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PERCEPTIONS OF PRIMARY PRE-SERVICE TEACHERS IN THE UTILIZATION OF PLANT IDENTIFICATION APPS AS EDUCATIONAL TOOLS

Peter Paul Canuto

Abstract. *Plant identification apps make learning about plants more convenient. This study explored the participants' perceptions of using three plant identification apps, PlantNet, PictureThis, and LeafSnap, as potential educational tools. Problems experienced, differences in perceptions, and the participants' most preferred apps were also determined. Through purposive sampling, the study engaged 162 primary pre-service teachers in the Cordillera Administrative Region (CAR), Philippines. Data were collected through a developed questionnaire and analysed quantitatively. The questionnaire was reliable with an identified single component for perception. Participants first explored and used the apps to identify local plants, thereafter, responding through an online questionnaire. Results showed that participants strongly perceived the apps as engaging, helpful in plant identification, easy to browse, providing details, effective as emerging tools, and significant for scientific literacy, except for consistency of results. There were significant differences, but with small effect sizes, indicating negligible differences in the perceptions of male and female participants regarding the apps' consistency of results and effectiveness. Weak internet connection was the primary issue affecting the apps' utilization. The pre-service teachers preferred LeafSnap over PictureThis and PlantNet. Conclusively, this study affirmed the potential of the apps for students learning about plants, further supporting their feasibility as emerging educational tools.*

Keywords: *educational tools, plant identification apps, PlantNet, PictureThis, LeafSnap, primary pre-service teachers*

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Introduction

Teaching botany among students has always been challenging. However, rapid technological advancement and the integration of computer science research paved the way for the development of mobile learning that supports and promotes plant profiling and raising plant awareness. One such advancement to support learning about plants is automated plant identification apps that can be readily downloaded and installed on smartphones. Utilizing plant identification apps combined with the curation of digital plant images and image recognition technology is already becoming functionally significant (Boho et al., 2020; Jones, 2020) as it easily supports our ability to identify plants (Wäldchen et al., 2018).

Sadly, there has been a drop in the public's knowledge and interest in studying plants, which may result from urbanization and the industrial and technological revolution (Burke et al., 2022). There is also an observed lack and underrated interest in plants among students despite their ecological and economic relevance (Weigelt et al., 2022). Some studies indicated that most students preferred to study animal species compared to plants (Balas & Momsen, 2014; Wandersee & Schussler, 1999). Students also find plant identification more complex and tedious than animal identification (Wang, 2017). These factors may relate to the concept of "plant awareness disparity (PAD)", proposed by Parsley (2020). This concept expounds the individual's tendency to ignore plants in their surroundings, where they visualize plants as a scenic aggregation of green mass secondary to animals (Parsley, 2020; Parsley et al., 2022).

PAD is a modified term of "plant blindness" by Wandersee and Schussler (1999) since the former term is often perceived as associated with visual disability and discriminatory towards persons with disabilities as a whole (McDonough MacKenzie et al., 2019; Parsley, 2020). Students experience PAD depending on their attention or regard for plants, attitude or feeling of learning about plants, knowledge or recognition of the relevance of plants, and relative interest between plants and animals (Parsley, 2020; Parsley et al., 2022). This occurrence may be due to one's perception and how the brain functions (Strgar, 2007). Students perceive that they have more similar characteristics to animals, such as movement and physical resemblance, than

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plants (Hoekstra, 2000). Students strongly (Prokop & Fančovičová, 2023) and automatically prefer animals first to plants since they belong to the animal kingdom (Flannery, 2002).

Plants are vital players in biogeochemical processes, such as carbon and nitrogen cycles, contributing to our approaches related to global climate and climate change. With the importance of plants, schools and teachers should keep their instruction manageable because they are significant to our understanding of ecosystems (Pany et al., 2019) as it underpins food webs (Hill, 2022). Because of these factors, teachers must engage and exert effort to raise interest in botany and promote student plant awareness and appreciation (Pany et al., 2019; Strgar, 2007). One way to achieve these goals is through plant identification applications (apps) that enable the students to gain knowledge of plant species (Zhu et al., 2017).

There has been a significant increase in the use of plant identification apps over the years (Baker, 2023). With the correct plant identification app, individuals can contribute to citizen science initiatives, engage with nature, and determine which plant species are invasive or dangerous (Airhart, 2023). Nonetheless, these apps must be meticulously utilized to effectively impact science literacy and citizen science. It is therefore recommended to use plant identification apps that have reputable sources, such as government or university-affiliated sites (Hill, 2022). It is noteworthy to use apps thoroughly tested and evaluated for their accuracy in identifying plants (Pärtel et al., 2021). In the academe, teachers must use these apps based on reputable sources and expert systems to ensure their contribution to students' plant knowledge (Wang, 2017).

