

BOESKO: Designing A Synoptic Multi-platform Digital System for Citizen Participation

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Abstract— Digital citizen participatory toolkits are gaining interest among researchers and practitioners for their crucial role in empowering citizens, promoting accountability, and ensuring diverse voices are heard in policymaking. This study aims to develop and implement BOESKO: Building on Opinions and Sentiments for Sustainability and Knowledge Opportunities (formerly known as Kalahok) - a multilingual, inclusive, deliberative, synoptic, digital participatory toolkit that digitized data collection and analysis to engage communities in governance using technology-based methodologies. BOESKO is available in English, Filipino, Ilokano, and Bikol versions for web and mobile devices. It primarily encourages public feedback on disaster preparedness and Universal Access to Quality Tertiary Education (UAQTE) implementation in the Philippines. Its adaptable design extends its utility beyond its initial scope. BOESKO explored machine learning, natural language processing, and software integration for data gathering, processing, visualization, and system development while employing a hybrid approach with Extreme Programming (XP) and Scrum. Significant findings demonstrated that BOESKO enabled the orderly solicitation and submission of inputs from local communities through the creation, management, consolidation, analysis, and visualization of responses. The result of the analysis based on the performance of BOESKO's web application and mobile application 4.78 and 4.40, respectively, and this can guide agencies in formulating data-driven policies for UAQTE, Disaster Risk Reduction Management, Climate Adaptation (DRRM/CA), among others.

Keywords— Digital citizen participation, E-participation, System development, Integrated systems, Multi-platform systems, Hybrid software methodology

I. INTRODUCTION

Technology influences every aspect of life; undoubtedly, it has become a necessary part of everyday activity. Its widespread use has changed how individuals interact with one another, conduct business, learn, and even participate in public activities. Due to the digitization of governments, e-participation has developed into a significant component for the collaborative democratic development of

politics and domestic countries with the involvement of citizens [1]. The importance of citizen participation in shaping public policy has increased over the years [2]. Every democratic government strives to be inclusive of all decision-making processes, and this endeavor will succeed in realizing the entire principles of democracy, accountability, and good governance [3].

The core of an e-participation system is typically through websites, an information and communication technology (ICT) infrastructure. This website is easily accessible on PCs, laptops, netbooks, tablets, and smartphones and offers constant internet connectivity. It is beneficial to create applications that can be downloaded on smartphones and tablets in order to improve information accessibility [4]. E-participation has developed into a useful collection of tools that closes the digital gap between citizens and their governments by utilizing developments in ICT [3], and it significantly contributes to the evolution of the political landscape [5]. Citizen involvement is crucial in forming comprehensive national policies, and is a pivotal sign of a successful democratic government [6], [3].

Building on Opinions and Sentiments for Sustainability and Knowledge Opportunities, or BOESKO, is a system developed to involve local communities in governance. It is implemented across various platforms, aiming to create a robust and efficient digital citizen participation platform. The main objective of this study is to effectively develop and implement BOESKO using carefully chosen and appropriate technology. Through this, it aims to promote public participation, facilitate the expression of thoughts and sentiments on the implementation of Universal Access to Quality Tertiary Education (UAQTE) or other domains, and offer possibilities for knowledge-sharing.

II. RELATED WORKS

The core of an e-participation system is typically through websites, an information and communication

technology (ICT) infrastructure. This website is easily accessible on PCs, laptops, netbooks, tablets, and smartphones and offers constant internet connectivity. It is beneficial to create applications that can be downloaded on smartphones and tablets in order to improve information accessibility [4]. E-participation has developed into a useful collection of tools that closes the digital gap between citizens and their governments by utilizing developments in ICT [3], and it significantly contributes to the evolution of the political landscape [5]. Citizen involvement is crucial in forming comprehensive national policies, and is a pivotal sign of a successful democratic government [6], [3].

System integration is the process of assessing and deconstructing a system's needs, assigning each one to a separate component, including software, hardware, or other systems [7], and seamlessly integrating these components to meet the system's objectives [8]. In a study by [9], integrated information systems in HEIs led to improved staff management and student workload efficiency. This integration streamlines daily tasks, enhances data processing accuracy and speed, and facilitates informed decision-making, especially concerning student support and reducing delays.

