1 Testing

1.1 Introduction

The testing phase of this project plays an important part in guaranteeing the dependability, functionality, and security of the established certificate verification system on the distributed ledger of Ethereum. Conducting thorough testing is vital to detect and fix any vulnerabilities, verify the accuracy of smart contract logic, as well as establish that the system fulfils its designated requirements. This chapter provides an overview of the testing approaches, tactics, and scenarios utilised to evaluate the performance and resilience of the certificate verification system for UPTM.

1.2 Unit Testing

The process of unit testing for a Certificate Verification system with Blockchain Technology at UPTM includes the investigation and assessment of individual components (referred to as units) within the system, to determine the expected performance. Table 8.2-1 shows the result of unit testing.

Table 8.2-1 Unit Testing Result

UNIT/ FUNCTION	DESCRIPTION	INPUT	OUTPUT	STATUS
ADD CERTIFICATE	Conduct a test of the execution of a new certification.	Certificate details (name, IC, programme, senate date)	The certificate has been successfully added	Pass
UPDATE CERTIFICATE	Conduct a test of updating an existing certificate	Certificate number and updated details	The certificate has been successfully updated	Pass
DELETE CERTIFICATE	Conduct a test of deleting an existing certificate	Certificate number	The certificate has been successfully removed	Pass
READ CERTIFICATE PUBLIC	Conduct a test of public reading of certificate details	Certificate number	The data provided by the certificate is available to everyone	Pass

READ CERTIFICATE	The process involves checking of certificate details by a registrar or trusted agent	Certificate number	The authorised user can access the specific information included in the certificate	Pass
SEARCH CERTIFICATE	Conduct a test of the traversal search mechanism employed for certificates	Certificate number	The set of values includes information about certificate data, including previous and succeeding certificate numbers	Pass
ISVALID CERTIFICATE	Conduct a test of the certificate validation	Certificate number	If the certificate exists, then true, if not, false	Pass
GET LIST CERTIFICATE STATUS	Conduct a test of the method used to search for the status of a list	None	The requested information includes the first and most recent certificate numbers, the overall count of certificates, and the timestamp of the most recent update	Pass
CHANGE TRUSTED AGENT	Conduct a test of trusted agent address changed	New trusted agent address	The update of the trusted agent address was executed successfully	Pass

1.3 Integration Testing

The process of integration testing in the context of certificate verification using blockchain technology at UPTM includes the verification and validation of the interactions and interoperability among various system components. The key focus consists of accomplishing the smooth integration of these components to effectively accomplish the desired functionality of the certificate verification system. Table 8.3-1 shows the result of integration testing.

Table 8.3-1 Integration Testing

UNIT/ FUNCTION	DESCRIPTION	INPUT	OUTPUT	STATUS
COMBINATION OF CERTIFICATE ADDITION AND VERIFICATION	Test the complete procedure of implementing a certificate into a system and subsequently validate its specific information	Name, IC, programme, senate date	The certificate has been properly added and accepted	Pass
COMBINATION OF CERTIFICATE UPDATE AND VERIFICATION	To assess the complete end-to-end process of updating a certificate followed by confirming the reliability of the changed information	Certificate number and updated details	The certificate has been successfully updated and confirmed	Pass
COMBINATION OF CERTIFICATE DELETION AND VERIFICATION	Perform a test of the complete procedure involved in dropping a certificate and verifying its removal	Certificate number	The certificate has been removed, and subsequent verification confirms its disappearance	Pass
COMBINATION OF PUBLIC AND AUTHORIZED USER READING	To measure the integration of public and authorised user reading functionalities	Certificate number	The data is accessible to both the general public and individuals with authorised access	Pass
COMBINATION OF TRUSTED AGENT ADDRESS CHANGE AND CERTIFICATE UPDATE	To assess the effectiveness of integrating the modification of the trusted agent address and the subsequent update of a certificate	Certificate details and new trusted agent address	The address of the trusted agent has been updated, and the certificate has been successfully updated	Pass

COMBINATION OF CERTIFICATE ADDITION WITH LIST STATUS RETRIEVAL	To assess the functionality of integrating the process of adding a certificate and retrieving the list status	Certificate details	The certificate has been successfully added, and the status of the list has been retrieved	Pass

1.4 System Testing

The system testing performed for the Certificate Verification utilising Blockchain Technology at UPTM consists of mainly functional and non-functional components. The primary objective of system validation is to ensure that the system not only fulfils its specified functionalities, but also satisfies important non-functional requirements, including security, dependability, compatibility, and performance. The successful completion of these tests guarantees the implementation of a resilient and dependable certificate verification system for stakeholders of UPTM.

