LeafQuest: A Mobile-Based Augmented Reality for Plant Placement, Discovery, and Growth

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ABSTRACT

The LeafQuest app is built to merge augmented reality (AR) and artificial intelligence (AI) in order to help users choose and visualize plants that is appropriate for their space available and given environmental conditions. Through the use of an artificial intelligence as a recommendation system, this will improve decision-making and user confidence building. LeafQuest is built to encourage plant fans, hobbyists, and incidental plant enthusiasts with easy-to-access, accurate plant data, and interesting plant facts. The LeafQuest walks users through the whole process from plant discovery and choice to plant care upkeep through and interactive and engaging user interface. LeafQuest is being developed per Agile method, which focuses on iterative design, and user feedback to make the application responsive to user's need and technology needs. The application delves into how augmented reality can become a practical means for visualization, how artificial intelligence can provide exact plant recommendations, and how mobile application can turn traditional plant care into dynamic, learning experience. The applications are meant to close the gap between knowledge of plant care and users' accessibility. The study gathered 80 survey responses from plant hobbyists, enthusiasts, and lovers in Metro Manila. It aimed to evaluate the quality of LeafQuest in terms of performance, ease of use, reliability, and overall system quality as a mobile-based augmented reality tool for plant placement, discovery, and development. Findings revealed that all criteria fell within the "Excellent" range (3.50–4.49), with weighted means between 4.12 and 4.24, indicating strong acceptance and positive reception from the respondents.

Keywords: Agile methodology, Artificial intelligence (AI), Augmented reality (AR), Gamification Recommendation system

INTRODUCTION

Society nowadays is influenced by information technology in the context of ways on how people interact with the environment. It is the foundation for every technological advancement, development, and invention, shaping the present and the future. Augmented reality (AR) is an emerging technology that places digital things into the real world. Gamification is the process of applying game aspects to non-game contexts, used to make applications in a fun way, like interactive augmented reality visualization systems.

With the help of augmented reality (AR) and gamification, LeafQuest is a mobile application that combines digital and natural strategies to create an immersive, interactive platform for virtual plant placement, discovery, and growth. It allows mobile devices to incorporate real plants in order to create a shared area composed of virtual plants and the real-world environment via the platform and the immersion. Through this app, users can discover the rich world of botany and create their own virtual gardens. This application of plant design not only fosters the user's creativity but also helps them learn as they can arrange the plants otherwise, find out about the short history and plant characteristics of different kinds, and see the effect of time on them.

The goal of this system is to build a dynamic and educational platform allowing people to cherish the natural world by engaging in virtual plant placement and discovering the different species of plants. The app, which uses augmented reality (AR) technology as a tool, allows users to easily associate virtual plants with their real surroundings during the exploration, imagination, and education process. This engaging and understandable

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technology entertains users to create various plant assemblies, learn about the interesting features, and imagine programs of plant growth, thus deepening their knowledge of botany as well as promoting environmental protection.

METHODOLOGY

This section describes the process used to develop LeafQuest, a mobile-based augmented reality application for finding, planting, and maintaining plants. The Agile methodology was selected as the development framework, allowing for flexibility and iterative improvements throughout planning, design, development, testing, and deployment. Data were collected through surveys, interviews, observations, user feedback, and previous studies to identify requirements as well as evaluate the system's quality and performance. This section also discusses research design, data collection, sampling, analysis, and the ethical considerations that ensures the study is valid, reliable, and meets academic rigor.

Research Design

The development of LeafQuest utilized the Agile Methodology. Agile is based on a progressive and iterative approach to software development that emphasizes adaptability, collaboration, and solutions centered around the user experience. Whereas traditional models begin with analysis and design, Agile supports the early delivery of useful software, flexible planning and scheduling, and continual improvement. The use of Agile ensured that LeafQuest was developed with continual responsiveness to user needs and/or change in any necessary related interface.

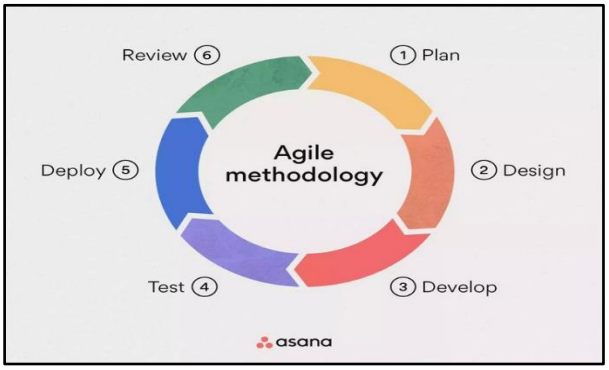

Figure 4.1: Agile Methodology

Planning

During the planning stage, the proposers worked as a team to establish objectives, requirements, and the scope of the project. They agreed on the needs LeafQuest would have to meet, as well as a list of the main features that should be included, such as gamified learning components to make the app fun and engaging to the learner, AI recommenders to suggest plants, plant identification features for the user to discover new plants, and modules for user interaction. The work was organized by assigning tasks and scheduling when to do the work.

