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NEUST Wayfinder: Redefining Campus Navigation with Advanced Technology and User-Centric Design

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ABSTRACT

This study aims to develop a navigation system that helps students, faculty members, and guests locate different areas within the campus. The study utilized a GIS to collect and analyze data, and the system was developed based on the Agile Development Life Cycle Model. The research included evaluation by end-users and IT experts, focusing on the system's usability and technical quality. Results revealed that the NEUST Wayfinder significantly improved navigation around the campus. However, limitations in data entry and output reliability were identified. The study also highlights the need for an efficient and secure system for campus navigation and emphasizes the importance of future advancements in technology for educational institutions.

Key words: Agile development, Campus Navigation, GIS, User-Centric Design

1. INTRODUCTION

Navigating large and continuously evolving university campuses presents significant challenges, particularly for students, visitors, and faculty members unfamiliar with the environment. The Nueva Ecija University of Science and Technology (NEUST) Sumacab Campus is no exception. As the campus grows with the addition of new buildings, facilities, and landmarks, finding one's way around has become increasingly difficult, often leading to delays, confusion, and frustration. New students and visitors are especially vulnerable to these navigation difficulties, which can result in missed appointments, tardiness, and even stress. The absence of an effective navigation tool heightens these issues, leading to inefficiencies in time management and reducing the overall quality of the campus experience.

The NEUST Wayfinder is designed as a personal campus guide, aiding users in efficiently navigating the premises. Developed with Unity Hub and VScode for the front end, and XAMPP and MySQL for the back end and database, the app uses programming languages such as C# and PHP. The integration of the Mapbox API enhances its functionality. This study centers on the development and evaluation of the NEUST Wayfinder mobile app, exploring its features, functionality, and the impact it has on students' navigation experiences.

Several research studies have examined the use of navigation tools in higher education, with notable contributions from a variety of scholars and technologists. Zhang et al. [8] developed a campus navigation system using the ArcGIS Runtime SDK for Android, utilizing high-resolution remote sensing images to create a detailed and accurate campus map. With data stored and managed in the cloud via ArcGIS Online, this system allows for real-time updates, addressing the complexities of navigation data upgrades and enabling users to access the latest information.

Similarly, Samah et al. [5] employed OpenStreetMap (OSM) and the Graphhopper API to guide users around Hospital Kuala Lumpur (HKL), allowing them to determine their current location and access the shortest walking routes. This study highlights the potential of combining open-source mapping with user-friendly interfaces, a strategy also used in the NEUST Wayfinder.

According to Laha et al. [2], many people visit campuses for various purposes throughout the year. While GPS-enabled smartphones allow easy campus access, it can still be challenging to locate specific rooms or departments within large campuses. Their proposed solution—a simple and robust Android-based ultrasonic indoor navigation system (U-INS)—enables users to navigate effectively within campus boundaries.

Further, Putra et al. [3] revealed optimal methods for selecting the fastest routes based on existing digital map applications, finding that these tools can speed up travel times and ease traffic congestion. Simões et al. [6] developed a navigation system for indoor environments to locate individuals accurately in complex areas, emphasizing the need for precise, location-based navigation tools in densely structured settings.

Kela-Madar [1] examined the influence of technological advancements, particularly mobile navigation apps, on the global economy. Their study focused on differences in available navigation apps and predicted future innovations, highlighting the relevance of mobile navigation technology in city and campus settings.

The widespread use of navigation systems is also supported by Trapsilawati et al. [7], who found that drivers use navigation tools to select the fastest or easiest routes. These tools, primarily enabled by GPS satellites, are accessible via smartphone apps like Google Maps and Waze, underscoring the value of reliable and accessible navigation technology.

These studies collectively underscore the potential of personalized navigation tools like the NEUST Wayfinder. They suggest that technology-driven navigation solutions can enhance wayfinding, reduce stress, and ultimately improve academic and personal outcomes. Integrating these best practices into the NEUST Wayfinder reflects a commitment to meeting current user needs while ensuring scalability for future improvements.

2. METHODOLOGY

This study employed a developmental research method to design, develop, and assess the efficiency, reliability, and accuracy of the developed navigation system. Developmental research, as described by Richey (2005), focuses on the systematic process of creating and evaluating programs, processes, and products, ensuring internal consistency and alignment with effectiveness criteria. This methodology is particularly suited for technology-based solutions, as it allows for a structured yet flexible approach to innovation.