1.4.1 Functional Testing

Table 8.4.1-1 shows the functional testing of UPTM management, students, employers and other universities.

Table 8.4.1-1 Functional Testing

TEST FUNCTION	EXPECTED RESULT	ACTUAL RESULT	STATUS
CERTIFICATE UPLOAD BY UPTM MANAGEMENT	The certificate has been successfully uploaded to the blockchain, and all the relevant data has been appropriately stored	Successfully upload the certificate into the blockchain. The transaction was completed and smart contract was deployed	Pass
STUDENTS/ EMPLOYERS/ OTHER UNIVERSITIES VERIFY THE CERTIFICATE	The system successfully retrieves and delivers accurate data regarding certificates	Successfully shows the accurate certificate of the student	Pass

1.4.2 Non-Functional Testing

Non-functional testing is conducted to verify the full compliance of the certificate verification system with essential features, including security, reliability, compatibility, and performance, as specified by the requirements. Table 8.4.2-1 shows the result of non-functional testing.

Table 8.4.2-1 Non-Functional Testing

REQUIREMENT	TEST FUNCTION	EXPECTED RESULT	ACTUAL RESULT	STATUS
SECURITY	An activity to retrieve certificate data without acceptable authorization	Access that has not been granted is prohibited, so guaranteeing the privacy of data	Unauthorized access prohibited	Pass
RELIABILITY	Test the usability of the user interface	The user interface is designed to be straightforward to enable easy interaction	User interface is easy to use	Pass
COMPATIBILITY	Utilise several web browsers, such as Chrome, Firefox to get entry into the system	The system operates smoothly on different web browsers	Successfully access by several web browsers	Pass
PERFORMANCE	Perform a test of the duration required to verify the authenticity of a certificate	The system exhibits prompt responsiveness both during regular usage and during periods of high demand	The system could be used during regular usage and high traffic network	Pass
RELIABILITY	When the certificate is not existed	The system is designed to show the search error	The system showed the non-existing certificate during the verification	Pass

1.5 Acceptance Testing

1.5.1 Alpha Testing

Alpha testing is a necessary stage of internal testing within the development process, which serves the purpose of verifying that a system complies with internal quality requirements before its release for wider testing or deployment. This approach expands on the concept of unit testing by assessing the integration and functioning of separate components within a larger system. Integration testing is a process that expands upon the validation of the integrated system, including an extensive assessment of the system as a single unit in order to assess both its functional and non-functional characteristics. Alpha testing involves the use of elements from both unit and integration testing, hence making an important contribution to the wider system testing attempts. Functional, security, compatibility, user interface, and performance testing are among the scenarios. The primary objective of alpha testing is to identify and address any potential issues or vulnerabilities in continuing to the next testing stages or the deployment of the product in an actual production setting.

1.5.2 Beta Testing

The beta testing phase is a necessary step in the developmental process of a system, such as a certificate verification system for UPTM. During this phase, end-users are subjected to testing in an authentic real-world setting. This stage involves the development of a prototype version of the web-based system, containing vital functions such as the capability to verify certificates. Additionally, a video presentation is included to improve the user's experience. The beta testing scenarios cover many activities such as verification of the certificates, gathering user feedback, evaluating prototypes, assessing performance, and validating security features. The anticipated outcome encompasses favourable feedback, identification of prospective enhancements, and confirmation of the system's preparedness for wider utilisation. This procedure promotes the improvement of the system by the incorporation of real user experiences, resulting in a product that is more adaptable and focused on users.