Design

The requirements developed during `design` were translated into an explicit system design. The user interface, layout, and system architecture were designed to help ensure the application was user-friendly and functional. Simple designs, such as wireframes and mockups, were developed to illustrate how the application would look and work. Meanwhile, technical documentation was prepared to guide the actual construction of the application.

Development

The players concentrated on developing the app progressively with cycles. Each cycle gave the app new features such as AR for plant placement, AI for plant recommendations, and gamification for enhanced learning. The team collected user feedback along the way to iterate on the features and help ensure the app was practical and

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fun for the target users.

Testing

Once developed, the app was tested for functionality and quality. Usability testing was one type of testing that was conducted, which allowed us to check if the app was easy to use. Compatibility testing was next in line, enabling us to test the app on different Android devices. Performance testing was also carried out to confirm the app was stable and would work as expected while in use. Functionality testing allowed us to check that all features of the app were working correctly and user acceptance testing allowed us to assess whether the app met user needs and expectations once developed.

Deployment

After testing was finished, LeafQuest was made available to the intended users in Manila. The deployment phase meant that the app was available for real-world use; plant enthusiasts and hobbyists could now evaluate the opportunities the app provided to support plant care, placement, and discovery in real-world contexts.

Review

After deployment, the app was reviewed to determine its effectiveness. Feedback was gathered in the form of surveys, interviews, and observations that provided valuable information about what was successful and what required improvement. The review validated LeafQuest strengths including its augmented reality components and gamified learning, while also providing ideas for future revisions. This allowed LeafQuest to continue to develop and ensure that the app remained true to its goals.

Data Collection Techniques

In order to inform the development and improvement of LeafQuest, a variety of data collection methods were utilized. Feedback was collected from users during the development process and once in use to assess overall satisfaction, usability, and suggestions for improvement. Surveys consisting of both closed and open-ended responses were conducted to gain an overview of user experiences and expectations for plant enthusiasts, hobbyists, and lovers. Interviews were then used to obtain richer detail about user expertise, experiences, challenges, and recommendations for LeafQuest. Observational studies enabled the researcher to observe how participants used the application and to identify any usability issues. Finally, related literature was reviewed in order to identify gaps and areas for possible improvement. This ensured that LeafQuest was built on both user feedback and previous studies.

Sampling Methods

Participants in the research were plant hobbyists, enthusiasts, and lovers based in Manila. They were selected because they represent the main users of the LeafQuest application and have knowledge and experience in caring for and discovering plants. As a result, a purposive sampling method was used to target individuals who could provide valuable input and feedback that would directly inform the development and enhancement of the system.

Data Analysis Procedures

The processes of data analysis required the collation and analysis of data gathered through surveys, interviews, observations, and user feedback. As part of the analysis process, responses were examined for similar themes, patterns, and issues relative to care of plants and the use of the LeafQuest application. The results were then interpreted based on the identification and assessment of user needs and the measured performance of the system, as well as identifying opportunities for improvement. This examination helped ensure findings were made based on reliable measurement and directly informed adaptations of the application.

Validity and Reliability Measures

As a demonstration of the validity of the LeafQuest study, the investigators will use data obtained from reliable

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sources such as interviews, surveys, observations and related studies to ensure the information captured accurately represents the needs and experiences of pleasure plant users. The questions and instruments to be utilized are aligned with the objectives of this study. The reliability is established through consistency in use of procedures followed across participants and cross-checking results from particular methods. These measures of validity and reliability will support the assertion that the findings were accurate, consistent and then stable to inform development of LeafQuest.

Ethical Considerations

The LeafQuest study adheres to ethical guidelines to protect participants while upholding a valid research process. All user information was kept completely confidential while still collecting identifiable information that would remain private. All privacy measures are based on the 2012 Data Privacy Act and participants were informed of the purpose of the study. The research team also engaged in fair and just use of the data, honestly reported the results of the research, and relied on ethical standards when conducting this study.