Literature Review

Botany in the Primary Science Curriculum and Local Plants

The present Kindergarten to Grade 12 (K to12) Science Curriculum of the Philippines aims to develop scientifically, technologically, and environmentally literate students. These literacies enable them to become productive in the community, solve complex problems, be innovative, make well-informed decisions, communicate effectively, exhibit scientific attitudes and values, and become responsible custodians of nature. This curriculum employs a spiralling progression of scientific concepts in Chemistry, Biology, Physics, and Earth and Space Science, leading to a deepened understanding of the students as they progress to higher levels. In particular, formal teaching of Science as a discipline starts at the Grade 3 level. From Kindergarten to Grade 2, science learning focuses on exploratory activities and arousing students' curiosity about the natural world to foster basic scientific knowledge and skills development. These conditions invoke students' readiness for formal Science learning (Department of Education, 2016).

The Philippine K to 12 Science Curriculum also underscores localized learning of plants found in the community. It reiterates that students need to learn about their local plants to understand food and nutrition, biodiversity, sustainability, medicinal and traditional uses, and strengthen plants' cultural awareness and heritage (Department of Education, 2016). The Cordilleran region is an agricultural community situated in mountain ranges. Due to its location, temperatures, humidity, and weather patterns differ across the region, making it ideal for various vegetable and fruit crops, including ornamental cut flowers. Some examples of locally grown vegetable and fruit crops include but are not limited to mongo or munggo (mung bean), camote (sweet potato), broccoli, cauliflower, okra (lady's fingers), kangkong (water spinach or swamp cabbage), lettuce, pechay (napa cabbage or snow cabbage), ampalaya (bitter gourd) fruit, tomato, string beans, squash, ginger, bell pepper, carrots, gabi (taro or taro root), radish, potato, camote (sweet potato), and cassava (Philippine Statistics Authority, 2022). Likewise, ornamental cut flowers include gladiola (sword lily), asters, gerbera daisies, coloured and white calla lilies, Shasta daisies, chrysanthemum, agapanthus (Lily of the Nile or African lily), anthuriums, statice (sea lavender), baby's breath, alstroemeria (Peruvian lily), milflores (hydrangea), lisianthus, carnations, and snapdragons (Cabreza, 2023) to name a few.

The foundations of learning about plants are laid at the primary level. Teachers formally introduce the students to the natural world, associating it with their basic scientific knowledge and skills. In this stage, students are exposed to the incredible diversity of plant life on Earth's ecosystems. They will learn to identify different types of plants, their parts, growth patterns, adaptations, modes of reproduction, and habitats. The plants' functions in the environment, their benefits, and proper care are also emphasized. This leads the students to develop recognition and appreciation for the vast array of colours, shapes, and sizes of plants (Department of Education, 2016).

Consequently, having innovative and creative teaching aids and supplementary resources is a must among

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teachers. These resources help the teachers instil a sense of wonder, curiosity, respect for the natural world, scientific literacy, environmental awareness, plant appreciation, and an understanding of the interconnections between plants, humans, and the environment. For these reasons, primary school teachers need a spectrum of educational materials that can be used inside and around the community. Using plant samples, slide presentations, and video clips is practical in teaching botany. Nonetheless, using interactive, digital, and mobile learning will contribute further to students' learning about plants, allowing them to explore more plants in their environment. Hence, the reason for exploring pre-service teachers' perceptions of the potential of plant identification apps as educational tools. As pre-service teachers, they are gaining and developing knowledge and skills for facilitating learning by using a broad range of teaching methodologies, innovative and creative resources, and utilizing educational technologies that they could apply in their future teaching profession (Commission on Higher Education, 2017). Allowing them to explore the plant identification apps and understand their perception may engage the pre-service teachers to effectively employ these apps during their practicum or future teaching endeavours.

Plant Identification Apps

Automated plant identification apps are mobile apps that use photo recognition algorithms and software programmed to identify plants (Pimm et al., 2015; Sachar & Kumar, 2021). Typically, the user takes a photograph of the whole or any of the parts of the unknown plant and then uploads it to the app's system. Once the photographs are uploaded, the app compares them to its database, analyses them, and then provides output or lists of closely possible results (Sachar & Kumar, 2021; Wäldchen & Mäder, 2018). For apps that provide lists of closely possible results, the first plant presented is considered the highest possible identification of the plant. In contrast, the others are suggestions allowing the user to select the most accurate result (Schmidt et al., 2022).

The app's databases may come from various sources, such as crowdsourced observations, remotely sensed images, or specimen collections from museums or herbariums worldwide (Pimm et al., 2015; Sachar & Kumar, 2021). Conveniently, the leaf is the most photographed plant part due to its presence throughout the year (Sachar & Kumar, 2021), regardless of the seasons. Characteristics used for comparisons and analysis between the uploaded photograph and the app's databases include the leaf's colour, shape, texture, and venation (Sachar & Kumar, 2021; Wäldchen & Mäder, 2018). Other plant parts commonly used by these apps for identification include stems, bark, flower, or fruits (Jones, 2020; Rzanny et al., 2019; Schmidt et al., 2022).