The navigation system developed by the researchers allows users to locate their desired destinations on campus by selecting a building within the application interface. The app then requires users to input their current location, enabling the system to connect the two points with a polyline, which functions as a routing guide. This approach to wayfinding, combining real-time data with visual routing, provides users with a clear path between their current position and their destination, making navigation more intuitive and accessible. By testing the system's efficiency, reliability, and accuracy, the researchers aim to ensure that it delivers precise and dependable results, minimizing errors and enhancing user satisfaction.

To guide the development of this system, the researchers employed the Agile System Development Life Cycle (SDLC), as illustrated in Figure 1. Agile methodology is characterized by its iterative nature, allowing for continuous feedback, refinement, and improvement at each phase of development. This method is particularly advantageous for projects like the NEUST Wayfinder, where user requirements may evolve, and enhancements can be integrated flexibly. Agile promotes a cycle of planning, development, testing, and feedback, ensuring that the final product is both user-centered and responsive to changes.

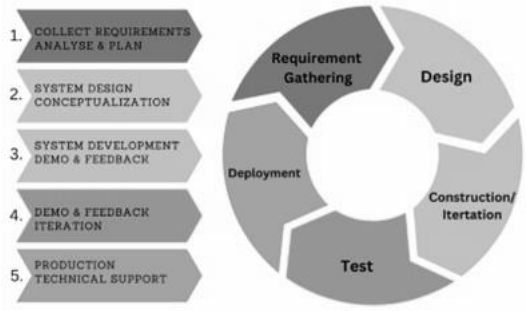

Figure 1: Agile System Development Life Cycle

3. RESULTS AND DISCUSSIONS

This section presents a comprehensive analysis of the design and development process of the NEUST Wayfinder application, based on data collected through questionnaires administered at NEUST Sumacab Campus in Cabanatuan City during the academic year 2023-2024. To ensure a robust evaluation, participants were divided into two distinct groups: end-users, consisting of students and visitors, and IT experts tasked with evaluating the technical performance of the application. This division allowed for a balanced assessment, incorporating both usability feedback and technical rigor, aligned with ISO/IEC 25010 software standards to ensure a comprehensive evaluation of the system's quality.

3.1 Design and Development of NEUST Wayfinder: Phases of the Agile Software Development Life Cycle

The NEUST Wayfinder application was developed following the Agile Software Development Life Cycle (SDLC), a framework that supports iterative and adaptive development. The following sections outline the five key phases of the Agile model employed in this project.

3.1.1 Requirement Gathering

One of the significant advantages of Agile methodology is its adaptability to evolving requirements throughout the project lifecycle. In the context of this study, the requirements were gathered through surveys and interviews conducted with students, visitors, and university staff using Google Forms. This allowed the research team to identify key navigation challenges at NEUST Sumacab Campus. The process also involved collaboration among stakeholders, including product owners, developers, and UX/UI designers. Based on high-level

user requirements, the team defined detailed acceptance criteria encapsulated in user stories. These criteria provided a clear vision of the system's functionality, ensuring that the final product met the needs of the users effectively.

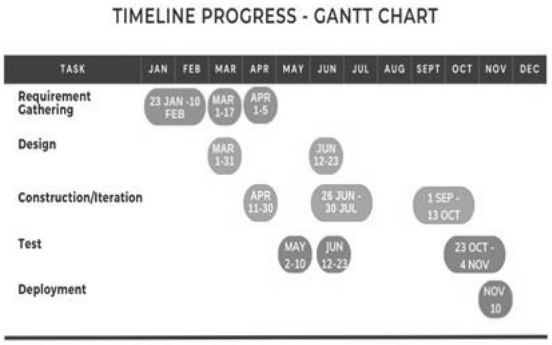

Figure 2: Project Gantt Chart

Informed by these initial insights, the research team planned the design and development of the NEUST Wayfinder. They carefully selected the appropriate development tools, including programming languages, APIs, Integrated Development Environments (IDEs), and databases, to ensure the system's reliability and performance. The timeline for the entire project, as outlined in the Gantt Chart (Figure 2), provided a structured roadmap for the research and development phases.

3.1.2 Design

The design phase aimed to create comprehensive visual representations of the system's architecture, including Use Case Diagrams, Data Flow Diagrams (DFD), and Entity Relationship Diagrams (ERD). These tools enabled the development team to map out system components and their interactions, providing a clear overview of how the NEUST Wayfinder would function in practice.