REVIEW OF RELATED LITERATURE

Augmented Reality in Plant Identification Mobile Apps

Bawingan et al. (2024) carried out a study to examine the experiences of users with mobile plant identification applications. Four of the most used apps were LeafSnap, PictureThis, Pl@ntNet, and PlantSnap. The apps were utilized by students, teachers, and hobbyists, who identified plants by snapping and uploading pictures. The study collected feedback using questionnaires, highlighting the difficulties and perceptions of users of the apps.

Gaified Application with Cooperative Experience Using Augmented Reality

Barra et al. (2024) developed BotanicAR as a cooperative AR game based on the Meta Quest 3 headset. The application is a multiplayer interaction with two to four players, combining augmented reality (AR) and virtual reality (VR) in one device. Players cooperate to fight against an invading virtual plant in their real space, using only hand gestures without handheld controllers.

Effects of Developing an Interactive AR Plant Structure Experiment System for Elementary Natural Science Course

Based on Jhuang, Z., Lin, Y., & Lin, Y. (2025), the study that they have conducted demonstrates how augmented reality technology enhances the interactive system of plant structure experiments. The study concluded that the usage of augmented reality in the plant experiments allowed students to stay in the visuals like real life and did not have to wait for the experimental results apart from giving attention to the experimental design and the nature of the presented material while simultaneously facilitating multi-sensorial learning.

Augmented Reality as a Tool in Plant Research for Medicinal Purposes

The study by Bukhari, S. and Sela, E. (2024) developed an augmented reality application for identifying plants that can be used as medicines. The results of the development of augmented reality applications on plants that can be made into medicines provide convenience to users in a search for information needed about the types of plants that can be used as medicines effectively and efficiently.

Bringing Plants to Life: How Augmented Reality is Changing Botany Education

A study by Liang Z. (2024) developed a system with augmented reality (AR) that helps students see plants better and makes learning more fun by allowing them to see plants in 3D models, watch plants grow, and look at the plants from different places without needing to leave their classrooms. As a result, students become more engaged and improve their comprehension.

Augmented reality and gamification: A framework for developing a supplementary learning tool

This study made by Godoy Jr., C.H. (2021) aims to develop a supplementary learning tool framework using a dynamic mobile application built with UnityAR and Vuforia to enhance the learning process for Senior High School (SHS) Earth Science students and teachers. The researchers adopt the Software. The study concludes that Augmented Reality and Gamification can enhance senior high school Earth Science education using the proposed framework.

A Comprehensive Review of Plant Recognition Approaches

The study of Dalvi, P. and Kalbande, D., (2023) discussed the role of plant identification in the field of botany and horticulture. The authors concluded that the method of plant identification of comparing a single attribute such as leaf, flower, seed, fruit, and trunk has its advantage, as it makes the identification process quicker and simpler.

The User Experience Design of Virtual and Augmented Reality for Environmental and Ecological Information-Focusing on the Conservatory of Seoul Botanic Park

A study by Zoh et al. (2022) explored the effects of virtual and augmented reality in terms of educating individuals about plants. The study concludes the importance of virtual reality and augmented reality in making ecological learning more engaging and interactive.

Conceptual Framework

The conceptual framework is based on the Input-Process-Output (IPO) model, which serves as the guide in presenting the structure and flow of the LeafQuest system.

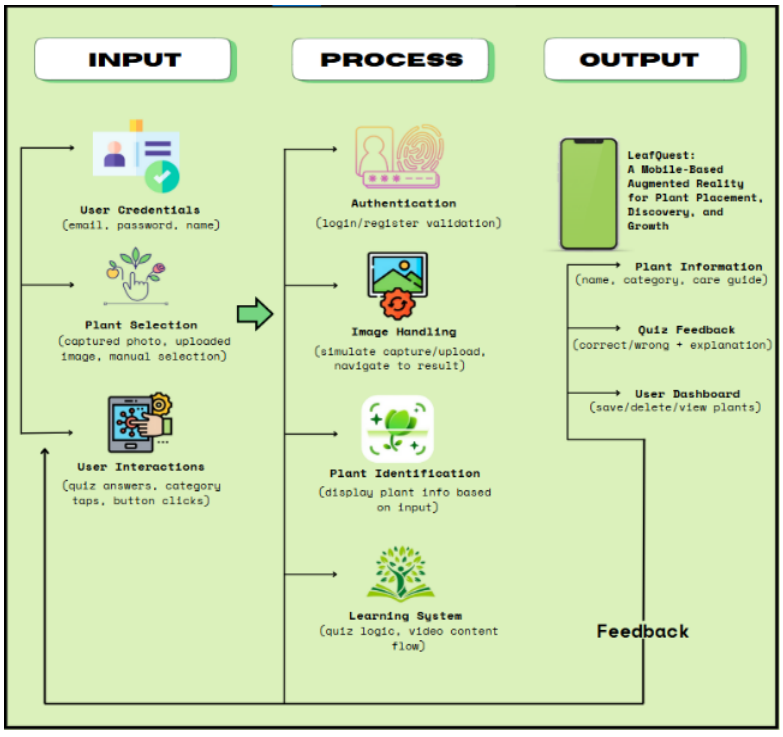

Figure 3.1: Input-Process-Output Model

Figure 3.1 illustrates the essential components that shaped the development of LeafQuest, a mobile-based augmented reality application created to enhance plant placement, discovery, and growth among urban residential users.