Multi-platform programs, commonly known as cross-platform applications, have completely changed the information technology industry. Applications that can run on all operating systems [10] and communication devices, including Android, Blackberry, and iOS mobile phones, are known as multi-platform applications [11]. In this field, frameworks such as Flutter and React Native have become effective tools. Using a single codebase, developers can produce visually appealing applications for mobile, web, and desktops using Google's Flutter [12], [13]. React Native combines web technologies with native smartphone programming to produce quick and responsive applications [14]. The advantages of multi-platform technology as a learning aid are highlighted in the study of [10], which shows how it lowers costs and improves accessibility for students. The importance of responsive web design (RWD) has become increasingly important as more people view websites using different devices. A responsive website dynamically adjusts depending on the technology and device used [15], [16]. The importance of device responsiveness in increasing user experience has been emphasized [17], particularly given the pervasive use of mobile devices for website access. In an effort to reduce performance trade-offs when used independently, hybrid software development, a combination of coordinated techniques and processes, has become popular [18], [19]. The effective fusion of Scrum and Extreme Programming (XP) into a single framework is known as ScrumXP [20]. The advantages of Scrum and XP are combined in this agile methodology, enabling organizations to continually improve through efficient technical techniques and customer-centric strategies. Pair programming and code refactoring, two essential engineering XP methods, improve both the speed and quality of software development [21].

Several studies have provided insights into the integration and deployment of digital systems, notably platforms for public participation. Cristobal et al. [22] developed an e-participation mobile application with system features, aiding district administrators and barangay officials with specific modules for effective communications and incident management. Llovido and Palaoag [23] developed an e-participatory platform for disaster risk reduction and management, making it easier to report incidents and provide feedback. In order to efficiently handle data processing and display visual representations of equipment management, a previous study [24] developed a platform with a focus on data visualization features. Microservice architecture supports modularity, scalability, and maintainability, providing real-time access to crucial data for administrators and users to make educated decisions about equipment management.

III. METHOD

In congruence with the approach employed in the study by [25], the researchers utilized a hybrid methodology as shown in Figure 1, combining the best practices and strengths of Extreme Programming (XP) and Scrum to address user requirements. Scrum and XP are effective methodologies for assisting software teams in their projects. In certain instances, these two strategies complement each other. While Scrum focuses on project management, XP provides useful software development practices [26]. Both approaches were determined to be appropriate for the design and development of integrated systems.

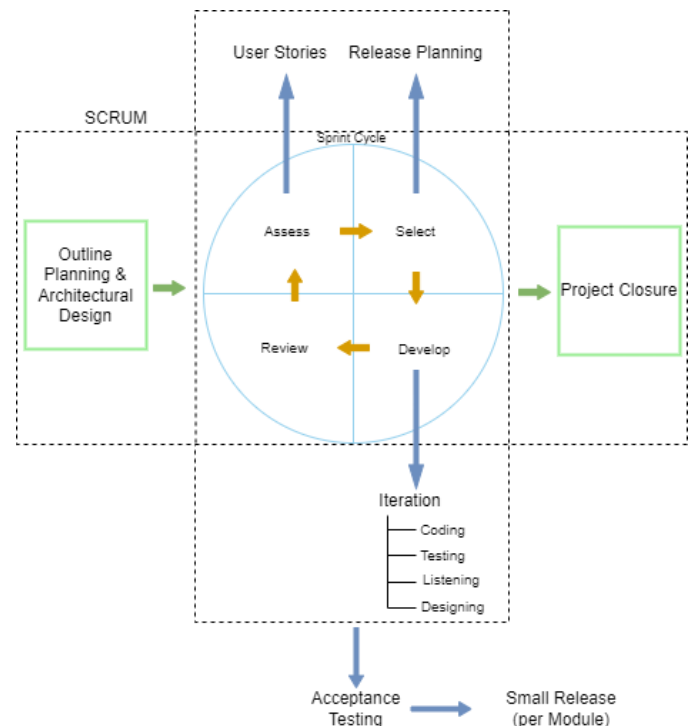


Figure 1. Scrum and XP Methodology

A. Outline Planning and Architectural Design

The main components of the BOSESKO toolkit were subjected to unit testing. Before proceeding to the next feature, each piece of code written for each class was tested. The system testing runs were documented.

The researchers outlined the precise goals of the proposed BOSESKO toolkit. The involved sectors were the subject of extensive efforts to establish collaborations and hold meetings and field visits. The preliminary interview results, along with other crucial inputs, provided insightful information and guidance, highlighting the value of digital public participation. These contributions emphasize the factors that should be taken into consideration, particularly in the design and development of the system.