1.5.3 Analysis of Acceptance Testing

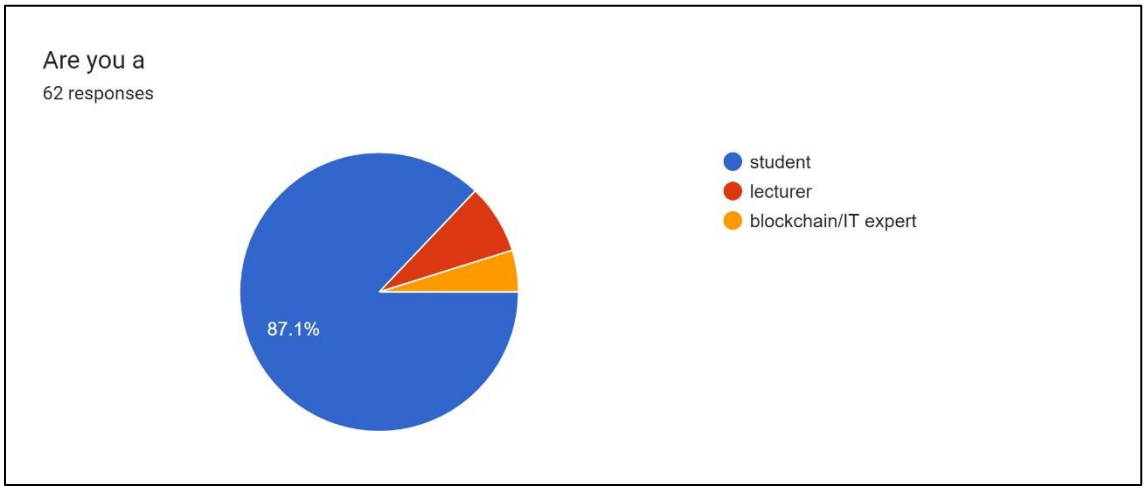

Figure 8.5.3-1 Question 1

Figure 8.5.3-1 shows the result of question 1. During the acceptance testing phase of the Certificate Verification system using Blockchain Technology for UPTM, a total of 62 individuals were involved as respondents. The participants were categorised as follows: 87.1% were students, 8.1% were lecturers, and 4.8% were blockchain experts. The findings of the investigation indicated a wide range of user engagement, with a particular focus on individuals who identified as students. The participation of lecturers demonstrated an understanding of the academic dimensions, but the addition of blockchain professionals underlined the system's attractiveness to those with specialised expertise in blockchain technology.

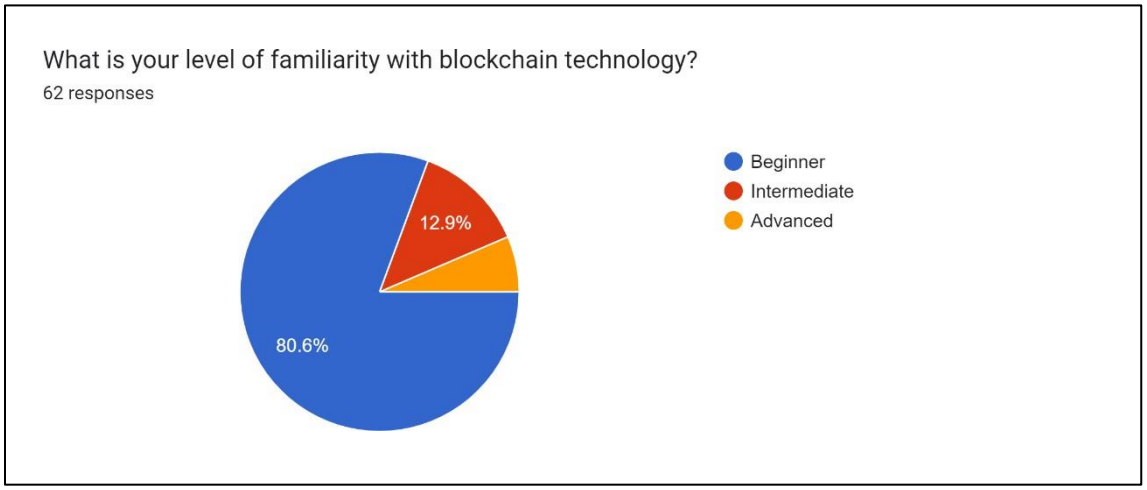

Figure 8.5.3-2 Question 2

Figure 8.5.3-2 shows the result of question 2. The majority percentage of participants in the field of blockchain consists of individuals who are new to the subject, accounting for 80.6% of the overall sample. A much smaller scale, specifically 12.9%, exhibits an intermediate level of knowledge, and only 6.5% indicates a more advanced comprehension of blockchain technology. The results of