Use Case Diagram

The system's use case diagram encompasses three actors: the system's end users (students and visitors) and the GPS, responsible for determining the end users' location. The diagram also illustrates key functions such as login, obtaining location, displaying routes, and room information. Figure 3 shows the system's use case diagram, providing a visual representation of the expected interactions and functionalities from the users.

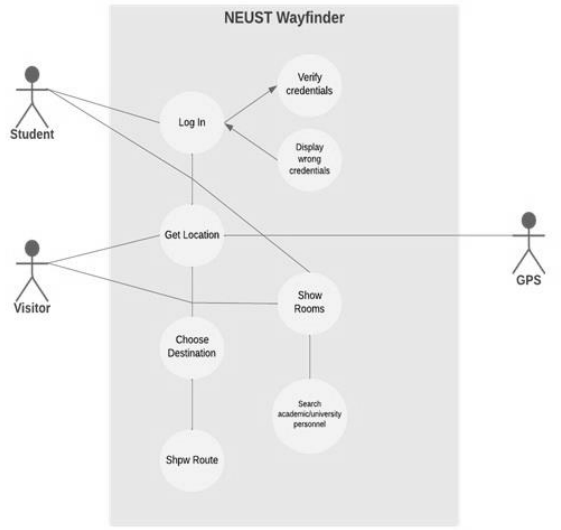

Figure 3: Use Case Diagram

Data Flow Diagram

A Data Flow Diagram (DFD) visually represents the flow of information within a system or process. It incorporates data stores, data inputs and outputs, and the various subprocesses through which the data traverses. DFDs utilize standardized symbols and notation to depict different entities and their interrelationships. This graphical tool serves as a comprehensive illustration of how data moves and transforms within the system, offering a structured and standardized approach to convey information flow in a clear and concise manner.

Figure 4 shows the context diagram of the developed system. This diagram consists of external entities and the processes covered by the designed NEUST Wayfinder.

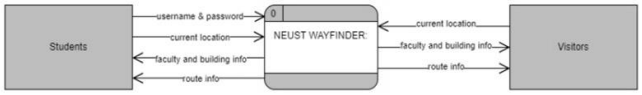

Figure 4: Context Diagram

Level 1 DFD

The Level 1 Data Flow Diagram (DFD) outlines the subprocesses derived from a context diagram within the developed system, offering a more detailed view of specific processes. The figure 5 below illustrates the Level 1 DFD of the developed system.

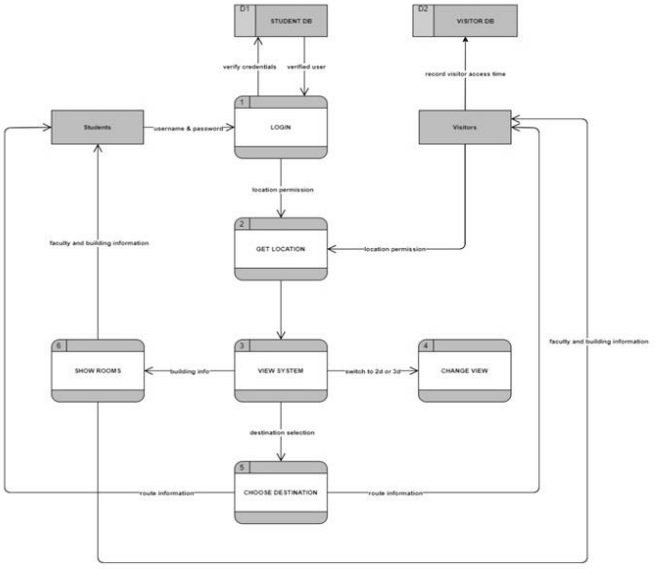

Figure 5: Level 1 Data Flow Diagram

Level 2 Diagram`

The Level 2 diagram provide more detailed of level 1 sub-process, specifying individual parts of steps. The figure 6 below illustrates the Level 2 DFD of the developed system.