The selection of plant identification apps, PlantNet, PictureThis, and LeafSnap, involved in this study was primarily based on Hill's (2022) long-term evaluation. From 2018 to 2021, Hill (2022) and their students tested 14 apps concerning the apps' accuracy in identifying plants. In 2021, they tested eight apps up to 90 to 140 times to identify plants at the W. J. Beal Botanical Garden, Michigan State University. They have photographed plants of flowering broadleaf ornamental species and several kinds of flowering and vegetative weeds categorized by broadleaf weeds, grass or grass-like weeds, and a seedling winter annual weed. Their study also included the botanical garden's usual agricultural and turf weeds. In the end, as of the fall of 2021, Hill (2022) ranked PictureThis as the top-performing app based on the app's comparative percentage of correctly identifying the plants. The PlantNet app ranked second, while LeafSnap ranked fourth. PlantStory, the third in rank, was not chosen for this study since it was newly evaluated by Hill (2022) in 2021, unlike the other three apps. PlantStory is also best described as a marketplace for plants, focusing on commercial rather than educational purposes.

PlantNet

PlantNet or Pl@ntNet is an excellent software for identifying plants quickly. It also provides consistent and accurate identifications of plants compared to others. The app functions through the support of the Agropolis Foundation. It was developed as a project through sponsorship of four French research institutes consisting of the National Institute of Agricultural Research (INRA), the French National Research Institute for Sustainable Development (IRD), the French Institute for Research in Computer Science and Automation (INRIA), and the French Agricultural Research Centre for International Development (CIRAD), including the Tela Botanica Network (Baker, 2023; Wäldchen et al., 2018).

PlantNet provides guides on how to use the app's features (Baker, 2023). Using filters, it can identify plants using photos of leaves, flowers, fruits, or bark. It also uses the Global Positioning System (GPS) and Map option to accurately identify plants (Baker, 2023; Wäldchen et al., 2018). It relies on quality image recognition and user

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involvement (Baker, 2023). It can share photo documentation for research purposes but does not share data with third parties for advertisement (Airhart, 2023). PlantNet also supports multiple languages (Baker, 2023) and does not contain pop-ups and ads requiring users to pay for other features (Airhart, 2023). However, it does not give detailed information, which may be lacking for others (Airhart, 2023).

Based on the evaluations of Hill (2022), PlantNet emerged as the second top-performing app. It achieved 55% accuracy in identifying seedling winter annuals and almost the same performance as PictureThis in identifying vegetative grass-like weeds. Hart et al. (2023) determined the apps' accuracy at 86.6%. On the other hand, based on the works of Hill (2022), CNN journalist Baker (2023) and her colleagues conducted a related evaluation and concluded that PlantNet is the most accurate plant identification app among the apps they have tested. Thus, they highly recommend PlantNet as the best app for most people. Another evaluation of the app by The New York Times Wirecutter journalist Airhart (2023) and her colleagues found that PlantNet is simple, quick, and easy to use compared to other apps, ultimately picking the app as the best among the apps they have also tested. Alternately, Otter et al. (2020) found that the app had 47% accuracy in identifying toxic plants, making it second in rank.

PictureThis

PictureThis is a plant identification app developed by Glority Global Group Limited, an artificial intelligence (AI) resource based in China. It uses AI deep learning technology to search its database and identify plants (Parkins, 2019). Their official website shows that the app can identify more than 10,000 plant species. PictureThis provides topics related to the identified plant, such as full description, toxicity, informative videos, and natural history in considerably more detail (Airhart, 2023). Aside from these, it has a "plantpedia", a digital plant encyclopedia containing helpful information, such as ideal habitat, soil requirements, planting season, and pest control. The app allows users to share pictures and answer plant-related questions through its worldwide social community and forum sections. It also has a "flower map" feature that allows users to tag plants in their locality (Parkins, 2019).

Hill (2022) concluded that PictureThis is the top-performing app. Hill (2022) and her students found that PictureThis ranked the top-performing plant identification app with 67% accuracy among the 130 plant samples. It maintained its number-one rank four years in a row. Further, it was the favourite of Hill's (2022) students due to its high accuracy and ease of usage. Though it maintained its top rank, it presents a low accuracy of 47% when identifying vegetative grass or grass-like weeds compared to other categories. Accordingly, a closer inspection of the grass structures, such as floret and ligule, is necessary and is mostly not seen in the whole plant picture. Similarly, Schmidt et al. (2022) found that PictureThis resulted in a high correct identification of 81.36% genus and 67.84% of species of combined leaf and bark structures among 55 tree species. With these high accuracy results, they will likely recommend the app for their students' use. Another study by Otter et al. (2020) concluded that the app was the best among the apps they have used, with a 59% accuracy rate in identifying toxic plant species. On the contrary, Airhart (2023) and her colleagues found that PictureThis is less user-friendly than the other tested apps. It is also too easy to unintentionally subscribe to paid extra features and advertisements popping up from the app.

LeafSnap

LeafSnap was developed by researchers from the Smithsonian Institution, the University of Maryland, and Columbia University (Wäldchen et al., 2018). It compares the plant's picture to its database of over 9000 images (Kress et al., 2018). The app retrieves photos on its database similar to the uploaded one. However, the user has the last say in whatever species they think best fits the findings (Wäldchen et al., 2018). LeafSnap has a broader, more accurate advanced identification function that can identify the plant using photos of the whole plant, leaves, or flowers. It presents caring guides and reminders for plants which can be helpful for the users. Users can also create plant photo collections and data sharing (Baker, 2023). Moreover, it provides background information about the species and its geographic location (Kress et al., 2018).