this study indicate that the majority of users in the system had different degrees of knowledge regarding blockchain technology. This underscores the significance of incorporating user-friendly design and effective communication in the system's deployment and documentation.

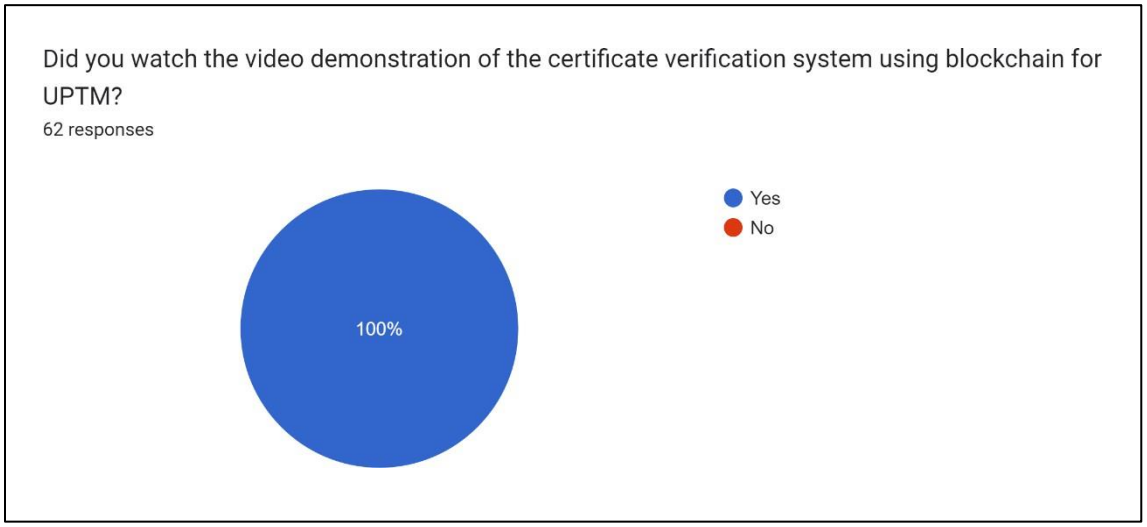

Figure 8.5.3-3 Question 3

Figure 8.5.3-3 shows the result of question 3. All participants, representing the total number of respondents, indicated that they viewed the video demonstration of the Certificate Verification system utilising blockchain for UPTM prior to completing the questionnaire. This suggests a thorough involvement with the many aspects and capabilities of the system, guaranteeing that participants were provided with a visual understanding of the procedures and exchanges. The complete engagement of all participants in the video presentation indicates a high degree of readiness and familiarity among the respondents, establishing an effective basis for their comments and responses in the next questionnaire.