Input Phase. The students registered by creating an account and entering basic information (name, student number, department, and course) which will be important for authentication. Once authenticated, they will be

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able to access to the features of the system, keyword and voice search capabilities that use Natural Language Processing (NLP) to facilitate academic materials search for the students. The system will also allow students to contribute their own academic works over time which will increase the amount of material on the system.

Process Phase. To ensure integrity when adding submissions, librarians or administrators verify student registrations and academic submissions. The accepted works are stored in a secured database and organized according to metadata categories such as course and department. While this is happening, librarians also perform quality checks chosen at random to verify accuracy and relevancy. This will ensure only credibility and academically organized resources are added to the system.

Output Phase. The system offers an accessible and organized digital archive where students and faculty can find approved research materials at any time using a web browser. MerlArchive facilitates efficiency and builds research skills by providing dashboards to track approvals and document status. This digital archive can help create an academic setting that is more collaborative, accessible, efficient, and driven by technology for the university community.

RESULTS AND DISCUSSION

Results

In this study, a total of 80 usable survey responses were received from plant enthusiasts, hobbyists, and aficionados in Manila. The survey was administered to evaluate LeafQuest's effectiveness in terms of its features and functionality, ease of use or usability, reliability, and quality of the app as a mobile-based augmented reality tool to enhance the plant placement, discovery, and growth. The data were analyzed based on the mean scores of the surveys, percentage ratings, and visual graphs to display the overall perception and acceptance of the application. The evaluations were based on the ISO/IEC 25010 standard. Each of the categories provides a summary of responses, mean scores, and an interpretation. The outcomes were summarized and then compared to the essential features of LeafQuest to demonstrate the system was able to meet the needed features or expectations of its targeted user audience.

Results

Functional Sustainability

This category was evaluated using five criteria, which are: completeness of features, accuracy of augmented reality display, correctness of plant information, functionality of tracking and growth, and effectiveness of plan recommendation system. The results show that 90% of participants agree or strongly agree with the app regarding functional sustainability, and 8% are neutral, while 2% disagree. The mean score of 4.15 is interpreted as "Highly Agree".

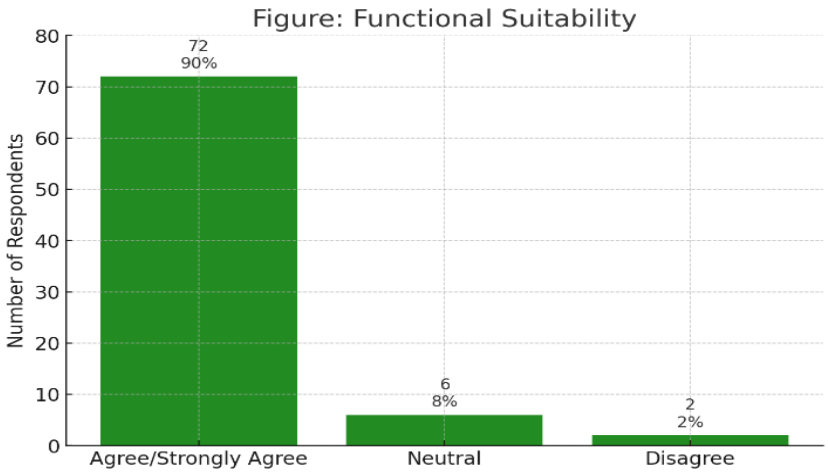

Figure 5.1: Bar Graph of the Responses in Functional Sustainability of LeafQuest

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Figure 5.1 shows the respondents finds the app to be successful in providing the necessary features for plant placement and growth monitoring. The augmented reality tool was generally perceived to be accurate in positioning virtual plants within live spaces. Users also confirmed that the plant-related information such as names and caring tips are reliable. The plant tracking and growth functions performed as expected, while the recommendation system were deemed helpful in suggesting suitable plants for the user environment.