B. Sprint Cycle

In sprint cycles, the system progresses incrementally during each cycle. The four phases of a sprint are assess, select, develop, and review. This displays logs from the time when each sprint cycle is finished, implying the availability of an updated system version for evaluation. The project's backlog, a list of tasks required to be completed, serves as the basis for planning. It is a collection of prioritized features that are presented as user stories. The stakeholders' suggestions made during the exploratory meetings served as a foundation for the researchers as they established the goals and scope of their project. This aids the researchers in grasping the various system components that require their focus. The selection phase involved a Focus Group Discussion (FGD) in which participants were divided into beneficiary and implementer groups to select features and functionality that would be developed during the sprint. Researchers have integrated user requirements and specifications into technological designs, to establish functionality. A use-case design was created. Partially outlined system features served as a guide for the design of the system's processes and database. Subsequently, a release schedule was established. Jira was used to track all work-related activities to ensure the timely deployment of the system.

1) **Develop:** Coding, testing, listening, and designing undergo iterations at this stage. It is necessary to have a well-designed system architecture that enables seamless interaction between various platforms and identification of connectivity for particular component features. To create a cohesive system structure, a use case diagram—a visual representation of the connections and interactions between various actors and modules in the system was employed. The use case diagram can be used to guide the application of its features and functionalities.

2) **Coding:** In this study, cutting-edge front-end technologies such as TypeScript, React, Next.js were used to produce an interactive user experience. Nest.js was used on the backend because it provides functional and scalable features. Chart.js and TailwindCSS were utilized to improve the design aesthetics and data visualization. VSCode and GitHub are essential tools for code editing and management. Postman was used to thoroughly test and validate the APIs to

guarantee top performance. MySQL, HeidiSQL, and TypeORM were used to manage and interact with data. In parallel, Android Studio and Flutter were used for the mobile app to produce versatile and high-performance applications.

3) **Testing:** The main components of the BOSESKO toolkit were subjected to unit testing. Before proceeding to the next feature, each piece of code written for each class was tested. The system testing runs were documented.

4) **Listening:** Series of meetings with stakeholders were conducted to create and evaluate the questionnaire to be implemented in the toolkit. Based on the comments and suggestions from stakeholders, changes to the system were made. To ensure that these recommendations were carried out systematically until all specified system functionalities were fully realized, an incremental method was adopted.

5) **Designing:** The design of the toolkit in the various platforms prioritizes user-centered principles, incorporating feedback from technical experts and adhering to accessibility standards. It employs a visually appealing and responsive interface, ensuring a seamless experience across devices. Scalability and inclusivity were central considerations, with plans for ongoing improvements and user-driven refinements.

6) **Review:** The completed work was examined and delivered to the stakeholders at the end of the sprint. Subsequently, the following sprint cycle was started.

7) **Acceptance Testing:** The BOSESKO toolkit underwent an initial evaluation by researchers and users, as well as a thorough technical validation process. The system is functional, but evaluators noted that further work is needed to improve its usability and performance. The evaluation of the toolkit is still in progress to ensure that all modules are properly examined to meet the highest standards of functionality and user experience.

8) **Small Release:** For every essential feature developed, small releases were presented to stakeholders to collect feedback for further refinements in future releases.

9) **Project Closure:** A user manual, brochure, and video tutorial were all created to fully describe the features and functionalities of the system. These would guide the respective users of the toolkit.

IV. RESULTS AND DISCUSSION

A. BOSESKO System Functions

BOSESKO is composed of software components available in web and mobile applications. It is a comprehensive data-gathering, analysis, and visualization system, making it a synoptic software. The proponents used multiple programming tools and techniques to develop the software system. Software integration played a vital role in development.

The mobile app is developed using Flutter with BLOC framework. SQLite serves as the local database of the mobile app. NodeJS was utilized for the backend development

of the web app, while React.JS was for the front-end development and visualization. MYSQL is the central database of the web app. Additionally, the synchronization of the mobile and web applications is made possible using the REST application programming interface (API). Python is the primary tool for the data miner / NLP component. Microservices technique prepared the survey raw data for the data miner program and performed data cleaning. The web application and data miner integration is done using the FAST application programming interface (API). The following are specific system functions.

B. Web App

The web application is hosted in the cloud server with access to the database server, which serves as the primary data repository of the system. This application provides a responsive layout for multiple platforms and browsers. The following are its specific modules

- 1) **Administrator Dashboard.** This module allows administrators to manage different software system functions. This page, as demonstrated in figure 2, serves as the backend manager of the system accessible in the web application.
- 2) **Access Manager.** This module manages the system accounts, including their types, roles, and privileges. Figure 3 demonstrates that with the access manager, permissions can be read, created, updated, or deleted for a specific system module.