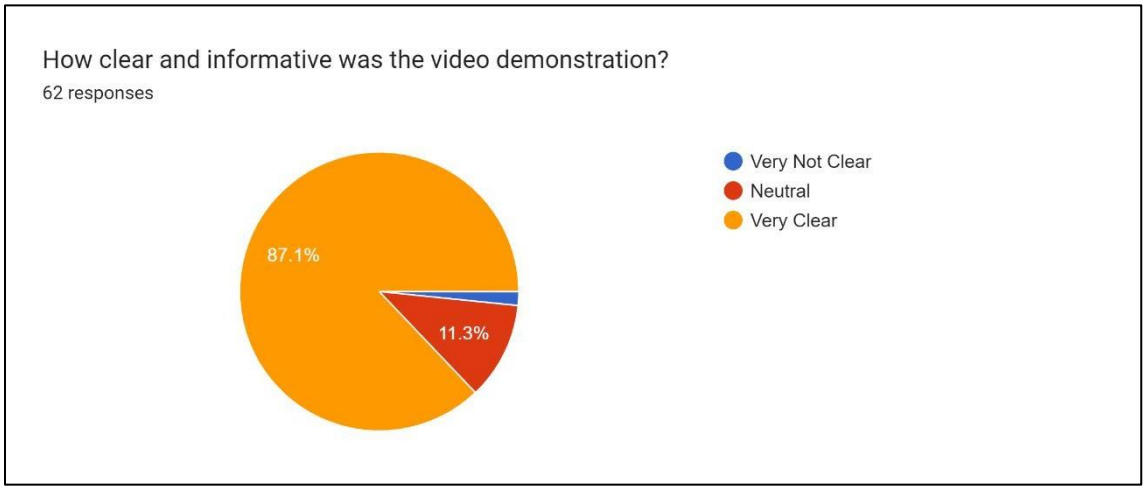

Figure 8.5.3-4 Question 4

Figure 8.5.3-4 shows the result of question 4. A significant proportion of participants expressed that the video demonstration was clear demonstrating that the graphical representation effectively presented the attributes and operations of the Certificate Verification system employing blockchain for UPTM. Several neutral opinions suggest that a minority of participants did not express strong agreement or disagreement on the clarity of the video. This could perhaps be attributed to a range of personal perceptions or expectations.

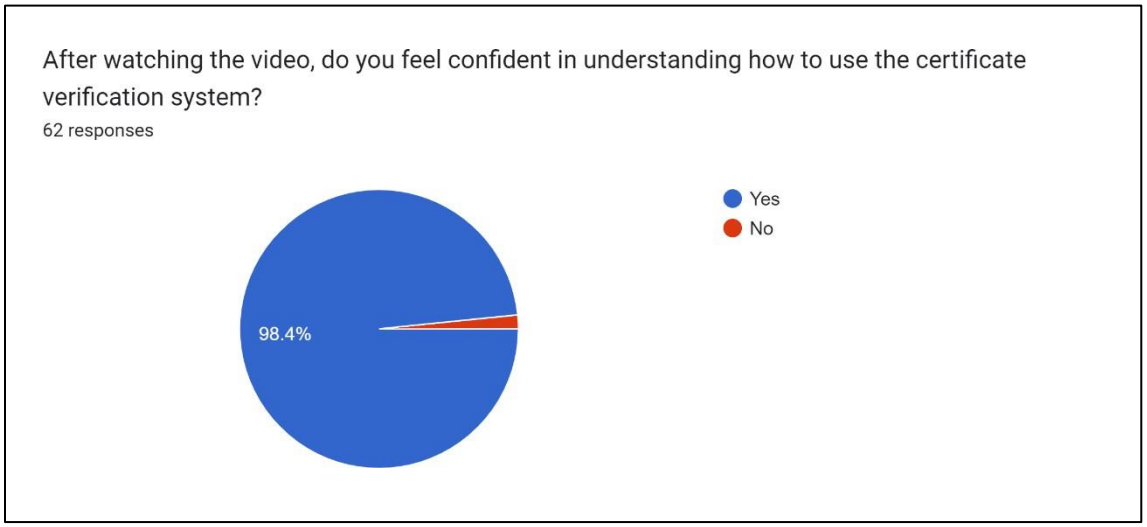

Figure 8.5.3-5 Question 5

Figure 8.5.3-5 shows the result of question 5. The statistically significant majority of participants in this study, which is 98.4% indicate an impressive amount of trust regarding their understanding and effectiveness in using the system. The outcome demonstrates the success of the video demonstration and the system's design in terms of user-friendliness, hence enhancing user confidence in utilising the Certificate Verification system integrated with blockchain technology for UPTM.