Compared with other apps, LeafSnap was identified as the fourth-best app by Hill (2022). It achieved an accuracy of more than 40%. It was able to have better performance in identifying flowering ornamentals. Wäldchen et al. (2018) indicated that LeafSnap achieved 96.8% among 184 tree species, making it to the top five and an overall recognition rate of 73% accuracy. Hart et al. (2023) measured the apps' accuracy at 86.9%. Alternatively,

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Kress et al. (2018) observed a 10% to 100% accuracy variance among the tree species samples. Nonetheless, they have noted that LeafSnap is continuously undergoing improvement using deep learning. Moreover, Airhart (2023) observed that using the app presented challenges since operating could be more intuitive. It also presents pop-ups and advertisements that may cause accidental subscription of the user.

Research Gap to be Filled

Even with the growing number and use of plant identification apps, only a few studies (Wang, 2017; Yujuan et al., 2021) were conducted on the feasibility and capability of mobile plant identification apps as educational tools. Most studies conducted on these apps focused primarily on their features, accuracy, user-friendliness, and downsides (Airhart, 2023; Baker, 2023; Hart et al., 2023; Hill, 2022; Kress et al., 2018; Otter et al., 2020; Pärtel et al., 2021; Schmidt et al., 2022; Wäldchen et al., 2018). There is still a lack of recognition of these apps' potential for science teaching. This prompted the researcher to explore the prospect of using plant identification apps for learning about plants which are deemed beneficial to raise plant awareness and recognition and impede PAD among the students. Instead of accuracy, this study centred on examining and understanding the perspective of future primary school teachers about their views and experiences, thereby acknowledging the capabilities of the apps to be used in science education.

Research Aim and Research Questions

This study aimed to explore the potential of three plant identification apps, PlantNet, PictureThis, and LeafSnap, as emerging and interactive educational tools for students learning about plants. Mainly, it aimed to determine the perceptions of primary pre-service teachers in using the apps as a probable teaching aid in upper primary grade levels and their significance for supporting the development of scientific literacy. It also aimed to determine the problems experienced by the participants in using the apps. The differences between the participants' perceptions according to gender and their most preferred app were also determined. Moreover, the following research questions guided the conduct of this study:

1. What are the primary pre-service teachers' perceptions regarding using plant identification apps as educational tools?
2. Are there significant differences among the participants' perceptions according to gender?
3. What are the problems experienced by the participants while utilizing the apps?
4. Which app is the most preferred one by the participants?

Research Methodology

Research Design

The researcher employed a quantitative approach to gather and analyse the perceptions in using the three plant identification apps for learning about plants and the challenges experienced by the participants. A descriptive survey was used to understand the characteristics of the participants (Anastas, 2000), leading to the exploration of the participants' insights and struggles concerning the apps. Meanwhile, inferential statistics was used to compare the differences (Kuhar, 2010) among the participants' perceptions of utilizing the apps for teaching about local plants. This exploratory study focused on primary pre-service teachers' perceptive views and ordeals regarding their future use of plant identification apps. The pre-service teachers were enrolled in Bachelor of Elementary Education (BEEd) from four state and private universities in the Cordillera Administrative Region (CAR), Philippines. The BEEd leads explicitly to a teaching profession at the primary level. The apps utilized by the participants involved three plant identification apps that were selected based on the long-term study of Hill (2022). The participants used the apps to identify locally grown vegetable and fruit crops and ornamental plants around their community. The participants' overall perceptions and differences according to gender, problems they encountered, and most preferred apps were determined using an online survey questionnaire provided through email. The study was conducted throughout the two semesters of the academic year 2021 – 2022.

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Participants

The study involved 162 BEEd pre-service teachers. They comprised second to fourth-year undergraduate students, involving 46 (28%) males and 116 (72%) females. The number of participants was based on those pre-service teachers who volunteered, consented to this study, fully utilized the plant identification apps, and thoroughly answered the online questionnaire. Preliminary to data gathering, request letters were sent to a total population of 176 primary pre-service teachers enrolled in four universities. However, only 162 out of 176, or 92% of the participants, fully agreed, had used the apps and entirely responded to the questions. The remaining 8% of the participants either withdrew their participation or submitted incomplete responses. A 92% of positive responses resulted most likely due to the follow-up reminders (Fincham, 2008; Menon & Muraleedharan, 2020) undertaken by the researcher, attaining enough data to represent the population.

Furthermore, the participants were determined through purposive sampling, enabling their selection based on the structure of this study (Creswell et al., 2011). The curriculum design, objectives, and career opportunities of the degree, which calls for the development of qualified teachers with specializations in content and pedagogy for primary education (Commission on Higher Education, 2017), guided the selection of the BEEd pre-service teachers. The participants' gender is the only variable considered in the study. The year level of the participants was not included since some were classified as irregular students. In the context of the country's universities, an irregular student is a student who is enrolled with less than the prescribed number of course subjects or units in a given semester required by the curriculum of the degree program. It may also pertain to students attending classes across different year levels of the same program to comply with the required number of units for the degree. For the irregular students involved as participants, it is difficult to determine their specific year level; hence, the year level is excluded.

