquired knowledge to identify and classify additional plant specimens. They may repeat the identification process, compare different species, and evaluate whether the characteristics they observe support the classifications suggested by the application.

The theory therefore provides a useful explanation of how AI-supported plant identification can connect practical experiences with scientific concepts. In this study, Pl@ntNet is considered a supporting learning resource that facilitates experiential activities rather than a replacement for direct observation, scientific reasoning, or teacher guidance.

3.2 Technological Pedagogical Content Knowledge (TPACK)

The study is also informed by the Technological Pedagogical Content Knowledge framework developed by Mishra and Koehler (2006). TPACK explains the knowledge teachers require to integrate technology effectively into teaching by bringing together three essential dimensions: technological knowledge, pedagogical knowledge, and content knowledge. Technological knowledge concerns teachers' understanding of digital tools and their functions. In this study, it includes the ability to use Pl@ntNet to photograph plants, obtain identification suggestions, and access relevant species information.

Pedagogical knowledge relates to the teaching strategies used to facilitate learning. Teachers may employ inquiry-based learning, group discussions, field observations, collaborative activities, and practical exercises to help students understand plant classification. Content knowledge refers to teachers' understanding of biological concepts, including plant characteristics, plant groups, species identification, and classification principles. The effective integration of Pl@ntNet requires these three dimensions to work together. For example, a teacher should understand how the application generates identification suggestions, know how to organize meaningful field-based learning activities, and possess sufficient biological knowledge to guide students in evaluating the suggested identifications.

The TPACK framework is particularly relevant because the educational value of AI applications depends not only on the availability of technology but also on the teacher's ability to integrate it with appropriate instructional strategies and subject content.

4. Methodology

4.1 Research design and setting

A quantitative quasi-experimental pre-test–post-test non-equivalent control-group design was employed. The study was conducted in two selected secondary schools in Rwamagana District, Eastern Province, Rwanda. To protect the identity of participating schools in the publication, they are referred to as School A and School B. Each school contributed one experimental intact class and one control intact class. Individual students were not randomly assigned to conditions.

4.2 Participants and sampling

The study included 370 Senior One students: 185 in the experimental condition and 185 in the control condition. School A contributed 92 experimental and 93 control students; School B contributed 93 experimental and 92 control students. The two schools were purposively selected, and intact classes were used as clusters. The sample comprised 180 male students (48.64%) and 190 female students (51.36%); 330 students (89.19%) were aged 11–14 years and 40 (10.81%) were aged 15 years or above.

4.3 Instructional intervention

Students in the experimental classes learned plant classification with the Pl@ntNet application. The reported instructional activities included observing plants, photographing plant specimens, using the application to obtain suggested identifications and related information, verifying the generated information, and applying plant-classification concepts during classroom and field-based activities. Control classes studied the same biology content through the traditional approach, described in the dissertation as teacher explanations, textbook references, classroom discussions and conventional practical activities without Pl@ntNet. The dissertation does not provide a sufficiently precise account of the intervention duration, number of lessons, lesson-by-lesson sequence or device allocation; these details should be added from the researcher's records before journal submission.

4.4 Instruments and data collection

Achievement was measured using a plant-classification test reported as being scored out of 30 marks. The same test was administered before and after instruction. The motivation questionnaire comprised four statements addressing enjoyment, motivation to learn more, interest in identifying plant species and willingness to use the approach for other biology topics. Responses were recorded on a five-point Likert scale, and an overall mean score was calculated. The questionnaire was administered after the instructional period.

The dissertation reports that three experts reviewed the instruments for clarity, relevance and alignment with the study objectives. A pilot study was conducted in a school outside the main sample. Internal consistency was reported as KR-20 = .77 for the achievement test and Cronbach's alpha = .86 for the four-item motivation questionnaire.

4.5 Data analysis

Data were analysed in SPSS Version 26. Descriptive statistics were used to summarize participant characteristics and achievement and motivation scores. Paired-samples t-tests were reported for pre-test and post-test comparisons within groups, while independent-samples t-tests were used to compare experimental and control groups. The dissertation specified a .05 significance threshold and reported confidence intervals and Cohen's d effect sizes. Because the design used intact classes and only two schools, findings are interpreted as associations with the instructional condition rather than definitive causal effects.