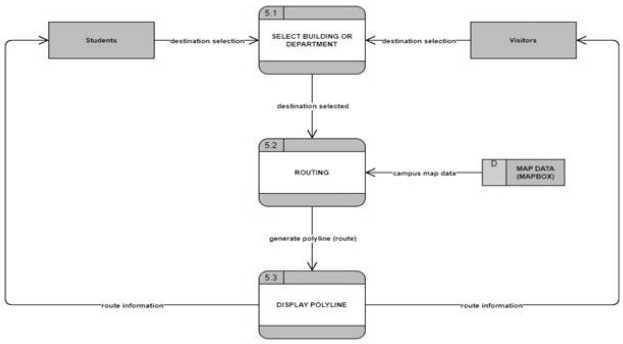

Figure 6: Level 2 Data Flow Diagram of Choose Destination

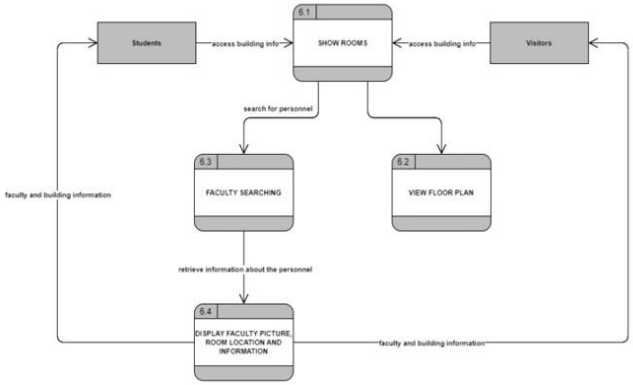

Figure 7: Level 2 Data Flow Diagram of Show Rooms

Entity Relationship Diagram

An Entity-Relationship Diagram (ERD) is a pivotal element in creating a good database design, illustrating the interconnections between different components through various types of relationships. Figure 8 shows the Entity-Relationship Diagram of the developed system, providing a visual representation of the relationships among the system's entities.

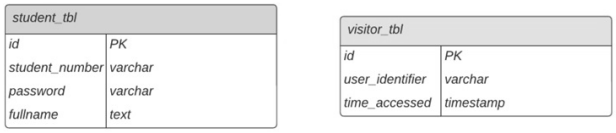

Figure 8: Entity Relationship Diagram

The researchers focused on incorporating two primary tables from the NEUST Wayfinder's database: the student_tbl and visitor_tbl. The student_tbl establishes a connection with the NEUST database, retrieving essential student information like student number, password, and full name. This information is integral for students to log in and access the system effectively. On the other hand, the visitor_tbl contains crucial data, including the user identifier and the timestamp capturing their access to the system. This structured approach ensures a streamlined and secure user experience for both students and visitors.

3. 1. 3 Construction/Iteration

During the construction phase, the development team worked collaboratively to translate the system design into executable code. This phase is crucial as it brings together the UI/UX design, backend infrastructure, and user feedback into a cohesive product.

Development began in April 2023 and concluded in October 2023, with the team utilizing programming languages and APIs such as HTML, JavaScript, CSS, and MapQuest API in the initial iterations. However, after receiving feedback from IT experts and end-users, the development team transitioned to using Mapbox API, which offered enhanced functionality and better aligned with user expectations. This iterative process allowed for continuous refinement of the system, improving both the performance and usability of the NEUST Wayfinder

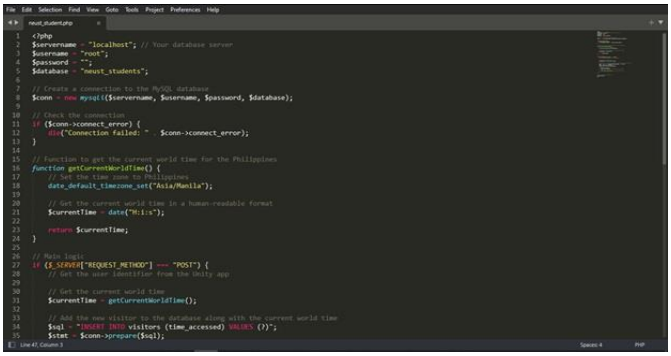

Figure 9: Coding Environment

3. 1.4 Testing

In this phase, the researchers initiated an evaluation of NEUST Wayfinder, involving both IT experts and end-users. Agile testing was employed, focusing on continuous testing and validation throughout the development process to prevent costly and time-consuming issues. Unlike traditional methods that defer testing until the end, Agile testing aims to deliver a potentially functional product after each iteration. This approach enables adaptability to evolving requirements and ensures more responsive and incremental value delivery to stakeholders.