Instrument

The researcher primarily developed the questionnaire with four sections. The first section of the questionnaire gathered the profiles, indicating gender, year level, and classification as either regular or irregular students, from the primary pre-service teachers. The second section comprised seven question items, as presented in Tables 4 and 5, items 1 – 7, regarding the participants' perceptions of the apps. These question items will be rated through a 5-point Likert scale measured with 1 = Strongly Disagree (SD), 2 = Disagree (D), 3 = Neutral (N), 4 = Agree (A), and 5 = Strongly Agree (SA). The third section consisted of a checklist with five question items enumerated in Table 6, items 1 – 5, regarding the problems they encountered while using the apps. This section allowed the participants to select the given options more than once. A selection of the three apps presented in Table 7 is the last section of the questionnaire prompting a singular response from the participants to choose the best app to use in teaching significant lessons related to local plants. The question items were integrated into an online questionnaire created using Google Forms.

Reliability and Factor Analysis

Content validation of the questionnaire was first requested from three faculty members with expertise in Biology teaching. Some of the statements were then paraphrased based on validations. Thereupon, pilot testing was conducted involving 30 primary pre-service teachers from a state and a private university in the same region, excluding these universities during the primary data gathering. As a result, the questionnaire was found reliable, with a determined coefficient of reliability of .952 using Cronbach's alpha. Subsequently, exploratory factor analysis was done on the seven question items regarding perception, ruling out questions concerning problems with multiple responses and the most preferred app. The correlation matrix in Table 1 shows that the Pearson correlation coefficient of each question item ranges from .409 to 1. Most items showed a high correlation with each other, considering a correlation coefficient of .60 and above, indicating that the items belonged to the same factor. Those items with a correlation coefficient of below .60 showed moderate correlation, such as in the case of Item 3 correlated with Items 4, 5, 6, and 7. There were no negative and weak correlations identified among the items.

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Table 1
Correlation Matrix of Question Items Regarding Perceptions

		Item 1	Item 2	Item 3	Item 4	Item 5	Item 6
	Item 1	1.000					
	Item 2	.631	1.000				
	Item 3	.608	.544	1.000			
Correlation	Item 4	.510	.653	.581	1.000		
	Item 5	.681	.709	.409	.454	1.000	
	Item 6	.576	.769	.445	.466	.727	1.000
	Item 7	.538	.775	.487	.634	.703	.806

Kaiser-Mayer-Olkin (KMO) and Bartlett's test of sphericity was also done. The KMO was determined as .859 (greater than .70), indicating enough items to produce a factor. Likewise, Bartlett's test is significant ($\chi^2(21) = 133.65$, $p = .001$) at 5%, showing that the variables were correlated highly enough to provide a reasonable basis for factor analysis. Based on the total variance explained shown in Table 2, only the first component has an eigenvalue greater than 1. This result stipulated that there is only one possible factor. The cumulative percent showed that only one factor accounts for 66.54% of the variance.

Table 2
Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.658	66.539	66.539	4.658	66.539	66.539
2	.806	11.521	78.060			
3	.582	8.315	86.375			
4	.370	5.292	91.667			
5	.228	3.258	94.924			
6	.207	2.964	97.889			
7	.148	2.111	100.000			

Similarly, the component matrix shows that only one factor was extracted, as indicated in Table 3. Item 2 has the highest correlation value among all the items, indicating its strong association with the only component. Meanwhile, Item 3 has the lowest correlation value, though still indicating a strong association with the component. The remaining items also disclosed strong associations based on their correlation values. Since there is only one component, all items were correlated with only one factor. Considering all the question items, the commonality among them is that they all relate to using and evaluating the mobile apps used for plant identification, referencing the user's perceptions.

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Table 3
Component Matrix of the Items

Items	Component
	1
Item 2: I found the mobile apps helpful for identifying plants	.899
Item 7: The mobile apps are significant for supporting scientific literacy	.876
Item 6: I found the mobile apps as an effective emerging tool for learning about plants	.852
Item 5: The mobile apps provide significant details about the plants	.830
Item 1: I found the mobile apps engaging for plant exploration	.792
Item 4: There is consistency of results among the three mobile apps	.745
Item 3: I found it easy to browse within the mobile apps' interface	.697

Procedures

First, a letter of permission indicating the study's objectives and the participants' contribution was sent to the target primary pre-service teachers through emails. Then, consent forms asking for the participant's involvement in the study were also sent to those who positively gave their permission. After the participants' approval, they were instructed to download and install the three plant identification apps, PlantNet, PictureThis, and LeafSnap, from either Play Store for Android systems or App Store for iOS systems, depending on the model and compatibility of their smartphones. Afterwards, the participants were asked to use the plant identification apps to identify local vegetable and fruit crops and ornamental plants they liked. The plants to be identified may or may not be familiar to them. They may take photos of the whole plant, its flowers, leaves, of barks. The participants were allowed to use the apps to identify unlimited local plants. This condition allowed the participants to be immersed in using the apps and familiarize themselves with their features. However, they were only allowed to finally choose five plants for the purpose of this study. They also had to take note of the scientific name of the identified plant by the apps for comparison of result consistency. For monitoring and record purposes, the participants were also instructed to take a screenshot of the apps' results and send it through the researcher's email. After using the apps, a link to the Google Form containing the online questionnaire was forwarded to the participants for them to answer. Results were then tabulated using spreadsheets. The conduct of this study upholds the practice of scientific inquiry and the ethical and professional standards in doing research. The contact information, especially the participants' email addresses, was gathered through their professors' referrals and was strictly used for communication purposes relevant to this study. Consent forms were asked from the participants' emphasizing their voluntary participation. The online questionnaire was sent and monitored personally by the researcher. The submitted responses and their tabulated data were compiled and kept confidential.