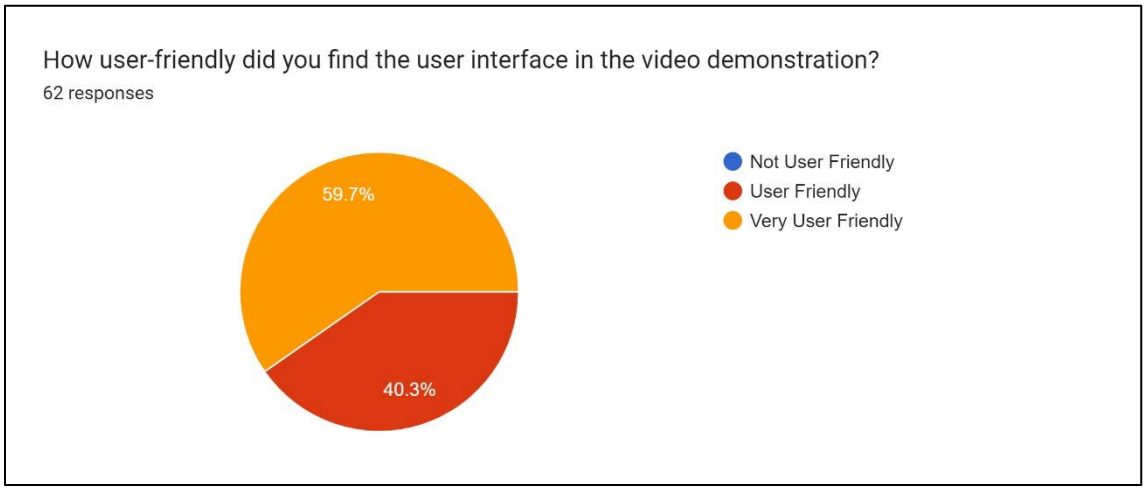

Figure 8.5.3-6 Question 6

Figure 8.5.3-6 shows the result of question 6. A significant number of the respondents expressed an encouraging perspective, as nearly 60% indicated that the user interface exhibits a high degree of user-friendliness. Furthermore, an important majority of respondents (40.3%) indicated that they perceive the user interface to be, at the very least, user-friendly. This observation implies a generally favourable view of the user interface, suggesting that an important number of people perceive it as being effortless to navigate. The comment underscores the significance of including user-friendly design principles to guarantee a positive user experience with the Certificate Verification system that uses blockchain technology for UPTM.

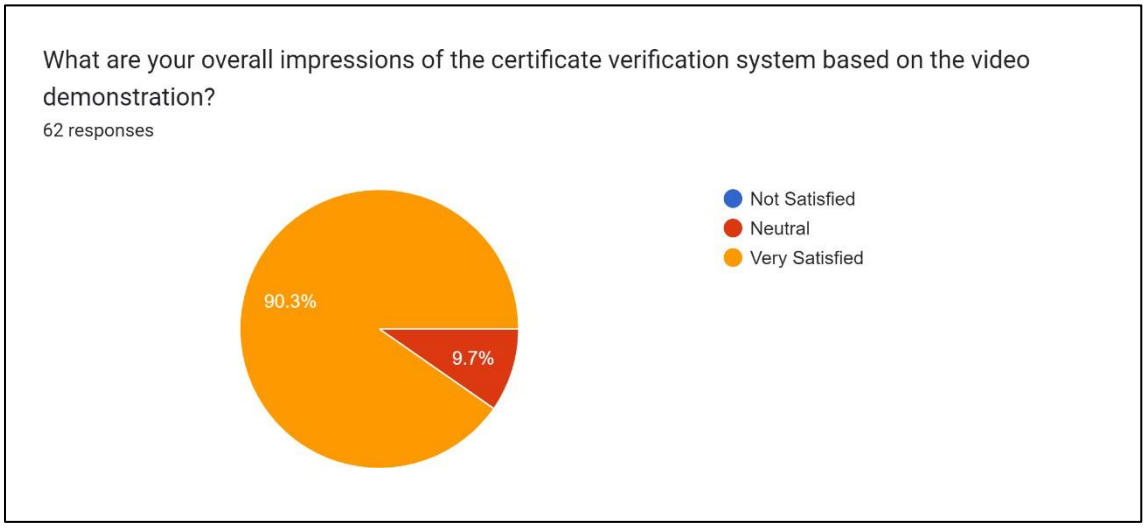

Figure 8.5.3-7 Question 7

Figure 8.5.3-7 shows the result of question 7. 90.3% of those who took part conveyed an impressive level of satisfaction with the Certificate Verification method, as seen by their positive reactions to the video demonstration. The favourable emotion expressed by users is indicative of the system's

excellent presentation and functionality. A minority of users expressed a neutral opinion, which may suggest differences in personal perception or expectations. In general, the findings indicate an effective and acceptable response to the system among the people who were surveyed.