Performance Efficiency

The criteria was measure through load time, smoothness of AR visualization, navigation speed between screens, battery/data consumption and stability performance in extended uses. The results reveal that 88% agreed or strongly agreed, 9% were neutral, and 3\% disagreed, The mean score was 4.19 which interpreted as "Highly Agree"

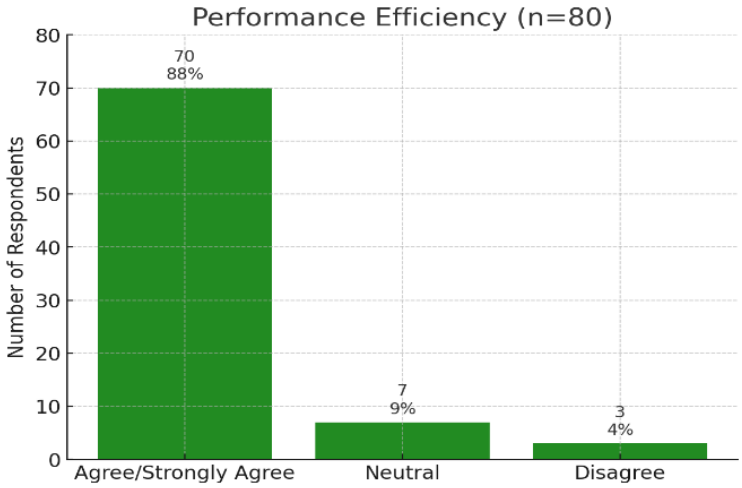

Figure 5.2: Bar Graph of the Responses in Performance Efficiency of LeafQuest

As illustrated in Figure 5.2, the respondents stated that the application usually loaded relatively quickly and enabled an uncomplicated transition between features. The augmented reality view was described as responsive with minimal lag or delays. The application also not noted to use an excessive amount of battery life or mobile data usage. Longer usage did not deduct in the overall performance of the application and overall time behavior and resource consumption displayed good efficiency

Bar Graph of the Responses in Usability of LeafQuest

Usability was assessed based on ease of learning, design/layout simplicity, navigation, accessibility of AR features, and clarity of labels and menus. The results show that 92% of respondents agreed or strongly agreed, 6% were neutral, and only 1% disagreed. The mean score of 4.24 reflects a “Highly Agree” interpretation.

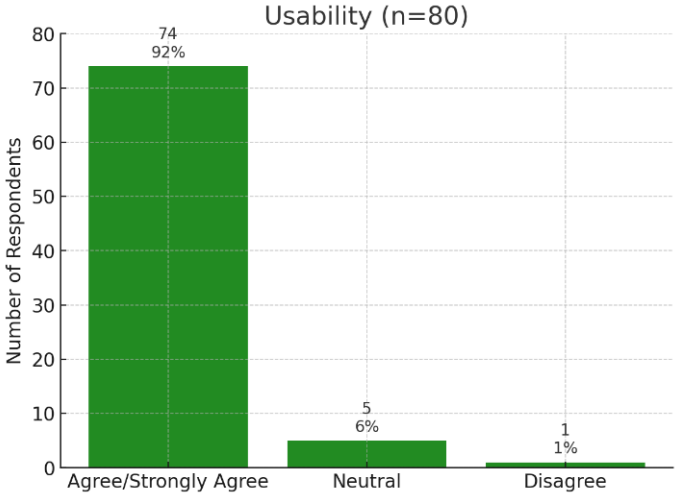

Figure 5.3: Bar Graph of the Responses in Usability of LeafQuest

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This shows that respondents indicated that the app is easy to learn even for first-time users. The interface design and layout contributed to straightforward navigation, enabling users to locate features without difficulty. The AR function was accessible and manageable, while labels, buttons, and menus were perceived as intuitive and easy to understand.

Reliability

This category is concerned with the availability, frequency of crashing and/or freezing, usability in the case of slow Internet speed, data persistence, and error recovery. The results show that 89% agreed or strongly agreed with the statement, 8% were neutral, and 3% disagreed. The mean score was 4.22, which should be read as being in the "Highly Agree" range.