5. Results

5.1 Baseline achievement

Before the intervention, the experimental and control groups had similar achievement scores in both schools. In School A, the experimental group scored M = 14.91 (SD = 3.50) and the control group M = 14.14 (SD = 2.38); the difference was not statistically significant, t(183) = 1.04, p = .30. In School B, the corresponding means were 15.62 (SD = 2.42) and 15.36 (SD = 2.61), with no significant difference, t(183) = 0.70, p = .49.

Table 1. Baseline achievement

School	Group	n	Pre-test M (SD)
A	Pl@ntNet	92	14.91 (3.50)
A	Traditional	93	14.14 (2.38)
B	Pl@ntNet	93	15.62 (2.42)
B	Traditional	92	15.36 (2.61)

Baseline motivation was also similar. In School A, the experimental and control groups had mean scores of 3.42 (SD = 0.86) and 3.41 (SD = 0.87), respectively; the reported test was not significant, t(183) = 0.08, p = .937. In School B, the corresponding means were 3.36 (SD = 0.86) and 3.34 (SD = 0.88), also indicating very similar starting levels.

5.2 Changes in achievement following instruction

In School A, the experimental group's mean achievement increased from 14.91 (SD = 3.50) to 21.04 (SD = 2.87), a gain of 6.13 marks. The within-group increase was statistically significant, t(91) = 16.67, p <

.001, with a reported 95% confidence interval for the mean gain of 5.40–6.86 and Cohen's dz = 1.74. The control group changed from 14.14 (SD = 2.38) to 14.19 (SD = 2.21); this change was not significant, t(92) = 0.52, p = .607.

In School B, the experimental group's mean increased from 15.62 (SD = 2.42) to 22.96 (SD = 2.75), a gain of approximately 7.34 marks. The reported within-group test was significant, t(92) = 24.76, p < .001, with a 95% confidence interval of 6.75–7.92 and Cohen's dz = 2.57. The control group increased from 15.36 (SD = 2.61) to 15.79 (SD = 2.89); the dissertation reports t(91) = 4.53, p < .001, and Cohen's dz = 0.47 for this smaller gain.

Table 2. Changes in achievement following instruction

School	Group	Pre-test M (SD)	Post-test M (SD)	Mean change
A	Pl@ntNet	14.91 (3.50)	21.04 (2.87)	+6.13
A	Traditional	14.14 (2.38)	14.19 (2.21)	+0.05
B	Pl@ntNet	15.62 (2.42)	22.96 (2.75)	+7.34
B	Traditional	15.36 (2.61)	15.79 (2.89)	+0.43

5.3 Post-test comparisons between groups

The experimental groups outperformed the control groups at post-test in both schools. In School A, the experimental group scored M = 21.04 (SD = 2.87), compared with M = 14.19 (SD = 2.21) in the control group. The reported between-group difference was 6.85 marks, t(183) = 18.20, p < .001, 95% CI [6.11, 7.59], Cohen's d = 2.68. In School B, the experimental group scored M = 22.96 (SD = 2.75), compared with M = 15.79 (SD = 2.89) in the control group; the difference was 7.17 marks, t(183) = 20.18, p < .001, 95% CI [6.47, 7.87], Cohen's d = 2.53.

Table 3. Post-test comparisons between groups

School	Experimental post-test M (SD)	Control post-test M (SD)	Mean difference	t(df)	p	Cohen's d
A	21.04 (2.87)	14.19 (2.21)	6.85	18.20 (183)	< .001	2.68
B	22.96 (2.75)	15.79 (2.89)	7.17	20.18 (183)	< .001	2.53

5.4 Post-intervention motivation

Students in the experimental groups reported higher motivation than students in the control groups. In School A, the experimental group's overall motivation mean was 4.92 (SD = 0.25), compared with 3.57 (SD = 0.82) in the control group. The dissertation reports a statistically significant difference, $t(183) = 16.15$, $p < .001$, Cohen's $d = 2.13$. In School B, the experimental group mean was 4.88 (SD = 0.27), compared with 3.49 (SD = 0.84) in the control group; the reported difference was significant, $t(183) = 17.74$, $p < .001$, Cohen's $d = 2.23$.