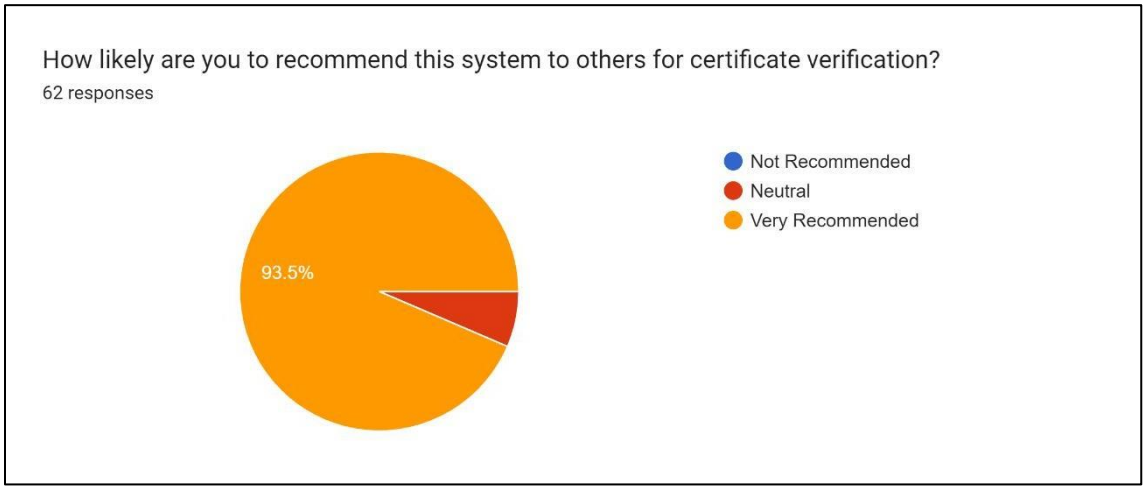

Figure 8.5.3-8 Question 8

Figure 8.5.3-8 shows the result of question 8. 93.5% of participants conveyed an encouraging tendency to endorse the Certificate Verification system for use by others certificates. The high recommendation rate indicates an important level of contentment and assurance in the system's operational and efficacious nature. The neutral responses observed in the data may be indicative of differing levels of personal factors or a more cautious approach among a minority of participants. In general, the findings highlight an important validation of the system's worth and dependability.