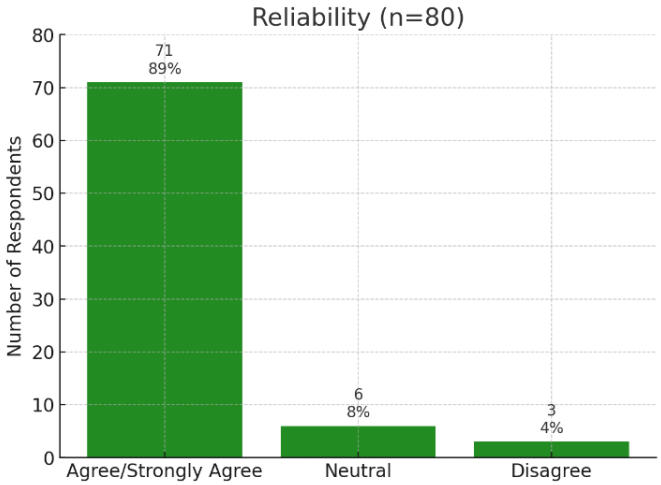

Figure 5.4: Bar Graph of the Responses in Reliability of LeafQuest

This indicates that respondents find that the app was generally available when needed and did not crash frequently. It remained functional even under slow internet connections, ensuring continuous usability. Importantly, plant progress data was retained even after closing the app, and the system was able to recover from occasional glitches with minimal disruption.

Security

Security was evaluated in terms of data protection, permission requests, data usage transparency, privacy, and suitability for children or other users. Findings show that 87% agreed or strongly agreed, 10% were neutral, and 2% disagreed. The mean score of 4.22 reflects a “Highly Agree” interpretation.

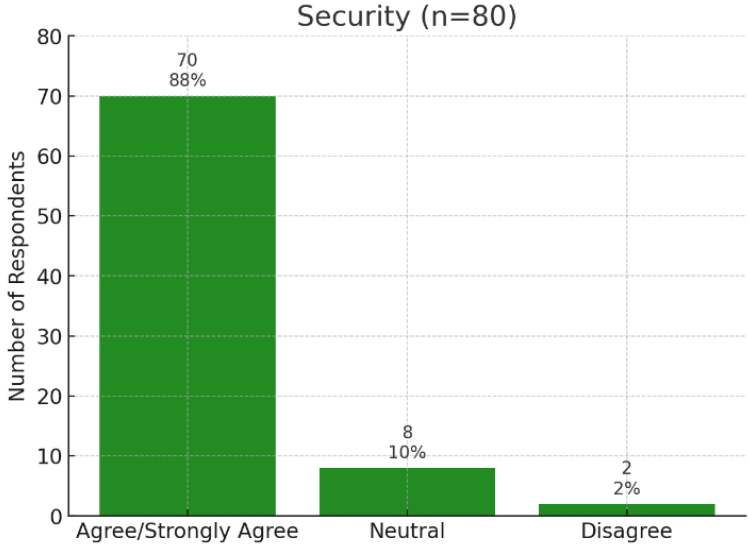

Figure 5.5: Bar Graph of the Responses in Usability of LeafQuest

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This means that respondents showed trust with sharing their personal information, since the app only requested permissions valid for camera access. Users also liked that the app clarified which data would be utilized and regardless of which data was used, their privacy was maintained with the app. Some users also reported that they felt comfortable with children, or other people using the app, without concern for data safety or misuse.

Maintainability

Maintainability was assessed using criteria related to completeness of features, organizational structure, absence of broken links/errors, and perceived ease of doing updates. The results indicated that 85% agreed or strongly agreed, 11% were neutral, and 4% disagreed. The mean score of 4.18 was considered, "Highly Agree."

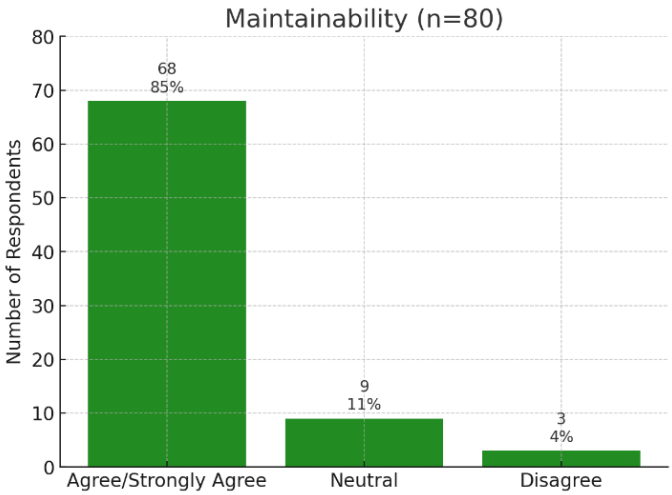

Figure 5.6: Bar Graph of the Responses in Maintainability of LeafQuest

Figure 5.6 illustrates that users found that the app performed without any visible bugs or incomplete functionality. The overall structure and organization of the app added to a reliable environment. There were no broken links or missing elements while using the app. In addition, most users thought the app would be easy to update, and they would be willing to use an improved version in the future.