Figure 2. Administrator Dashboard

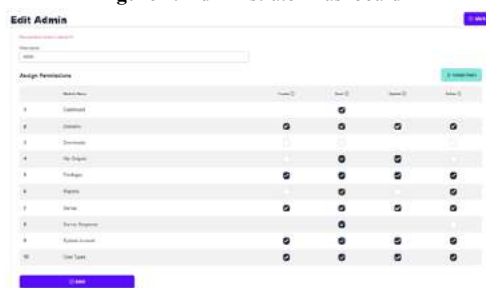


Figure 3. Access Manager

- 3) **Domain Manager.** BOSESKO is designed to allow customization, creation, and implementation of the toolkit for other e-participation domains, not exclusively for DRRM and UAQTE only. Figure 4 depicts the user interface for the mentioned purpose.
- 4) **Survey Manager.** This module allows creating, updating, deleting, activating, and deactivating surveys within an active domain. Users can specify the survey's description and start and end dates, as shown in Figure 5.

- 5) **Question Manager.** Figure 6 is the question manager used to administer questions of an active survey. Question types include multiple choice, open-ended, true or false, drop-down selection, date picker, and rating. Each type has its settings and configuration, like the required answer, audio recording, graph visibility, multiple answers, other answers, maximum and minimum rating values, and follow-up questions.



Figure 4. Domain Manager

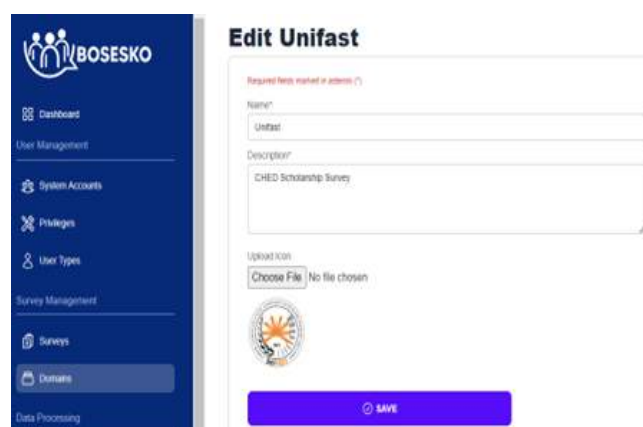


Figure 5. Survey Manager



Figure 6. Question Manager

- 6) Data Miner: NLP Toolkit. As shown in Figure 7, this module performs data searching, cleaning implemented using microservices, and analysis of survey responses via text or voice recording to identify patterns and extract useful information. The toolkit implements pre-processing, feature extraction, model training, and performance evaluation.
- 7) Data Visualizer. The Data Visualizer (Figure 8) is a report-generation tool that creates data visualization of survey responses. It displays a storyboard, charts, graphs, and other visual representations.



Figure 7. Data Miner

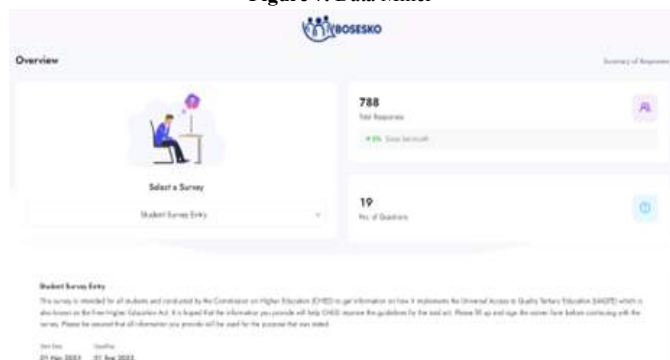


Figure 8. Data Visualizer

C. Mobile App

This mobile app is a tool for data gathering. It is compatible with Android and IOS devices. It has a local database that temporarily holds the user's data and is synchronized to the web application's database server when a stable WAN network is available. The following are the modules of the mobile application.

- 1) Domain/Survey Selector. This module (Figure 9) allows the respondents to choose their preferred domain and survey. The system can activate multiple domains with multiple surveys in it. This module is also accessible using the web application with a responsive layout.

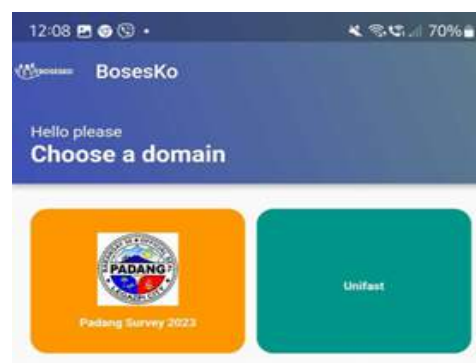


Figure 9. Domain / Survey Selector - Mobile App

- 2) Response Uploader. This module allows the respondents to actively respond using text input or voice recording. Respondents can also engage in the active survey using the web application. Figure 10, Figure 11, and Figure 12 show these features.