Table 4. Post-intervention motivation

School	Pl@ntNet M (SD)	Traditional M (SD)	Mean difference	Reported t(df)	p	Reported d
A	4.92 (0.25)	3.57 (0.82)	1.35	16.15 (183)	< .001	2.13
B	4.88 (0.27)	3.49 (0.84)	1.39	17.74 (183)	< .001	2.23

The four questionnaire items in the experimental groups also showed high means. In School A, item means ranged from 4.89 to 4.95; in School B, they ranged from 4.86 to 4.98. The highest reported item mean in School B concerned willingness to continue using the approach for other biology topics ($M = 4.98$).

6. Discussion

The study found that students who learned plant classification with Pl@ntNet achieved higher post-test scores than students who received traditional instruction in both participating schools. The experimental groups also showed substantial pre-test to post-test gains, while the control group in School A showed almost no change and the control group in School B showed a smaller gain. The consistency of the between-group pattern across the two settings is encouraging and suggests that the application, when integrated into instruction, may help students connect classification concepts with the observation and identification of actual plants.

One plausible explanation is that image-supported identification gave students a more active role in the lesson. Photographing plants, examining suggested identifications and relating the information to visible characteristics may have helped students move between concrete examples and abstract

classification concepts. This interpretation is consistent with experiential learning theory (Kolb, 1984). It also aligns with research describing digital identification tools as resources for biology teaching and organism identification activities (Finger et al., 2022; Mäder et al., 2021; Unger et al., 2021). The application should nevertheless be used as a prompt for evidence-based observation: students should be asked to justify an identification from plant features and consider that automated suggestions may be incorrect.

The higher motivation scores in the experimental groups may reflect the interactive and exploratory character of the learning activities. Students had opportunities to investigate plant species and receive immediate information, potentially making the topic more relevant and enjoyable. The result is compatible with broader literature suggesting that technology-supported learning can promote engagement when it is embedded in purposeful pedagogy (Mnguni et al., 2024; Wang et al., 2024). However, because the motivation instrument was administered only after the intervention, the study cannot establish within-student changes in motivation over time. The similar baseline motivation figures reported in the dissertation are descriptive; it is not clear whether the same questionnaire was administered before the intervention in a fully documented manner.

The findings also have practical implications for competence-based biology teaching in Rwanda. Pl@ntNet may offer one way to use local biodiversity as a learning resource, particularly for topics requiring observation, comparison and classification. Effective implementation is likely to depend on teachers' ability to design inquiry activities, access to suitable devices and electricity, and reliable access to the application's functions. The tool should complement, rather than replace, direct observation, teacher explanation, textbooks and practical work. This is consistent with the TPACK perspective, which emphasizes the integration of technology with content and pedagogy (Mishra & Koehler, 2006).

7. Limitations of the study

This study encountered two main limitations; First, the study involved only two purposively selected schools in one district, limiting generalizability. Second, intact classes rather than individually randomized students were assigned to conditions; unmeasured class, teacher or school differences may therefore have contributed to the observed outcomes.

8. Conclusion and implications

In these two Rwamagana secondary schools, Senior One students who received plant-classification instruction integrated with Pl@ntNet achieved higher post-test scores and reported higher post-intervention motivation than peers taught through traditional methods. The results support the potential of AI-supported plant identification as a complementary resource for experiential and inquiry-oriented biology teaching. They do not establish that the application alone caused the observed differences, given the quasi-experimental design and limited number of schools. Schools and teacher educators considering this approach should prioritize teacher preparation, equitable access to devices and electricity, critical evaluation of AI-generated identifications, and the integration of digital tools with direct scientific observation. Larger studies across multiple districts, with clearly documented intervention procedures and delayed assessments, are needed.

References

Bizimana, E., Mutangana, D., & Mwesigye, A. (2023). Switching from knowledge to competence-based teachings: Biology teachers' attitudes and instructional practices. European Journal of Mathematics and Science Education, 4(3), 201–215. https://doi.org/10.12973/ejmse.4.3.201

Chase, M. W., & Reveal, J. L. (2009). A phylogenetic classification of the land plants to accompany APG III. Botanical Journal of the Linnean Society, 161(2), 122–127. https://doi.org/10.1111/j.1095-8339.2009.01002.x

Coşkunserçe, O. (2024). Use of a mobile plant identification application and the out-of-school learning method in biodiversity education. *Ecology and Evolution, 14*(4), e10957. https://doi.org/10.1002/ece3.10957

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Plenum Press.