Compatibility

This criterion measured the smoothness of the app on the devices, usability offline, functionality of all features, compatibility with device resources, and adaptability of the display. The results revealed that 83% either agreed or strongly agreed, 12% neutral, and 5% disagreed, respectively. The mean was 4.12, indicating "Highly Agree."

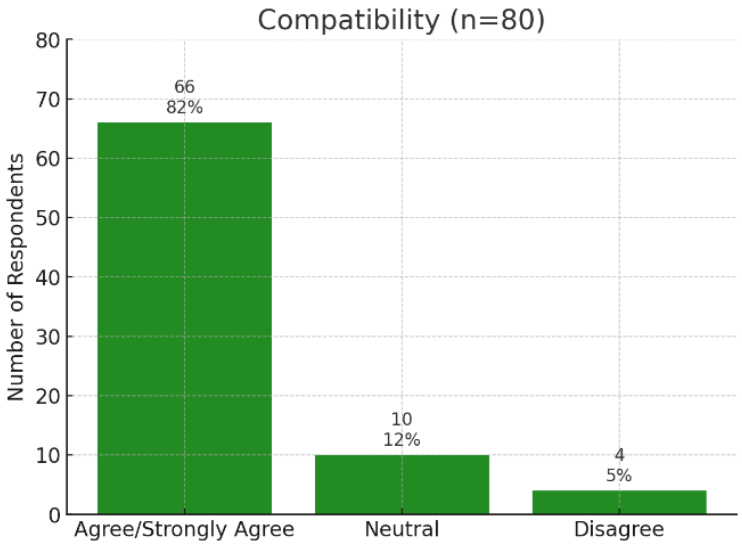

Figure 5.7: Bar Graph of the Responses in Maintainability of LeafQuest

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Respondents indicated in Figure 5.7 that the app mostly run without problems on their devices and rendered appropriately on various device screen sizes and resolutions. The functionality for AR, the information about the plant, and the placement of the plant worked regularly. Although somewhat limited in functionality while offline, the majority of user reports indicated use and suitability across different contexts and devices.

Evaluation Metrics

The assessment of LeafQuest: A Mobile-Based Augmented Reality for Plant Placement, Discovery, and Growth was carried out with a survey of 80 respondents. The survey uses various percentages, averages, and graphing results to measure the quality of the app using the ISO/IEC 25010 model and within ISO/IEC 25020 metrics.

The results reveal that all ratings are found to be in the "Excellent" range (3.50–4.49), and the weighted means ranged from 4.12 to 4.24. Thus, indicating strong acceptance patterns across respondents. Usability received the highest mean score of (4.24) meaning the app is simple/ smooth to use, easy to learn, and provides easy navigation. The second highest scores were close behind for Reliability (4.22) and Security (4.22) indicating that the app is stable, reliable, and safe. Functional Suitability (4.15), Performance Efficiency (4.19), Maintainability (4.18) and Compatibility (4.12) consistently measure quality indicating that the system provides effective app placement, performance efficiency, device compatibility, and readiness for future improvement.

In conclusion, LeafQuest is an augmented reality application that is both accepted and effective. The app received high rating of "Excellent" for all the ISO/IEC 25010 quality ratings based on ISO/IEC 25020 metrics.

CRITERIA	GENERAL WEIGHTED MEAN	INTERPRETATION
1. Functional Suitability	4.15	Excellent
– Features support plant placement, discovery, and growth	4.16	Excellent
– AR placement is accurate and reliable	4.12	Excellent
– Plant information provided is correct and useful	4.14	Excellent
– Tracking and growth functions perform as intended	4.15	Excellent
– Plant recommendation system provides suitable suggestions	4.17	Excellent
2. Performance Efficiency	4.19	Excellent
– Loads quickly and runs smoothly	4.20	Excellent
– AR is responsive and has minimal lag	4.18	Excellent
– Consumes reasonable battery and data resources	4.19	Excellent
– Maintains stability even during long usage	4.20	Excellent
3. Usability	4.24	Excellent
– Easy to learn for new users	4.25	Excellent
– Navigation is simple and clear	4.23	Excellent
– AR features are accessible and manageable	4.24	Excellent
– Labels, menus, and buttons are understandable	4.23	Excellent
4. Reliability	4.22	Excellent
– System runs without	4.21	Excellent