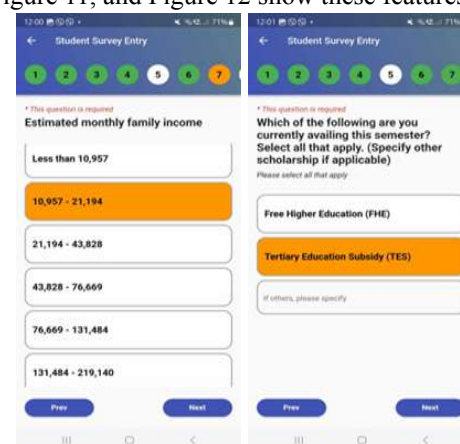


Figure 10. Response Uploader for Mobile App



Figure 11. Response Uploader for Web App

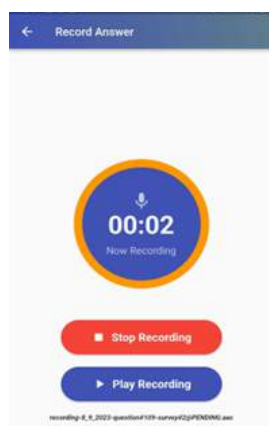


Figure 12. Response Audio Recorder for Mobile App

C. Evaluation

Table 2 presents the performance of BOESKO's web application and mobile application across various functional aspects. The evaluation uses the ISO 25010 software product functional suitability test. The average scores indicate that BOESKO excels in functional completeness, with a perfect score of 5.00 for the web application and a strong 4.33 for the mobile application. This suggests that the web application is more feature-rich and comprehensive than its mobile counterpart. Furthermore, both versions of BOESKO exhibit high levels of functional correctness, scoring 4.67 for the web application and 4.33 for the mobile application. This indicates that the functionality of the applications is generally reliable and free from significant errors, with the web application being more consistent in this regard. Regarding functional appropriateness, both the web and mobile applications of BOESKO received strong scores of 4.67. This suggests that BOESKO's functionality, whether accessed through a web browser or a mobile device, is well-suited to its intended purpose.

Table 2. Functional Suitability Evaluation result for BOESKO application

Quality Characteristic	BOESKO Web application	BOESKO mobile application
Functional completeness	5.00	4.33
Functional correctness	4.67	4.33
Functional appropriateness	4.67	4.67
Weighted Mean	4.78	4.40

V. CONCLUSION

BOESKO, a synoptic digital participatory toolkit, has been developed to engage communities in governance by utilizing technology-driven approaches. With its multilingual and inclusive features, it has the potential to play a vital role in gathering public feedback on critical issues such as the implementation of Universal Access to Quality Tertiary Education (UAQTE) in the Philippines and disaster preparedness, providing a convenient channel for public participation. This study employs state-of-the-art technologies

to build web and mobile applications, successfully creating a reliable, universally applicable, and effective digital platform for public involvement through a hybrid methodology.

The web and mobile application functions of BOESKO give users the freedom to choose domains, take surveys, and offer feedback, improving citizen involvement and functionality. Based on the functional suitability test of software product quality evaluation, BOESKO's web application obtained 4.78; on the mobile application, it perceived a 4.40 total weighted mean. Survey management is highly emphasized on the platform, leading to better data handling and user control for improved usability. Furthermore, BOESKO is a multiplatform application that considerably increases its reach by making it accessible to all citizens. Additionally, it guarantees an agile and consistent user experience across all platforms, improving functionality, usability, and engagement. This study highlights the superior feature set of BOESKO in comparison to other survey applications. The development and implementation of BOESKO show the potential of online platforms for public participation in promoting inclusive and democratic decision-making. BOESKO has the potential to close the gap between citizens and governments by utilizing technology, data mining techniques, and user feedback, enabling engagement and fostering transparency and accountability. Future work includes determining the level of user acceptance of the toolkit and understanding the relationship of each factor that could affect its utilization.

ACKNOWLEDGMENT

The researchers would like to thank the Philippine Commission on Higher Education (CHED) Leading the Advancement of Knowledge in Agriculture and Science (LAKAS) Project No. 2021-007, eParticipation 2.1: Harnessing Natural Language Processing (NLP) for Community Participation, for providing the necessary funds to make this research possible. The researchers are truly grateful for their contribution to the research.

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