3. 1.5 Deployment

This phase plays important role in the Agile development lifecycle as it entails making the constructed, tested, and integrated software available for end-users. Deployment involves the process of releasing a software application or system for use by the end-users or customers.

The NEUST Wayfinder was introduced to the students, teachers, and visitors of NEUST Sumacab Campus during this phase. Additionally, the researchers presented the developed system to IT experts for evaluation.

To effectively showcase the system's functionality, the researchers presented it through a video demonstration, illustrating its usage for campus navigation. This video not only serves as a practical guide for end-users but also aids IT experts in evaluating the technical aspects and usability of the system, aligning with ISO 25010 standards.

3. 2 Assessment of IT Experts on the technical quality of NEUST Wayfinder based on the following ISO/IEC 25010 Software Product Quality Standards criteria.

The technical quality of the NEUST Wayfinder was rigorously evaluated by IT experts based on the ISO/IEC 25010 Software Product Quality Standards. This comprehensive assessment considered several key quality attributes, including functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability**.** By assessing these criteria, the evaluation provides critical insights into the system's robustness, effectiveness, and areas for potential enhancement, ensuring that the application meets the high standards expected in software development and user experience.

The results of the technical evaluation, as shown in Table 1**,** demonstrate the overall satisfaction of IT experts with the NEUST Wayfinder's technical performance. The system received a grand mean rating of 3.40**,** indicating that the experts were generally satisfied with the application across all quality dimensions. This rating reflects the system's alignment with ISO/IEC 25010 standards, ensuring that it meets industry benchmarks for quality software products.

Table 1: Assessment of the Technical Quality based on the ISO/IEC 25010 standards of NEUST Wayfinder by IT Experts

Software Characteristics	Mean Rating	Verbal Description
Functional Suitability	3.52	Highly Functional
Performance Efficiency	3.31	Highly Efficient
Compatibility	3.39	Highly Compatible
Usability	3.28	Highly Usable
Reliability	3.40	Highly Reliable
Security	3.36	Highly Secured
Maintainability	3.44	Highly Maintainable
Portability	3.49	Highly Portable
Grand Mean	3.40	Highly Functional/ Efficient/ Compatible/ Usable/ Reliable/ Secured/ Maintainable/ Portable

3.3 Assessment of end users on the technical quality of NEUST Wayfinder: Your Personal Guide for Campus Navigation based on the following ISO/IEC 25010 Software Product Quality Standards criteria.

The technical quality of the NEUST Wayfinder was evaluated by end users—primarily students and visitors—using the ISO/IEC 25010 Software Product Quality Standards**.** This assessment focused on three key quality attributes: functional suitability, performance efficiency, and usability. These criteria are crucial for determining how effectively the application supports the needs of its users in navigating the campus environment.

Table 2 presents the results of the end users' evaluation. The grand mean rating of 3.80 indicates that end users were highly satisfied with the overall performance of the NEUST Wayfinder. This high level of satisfaction demonstrates that the system effectively meets the core requirements of campus navigation, providing a smooth and intuitive user experience.

Table 2: Assessment of the Technical Quality based on the ISO/IEC 25010 standards of NEUST Wayfinder by End Users

Software Characteristics	Mean Rating	Verbal Description
Functional Suitability	3.90	Highly Functional
Performance Efficiency	3.80	Highly Efficient
Usability	3.71	Highly Usable
Grand Mean	3.80	Highly Functional/ Efficient/ Usable

4. CONCLUSION

Based on the findings of this study, several conclusions were drawn. First, there is a clear need for improved campus navigation, as the study highlighted significant challenges faced by students and visitors in finding their way around the campus. This need served as the foundation for developing the NEUST Wayfinder. Second, the NEUST Wayfinder was successfully developed using the Agile Development Life Cycle Model. The system is fully operational and will continue to undergo monitoring, testing, and maintenance to ensure its ongoing reliability and performance. Third, the NEUST Wayfinder received positive evaluations based on the ISO/IEC 25010 Software Product Quality Standards, with both IT experts and end users expressing high levels of satisfaction. The mean ratings of 3.80 from end users and 3.40 from IT experts reflect the system's efficiency, functionality, and effectiveness as a navigation tool for the university. Lastly, the successful implementation of the NEUST Wayfinder holds significant potential for supporting campus growth and improvement. By addressing the critical issue of navigation, the system enhances the campus experience for both students and visitors, contributing to the university's continued expansion.

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