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frequent crashes		
– Plant data remains saved and available	4.22	Excellent
– Functions under slow internet conditions	4.21	Excellent
– Can recover smoothly from errors or interruptions	4.23	Excellent
5. Security	4.22	Excellent
– Protects personal data and privacy	4.23	Excellent
– Requests only necessary app permissions	4.22	Excellent
– Provides transparency in data usage	4.21	Excellent
– Safe for children or general users	4.22	Excellent
6. Maintainability	4.18	Excellent
– App runs without bugs or broken features	4.17	Excellent
– Organized structure supports stability	4.18	Excellent
– Can be updated or upgraded easily	4.19	Excellent
7. Compatibility	4.12	Excellent
– Works across different mobile devices	4.11	Excellent
– Displays correctly on different screen sizes	4.13	Excellent
– Features perform consistently across platforms	4.12	Excellent

Figure 5.6 Overall Summary Survey

DISCUSSION

The survey findings offer strong confirmation that LeafQuest effectively meets the needs of its target users--students, plant lovers, and individuals interested in sustainable living/reduced impact lifestyles. The overall high ratings over the IS0/IEC 25010 categories, measured against the ISO/IEC 25020 method, indicate the system is working as specified, efficient for a given purpose, and easy to use.

First, the strong ratings in Usability indicates that LeafQuest is fairly easy to navigate and operate. Respondents felt that even the interface, menuing, and augmented reality worked features were easily learned. This ease reduced barriers for new users, and motivates them to use the app frequently, consequently making plant identification and placement easier for more users.

Second, the scores in Functional Suitability and Performance Efficiency demonstrate that the system provides verifiable results and delivers precise and reliable input. Users reported that the AR plant placements were precise, the plant data was reliable, and the app executed functions quickly, while consuming little excessive resources from the devices. In summary, these findings illustrate that many of LeafQuest's core functions fulfill pragmatic expectations and job expectations, and align well with the outcomes intended to assist users with proper plant placement and care.

Third, the Ratings for Reliability and Security showed slightly different gratitude from users, but still, rating selection showed user trust in the App for consistent and secure processing of data. Users reported having minimal applications crashes, application operations remained stable even during weakened wifi signals, and the data protection protocols were clearly communicated enhanced levels of user confidence in using LeafQuest. This was a key point for a mobile-based system that relies on the camera and storage permission performing administrative tasks in the App.

Fourthly, while the Maintainability and Compatibility categories did not rank as high as other categories, both still fall into the "Excellent" range. Respondents indicated that the app is reliably stable and can be made to work on many devices, and at the same time, they indicated that they look forward to even more updates and improvements. This demonstrates that LeafQuest is perceived to be a system that has a solid future in improving and developing for years to come.

Finally, the outcome of the survey goes beyond technical competence; it demonstrates the way LeafQuest adds value to the experience of an environmental awareness platform that utilizes technology. The app incorporates extended reality features alongside plant-based information to connect digital devices and the ethical responsibility to connect with the planet. This means LeafQuest can be positioned as not simply an app for adventure but also a way to facilitate educational purpose - and build community.

Overall, the favorable feedback on all quality measures indicates that LeafQuest achieved its purpose of being a stable, efficient, and easy-to-use augmented reality-based platform. The results support the program as a relevant and effective innovation for promoting plant discovery, installation, and sustainable growing practices.

CONCLUSION AND RECOMMENDATIONS

Conclusion

In conclusion, LeafQuest has shown itself to be a successful and innovative mobile application developed around gamification and augmented reality to facilitate plant placement, discovery, and growth. Surveys indicated consistently high scores for indicators with respect to all ISO/IEC 25010 quality characteristics assessed with ISO/IEC 25020 metrics; usability (4.24), reliability (4.22) and security (4.22) achieved the highest means. This suggests that the system is functional, easy to use, dependable, and secure.

With the results supporting that LeafQuest meets technical criteria and provides educational and environmental benefits, LeafQuest promotes sustainable behaviours while assisting users in making informed decisions about plant care and placement on an entertaining platform for both enthusiasts and learners. LeafQuest provides a solid platform to move forward as a relevant tool for environmental education, urban greening and community awareness.

Recommendations

Based on the evaluation and gathered feedback specifically from plant-related professionals from Arroceros Forest Park of Manila and the Bureau of Plant Industry, the following recommendations are proposed to further enhance LeafQuest:

Expand Plant Database and Localization – To enhance accuracy and culture relevance, include a much wider variety of native and endemic plant species from the Philippines, especially those found in urban gardens or the forest parks of Manila.

Professional Verification of Plant Information – Develop partnerships with center or experts in plant biology to verify and update plant care data, including keeping it relevant and evidenced-based for sustainable horticulture practices.

Integration of Environmental Context – Develop features that account for environmental conditions like sunlight, air, and soil quality, so that users may receive suitable plant recommendations for their specific environments.

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