Finger, A., et al. (2023). The medium matters! The effect of a mobile digital identification tool on students' intrinsic motivation during plant identification. *Journal of Biological Education*. https://doi.org/10.1080/00219266.2022.2147204

Finger, A., Groß, J., & Zabel, J. (2022). Plant identification in the 21st century-What possibilities do modern identification keys offer for biology lessons? Education Sciences, 12(12), 849. https://doi.org/10.3390/educsci12120849

Godfray, H. C. J., & Knapp, S. (2004). Introduction. Philosophical Transactions of the Royal Society B: Biological Sciences, 359(1444), 559–569. https://doi.org/10.1098/rstb.2003.1457

Hart, A. G., Bosley, H., Hooper, C., Perry, J., Sellors-Moore, J., Moore, O., & Goodenough, A. E. (2023). Assessing the accuracy of free automated plant identification applications. *People and Nature, 5*(3), 929–937. https://doi.org/10.1002/pan3.10460

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall.

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Prentice-Hall.

Jeno, L. M., Grytnes, J.-A., & Vandvik, V. (2017). The effect of a mobile-application tool on biology students' motivation and achievement in species identification: A Self-Determination Theory perspective. *Computers & Education*. https://doi.org/10.1016/j.compedu.2016.12.011

Joly, A., Bonnet, P., Goëau, H., Barbe, J., Selmi, S., Champ, J., Dufour-Kowalski, S., Affouard, A., Carré, J., Molino, J.-F., Boujemaa, N., & Barthélémy, D. (2016). A look inside the Pl@ntNet experience: The good, the bias and the hope. *Multimedia Systems, 22*, 751–766. https://doi.org/10.1007/s00530-015-0462-9

Lefort, T., Affouard, A., Charlier, B., Lombardo, J.-C., Chouet, M., Goëau, H., Salmon, J., Bonnet, P., & Joly, A. (2025). Cooperative learning of Pl@ntNet's artificial intelligence algorithm: How does it work and how can we improve it? *Methods in Ecology and Evolution, 17*(2), 392–403. https://doi.org/10.1111/2041-210X.14486

Mäder, P., Boho, D., Rzanny, M., Seeland, M., Wittich, H. C., Deggelmann, A., & Wäldchen, J. (2021). The Pl@ntNet app—Interactive plant species identification. Methods in Ecology and Evolution, 12(7), 1335–1342. https://doi.org/10.1111/2041-210X.13611

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers College Record, 108(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Mnguni, L., Nuangchalerm, P., El Islami, R. A. Z., Sibanda, D., Ramulumo, M., & Sari, I. J. (2024). AI integration in biology education: Comparative insights into perceived benefits and TPACK among South African and Indonesian pre-service teachers. Asia-Pacific Science Education, 10(2), 381–410. https://doi.org/10.1163/23641177-bja10086

Ndihokubwayo, K., & Habiyaremye, H. T. (2018). Why did Rwanda shift from knowledge to competence based curriculum? Syllabuses and textbooks point of view. African Research Review, 12(3), 38. https://doi.org/10.4314/afrrev.v12i3.4

Parsley, K. M. (2020). Plant awareness disparity: A case for renaming plant blindness. *Plants, People, Planet, 2*(6), 598–601. https://doi.org/10.1002/ppp3.10153

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Stagg, B. C., Hetherington, L., & Dillon, J. (2025). Towards a model of plant awareness in education: A literature review and framework proposal. *International Journal of Science Education, 47*(4), 539–559. https://doi.org/10.1080/09500693.2024.2342575

Unger, S., Rollins, M., Tietz, A., & Dumais, H. (2021). iNaturalist as an engaging tool for identifying organisms in outdoor activities. Journal of Biological Education, 55(5), 537–547. https://doi.org/10.1080/00219266.2020.1739114

Wandersee, J. H., & Schussler, E. E. (2001). Toward a theory of plant blindness. *Plant Science Bulletin, 47*(1), 2–9.

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. Expert Systems with Applications, 252, 124167. https://doi.org/10.1016/j.eswa.2024.124167

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators? International Journal of Educational Technology in Higher Education, 16, 39. https://doi.org/10.1186/s41239-019-0171-0