Data Analysis

A statistical limit of weighted mean was used to analyse the perception of the utilization of the plant identification apps for learning about plants among the participants. The statistical ranges consist of 1.00 – 1.80 = Strongly Disagree (SD), 1.81 – 2.60 = Disagree (D), 2.61 – 3.40 = Neutral (N), 3.41 – 4.20 = Agree (A), and 4.21 – 5.00 = Strongly Agree (SA). Frequency count, percentage, and ranking were used to determine the problems experienced by the participants in using the apps and to determine their most preferred teaching tool among the three apps. Moreover, a t-test was used to test if there were significant differences in the level of perceptions of the use of the apps between the male and female primary pre-service teachers.

Research Results

Table 4 shows that the primary pre-service teachers have strong perceptions towards the three apps after using them, except for one item. They strongly agree that the apps were effective emerging tools for learning about plants, followed by helpful apps for identifying plants. The participants expressed the same level of agree-

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ment regarding the apps' features in providing significant plant details and engaging for plant exploration. There is also a strong agreement relating to the apps' ease of browsing and significance for supporting scientific literacy. Notably, they have a lower level of agreement on the apps' consistency of results.

Table 4
Perceptions of the Primary Pre-service Teachers in Using the Plant Identification Apps as Probable Educational Tools

Perceptions	*M*	*SD*	Level
1. I found the mobile apps engaging for plant exploration	4.43	0.802	Strongly Agree
2. I found the mobile apps helpful for identifying plants	4.46	0.723	Strongly Agree
3. I found it easy to browse within the mobile apps' interface	4.35	0.784	Strongly Agree
4. There is consistency of results among the three mobile apps	3.91	0.866	Agree
5. The mobile apps provide significant details about the plants	4.43	0.738	Strongly Agree
6. I found the mobile apps as an effective emerging tool for learning about plants	4.49	0.766	Strongly Agree
7. The mobile apps are significant for supporting scientific literacy	4.31	0.774	Strongly Agree

There are variances in the participants' perceptions when grouped according to their gender, as Table 5 indicates. Though there is an overall strong agreement concerning the three plant identification apps, there are peculiar differences between the participant's perceptions at the .05 critical level. There are no observed significant differences in most perceptions between male and female pre-service teachers. On the other hand, results indicate significant differences between the male and female participants' perceptions towards the apps' consistency of plant identification results ($p = .020$) and effectiveness as emerging tools for plant learning ($p = .043$). However, further analysis (not shown in the table) conveyed that the effect size, determined by Cohen's, was $d = 0.49$, indicating a small effect size between the participants' perceptions of the apps' consistency of plant identification results. Similarly, the measured Cohen's was $d = 0.47$, indicating a small effect size regarding the effectiveness of the apps as emerging tools for plant learning. Thus, the effect sizes between the male and female participants concerning the two perceptions are negligible, even if they are statistically significant.

Table 5
Differences in the Participant's Perceptions in Using the Plant Identification Apps as Probable Educational Tools According to Gender

Perceptions	Males		Females		*df*	*t*	*p*
	M	*SD*	*M*	*SD*			
1. I found the mobile apps engaging for plant exploration	4.46	0.520	4.41	0.697	95	.325ns	.746
2. I found the mobile apps helpful for identifying plants	4.35	0.587	4.50	0.496	77	-1.166ns	.247
3. I found it easy to browse within the mobile apps' interface	4.37	0.594	4.34	0.628	85	.183ns	.855
4. There is consistency of results among the three mobile apps	3.65	0.810	4.02	0.695	77	-2.377*	.020
5. The mobile apps provide significant details about the plants	4.30	0.572	4.47	0.530	80	-1.302ns	.197
6. I found the mobile apps as an effective emerging tool for learning about plants	4.28	0.741	4.58	0.507	71	-2.062*	.043
7. The mobile apps are significant for supporting scientific literacy	4.17	0.680	4.36	0.563	76	-1.342ns	.183

Note: * = significant ($p < .05$); ns = not significant ($p > .05$)

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Aside from perceptions, Table 6 presents the problems encountered by the participants in using the three apps. Overall, the main problem encountered by the primary pre-service teachers relates to a weak internet connection that affected the apps' functions. This is followed by the consistency of results, the need for a subscription, the compatibility of the apps with their smartphones, and the complexity of the apps' interface. Further analysis showed that three problems attained the same ranking from both genders except the remaining two. Male and female pre-service teachers experienced the same problems concerning poor internet connectivity, the consistency of plant identification results of the three apps, and the need to fully subscribe to use the apps' features. Males, however, experience more complications in using than the compatibility of the apps. Females struggled more with the compatibility with their smartphones than the difficulty of the apps' user interface.