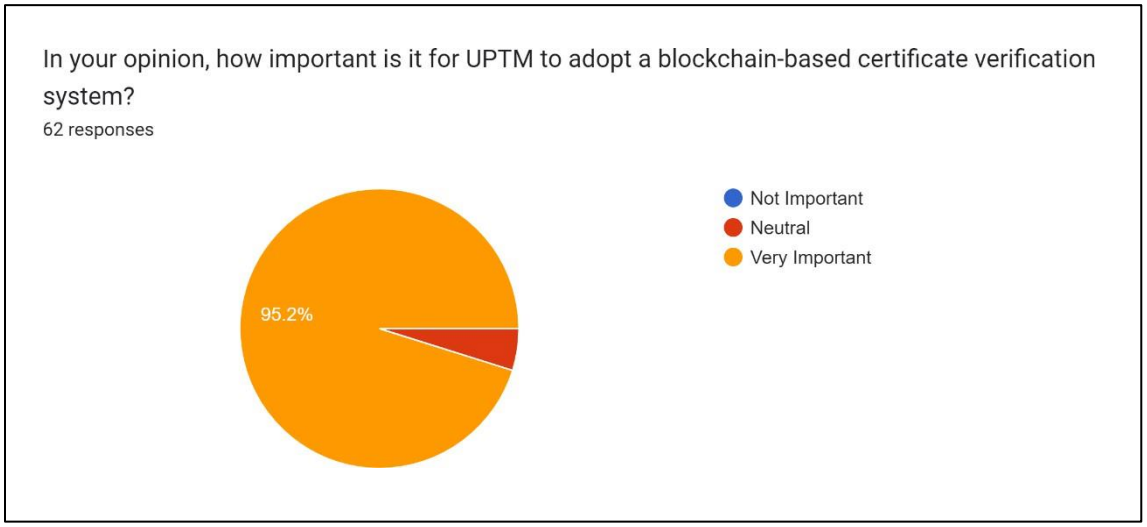

Figure 8.5.3-9 Question 9

Figure 8.5.3-9 shows the result of question 9. A significant majority of respondents, specifically 95.2%, express their confidence in the importance of UPTM's adoption of a certificate verification system based on blockchain technology. This statement demonstrates a strong degree of support for the potential benefits and advantages that could be derived from the implementation of such a system. These benefits encompass improved security, increased transparency, and higher efficiency in the processes involved in verifying certificates. The findings indicate a general agreement among participants regarding the importance and possible beneficial effects of using blockchain technology in the certificate verification system for UPTM.

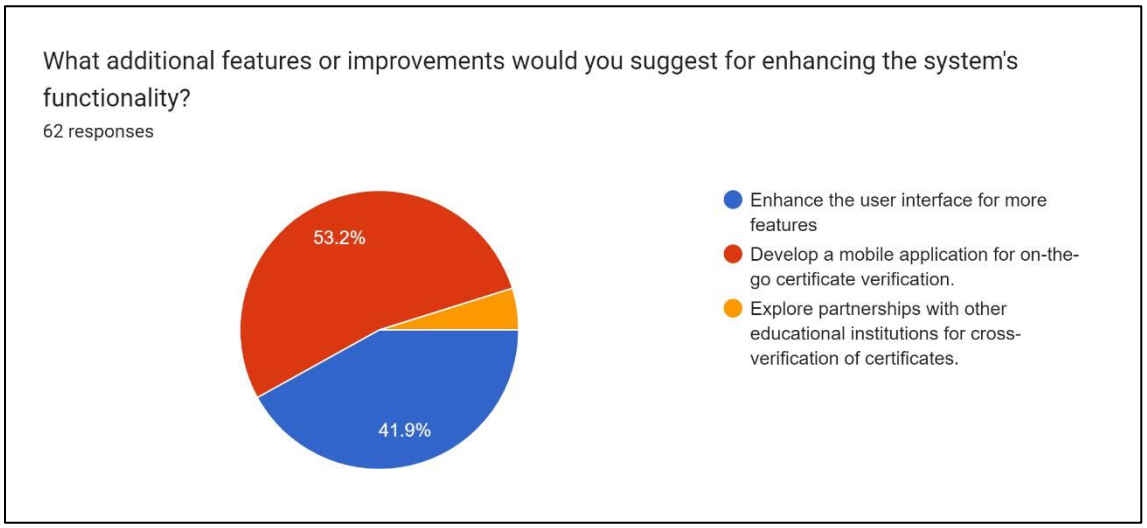

Figure 8.5.3-10 Question 10

Figure 8.5.3-10 shows the result of question 10. According to the findings of the survey, a significant proportion of participants, specifically 41.9%, expressed a desire to enhance the user interface to accommodate further functionalities. Additionally, a majority of participants, amounting to 53.2%, indicated a preference for the creation of a mobile application to facilitate certificate verification. A mere 4.8% of respondents expressed a desire to engage in collaborative efforts with other educational institutions for the purpose of cross-verification. Mobile accessibility was the preferred choice among the majority, while there was comparatively less enthusiasm for cross-verification links.

1.6 Conclusion

Unit testing was done to make sure that each component of the Certificate Verification system worked as intended before it was put through an extensive assessment process. Integration testing is a process that mainly aims to evaluate the smooth integration and cooperation among various

components. This is subsequently followed by system testing, which serves to verify the overall performance and dependability of the system. The final phase of acceptance testing encompassed the collection of user input when a varied range of individuals expressed their trust in the system's clarity, usability, and general happiness. A successful system deployment is made possible by these testing processes, which collectively validate the system's functionality, durability, and user-focused design.