Table 6
Problems Experienced by the Participants in Using the Plant Identification Apps

Problems experienced	Male			Female			Overall		
	f	%	Rank	*f*	%	Rank	*f*	%	Rank
1. The plant identification results are not consistent among the three mobile apps	13	19	2	34	21	2	47	21	2
2. The mobile apps are not compatible with the smartphone's specifications	9	13	5	15	9	4	24	11	4
3. The mobile apps' interfaces are complex to utilize	10	15	4	12	8	5	22	10	5
4. Subscription is needed among the mobile apps	12	18	3	26	16	3	38	16	3
5. The mobile app functions are affected by a weak internet connection	24	35	1	73	46	1	97	42	1

Regarding preferences shown in Table 7, LeafSnap emerged as the primary pre-service teachers' most preferred plant identification app. The other apps, PictureThis and PlantNet, ranked second and third, respectively. Correspondingly, the top preferred app between males and females varies. Males highly preferred PictureThis compared to LeafSnap by the females. Males secondarily chose LeafSnap, while females selected PictureThis. Both genders identified PlantNet as their least preferred among the three apps.

Table 7
The Most Preferred Plant Identification App Among the Participants

Plant identification apps	Male			Female			Overall		
	f	%	Rank	*f*	%	Rank	*f*	%	Rank
PlantNet	10	22	3	26	22	3	36	22	3
PictureThis	22	48	1	37	32	2	59	37	2
LeafSnap	14	30	2	53	46	1	67	41	1

Discussion

The overall perception regarding the plant identification apps of the primary pre-service teachers showed strong agreement, indicating the apps' prospective use as educational tools. This highlights the emerging and effective use of mobile learning through smartphones. The importance of teaching students about plants as fundamental to Biology (Pany et al., 2019; Strgar, 2007) may further increase due to using these apps. Aside from citizen science and scientific literacy, the students' technological literacy will be advanced. The fact that the participants find the apps engaging for exploring and helpful in identifying local plants reinforces the recognition and awareness of plants in our surroundings. These apps aid active and interactive learning outside of the classroom. Wang (2017) deduced that these apps contribute to students' outdoor engagement, affecting their learning and behaviour.

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The participants' strong agreement on the ease of using and browsing the apps agrees with Airhart's (2023) general observations of some apps. Most apps are user-friendly and contain menus and tabs that are easy to navigate. These features cause hassle-free browsing by the users. The essential details the apps provide about the identified plants are beneficial. As Airhart (2023) indicated, this feature gives users relevant information about the plant. This may enable the users to acquire knowledge and further explore the plant's growth and development, structure, habitat, and palatability. The details can then contribute to understanding the plant's aesthetic and biological features, as Wandersee and Schussler (1999) pointed out.

The strong perception of both primary and pre-service teachers on the potential of the apps to be used as an effective emerging tool for learning about plants and their significance in supporting scientific literacy affirms the usefulness of plant identification apps in education. This study supports and further contributes to the works of Wang (2017), implying the feasibility of plant identification apps in science instruction. It also supports Yujuan et al. (2021), who recommend using plant identification apps to train autonomous learning of students about plants. Wang (2017) concluded that these apps significantly improved the students' science learning and attitudes and caused better learning satisfaction than traditional teaching methods. With these apps, students may be able to identify plants easily (Wäldchen et al., 2018), nurture plant knowledge (Zhu et al., 2017), and to further recognize and appreciate plant's role in the biosphere (Hill, 2022; Pany et al., 2019). This may then lead to an increase in students' plant awareness and reduce their PAD. However, it must be noted that teachers must choose apps that are extensively evaluated (Airhart, 2023; Baker, 2023; Hill, 2022; Kress et al., 2018; Otter et al., 2020; Schmidt et al., 2022; Wäldchen et al., 2018) and uses reputable sources and expert systems (Hill, 2022; Pärtel et al., 2021) to ensure positive students' learning.

Regarding the consistency of results of the three apps to which the participants considerably agreed, it confirms the findings and evaluations of identified studies (Airhart, 2023; Hart et al., 2023; Hill, 2022; Kress et al., 2018; Otter et al., 2020; Schmidt et al., 2022; Wäldchen et al., 2018) that not all three apps provide the same plant names. The variances in the results imply the limitations of the apps and their accuracy in identifying plants through images. Despite the advancement of automated learning, AI, and deep learning, circumstances affecting the apps' accuracy rate are still unclear (Hart et al., 2023).

Though there are observed significant differences in the perceptions of the male and female pre-service teachers towards the apps' consistency of results and effectiveness as emerging tools for plant learning, their measured effect sizes are small. This implies trivial differences between the male and female perceptions, having low effect sizes and negligible differences. In this case, there are no practical variances in all of the pre-service teachers' perceptions according to gender. There are no differences in how the male and female participants perceive the apps' engaging capability for plant exploration, helpfulness in plant identification, ease of browsing, consistency of results, providing details, effectiveness as potential educational material, and relevant support for scientific literacy.

A weak or poor internet connection is the participants' main problem in using the apps. This condition is primarily affected by the country's performance in providing internet services, the cost of internet services and subscriptions (Rosales, 2023; Samaniego, 2023), telecommunications infrastructure, and the geographical environment (Salac & Kim, 2016). Due to poor connection, the participants may have difficulties accessing the features of the apps, uploading images, and loading results. Since these apps use online databases, a strong internet connection is advisable.

Problems relating to the consistency of results among the apps were also experienced. Accordingly, the consistency and accuracy in the plant identification results may be affected by several factors, including the diversity and differences of leaves as the basis for identification (Sachar & Kumar, 2021; Zhang et al., 2020), the bias and validation between the tests and the sample plant images which may result to unreliable species labels (Jones, 2020; Rzanny et al., 2019), the short span of production of flowers and fruits among plants (Perera & Arudchelvam, 2021), the lack of data presentation and depiction of other organs of the plant (Boho et al., 2020), the quality of the images uploaded (Hill, 2022), and the rareness of some species (Jones, 2020). This is especially true in the region since most data stored in the apps' databases are collected from Western countries, affecting the identification of local plants.

Similar to Airhart's (2023) evaluation, subscribing to the apps and the sudden pop-up ads were encountered as well by the participants. In the free versions, some apps provided a minimum number of photos to be uploaded within the day and prevented some features from being accessed, limiting the use of apps. Users must purchase and subscribe to the apps to fully enjoy their system. The participants' struggles with the applications' compatibility with their smartphones and the complexity of the apps' user interfaces are technological and reliant on the apps' software and operating system. Updating the apps, the incorporation of AI (Joly et al., 2016) and deep learning

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(Kress et al., 2018), developers' coding techniques and algorithms (Wäldchen et al., 2018), scientific institutions' contributions and validations (Joly et al., 2016), and image processing (Yanikoglu et al., 2014) may be some of the factors that affected the said problems.

Overall, the pre-service teachers prefer LeafSnap the best over the other two apps despite ranking as the fourth-best app, as Hill (2022) established. However, Wäldchen et al. (2018) still pointed out that the app had high accuracy. They may have ranked LeafSnap as the best due to its ability to provide plant care reminders and create albums of plant collections, as Baker (2023) presented. The second most preferred app is PictureThis, in contrast to Hill's (2022) and Otter's et al. (2020) inferences and Schmidt's et al. (2022) high recommendation of the app for students' use. Though Airhart (2023) found the app less user-friendly and full of pop-up advertisements, the pre-service teachers may have ranked it second due to its features, such as a plant encyclopaedia and local plant tagging, as Parkins (2019) described. PlantNet, the participants' least preferred app, counters the apps' second-best ranks by Hill (2022) and Otter et al. (2020). It does not also contend with Baker's (2023) and Airhart's (2023) high regard for the app. This may be due to the lack of plant information provided by the app, as reported by Airhart (2023), affecting the participants' view of the app. Nevertheless, it is important to note that the participants' preferences do not depend solely on the three apps' accuracy and consistency of results. Instead, it generally involves the participants' perceptions of the apps' features and potential as educational tools, including their experiences using the three apps.

Conclusions and Implications

Utilizing plant identification apps is feasible for classroom learning, as affirmed by the results of this study. The pre-service teachers strongly agreed on the apps' engaging characteristics, usefulness in plant identification, ease of browsing, providing information, effectiveness for learning about plants, and relevance in supporting scientific literacy. The participants showed lower perceptions regarding the apps' consistency of results. It was also determined that there were no significant and practical differences between the male and female participants' perceptions of the apps. This is despite the drawbacks they have experienced while using the apps, mainly affected by weak internet connection. Ultimately, the pre-service teachers selected LeafSnap as their preferred app over PictureThis and PlantNet. Conclusively, these plant identification apps can provide opportunities to reinforce and support instruction. Almost all students nowadays have smartphones and can access the internet. Various plant identification apps are free and readily available to identify plants quickly. Integrating these apps into teaching can be advantageous from an educational aspect and is very important for learning about plants. The use of these apps is recommended and timely, concerning the advancement of technology, its impact on science education, and in strengthening plant awareness for the conservation of natural resources. However, the apps should undergo a thorough and methodical evaluation to ensure their suitability for students' learning and congruence with the objectives of the lessons.

The findings of this study contributed to the enrichment of relevant literature. It also offered a glimpse into the participants' perceptions about the potential of plant identification apps for mobile learning. It allowed the exploration of these apps as emerging educational tools, therefore, presenting the participants' confirmation of the apps' possible classroom use for those educators who may be planning to do so. The non-comparison between the apps' accuracy of results is a limiting factor in the study. Listing the results and analysing their precision and consistency was not employed. Another factor relates to the number of apps involved in the study. There were only three apps explored in comparison to the earlier evaluations. Also, the participants involved were associated with primary grades where learning about plants is considerably at the beginning stage. Lastly, the study focused on the pre-service teachers' perceptions and did not consider student involvement. With these, future researchers should explore the effectiveness of plant identification apps in student learning other than perception. Adding similar and relevant apps is also suggested. Furthermore, an extensive study should be conducted on the apps' practicality as a teaching aid and their impact on science education.

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