Redesigning an Inclusive Digital Contact Tracing Service Systems: Product-Focus and Implementation Phase of Design Thinking Approach

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Abstract

Contact tracing is one of the effective mediums in containing the virus brought about by the coronavirus disease (COVID-19). In the Philippines, Valenzuela City is known for pioneering the digital contact tracing system known as Project X. Despite implementing this system, users of Project X encounter challenges in Accessibility, Registration, and Scanning. Moreover, the repetitive and prolonged time of filling out Health Declaration Forms causes inconvenience. This study aims to redesign Project X into an inclusive digital contact tracing system with a unified system for citizens' contact identification and health declaration. The research will be significant to Filipino citizens using digital contact tracing, contact tracers, the Local Government Units (LGUs), government agencies, and the future researchers who will be carrying out similar fields of studies. The researchers collected data through online interviews and survey questionnaires for the Analytical Hierarchy Process, Concept Scoring, and Usability Test. Alternative solutions such as RFID, Face ID, and Kiosk, and three design models were developed: RFID Card, RFID Keychain, and RFID Bracelet. Three design models were presented to the respondents for scoring and testing to get the best solution. Upon testing, the proponents received user feedback and recommendations for improvement.

Keywords
COVID-19, Digital Contact Tracing, Design Thinking, Service Systems

1. Introduction
Contact tracing has been one of the primary responses to mitigate the COVID-19. The LGUs from different cities implemented ways to determine the contacts, one of which is through the use of technology. The Valenzuela City adapted a Quick-Response (QR) scanning per establishment to trace individuals. Through the use of QR codes, citizens can give their personal information such as name, gender, birthday, and address to the establishment and LGU directly.

Despite implementing this system, it is still a challenge for the users in the Philippines to adapt to the digital contact tracing system. If applying the digital contact tracing system with the general population is a challenge, it must be more difficult for those with visual impairment. With this, contact tracing must be accessible to all, including those with visual impairments (Chan et al., 2021).

Applying the Design Thinking Approach, the users' pain points focus on the following: Accessing, Registering, and Scanning (Chan et al., 2021). For accessibility, problems arise such as lack of internet connection, difficulty navigating website address, difficulty accessing the QR codes, and non-tech-savviness. For registering, difficulty in reading website text, and complications in password requirements. And in scanning, forgetting to bring their QR code, QR scanner being unresponsive, equipment not reading the QR, and identity theft in losing their QR Codes. In addition, users also encounter problems in the repetitive filling out of health declaration forms in every establishment since it takes too much of their time.

The study's objective is to redesign an inclusive digital contact tracing system in the City of Valenzuela based on the study conducted by Chan et al., 2021. The inclusive digital contact tracing design also intends to concoct a unified digital contact tracing system that can benefit social care institutions and local government units by making contact tracing more efficient and rapid. From the results of the said study, the researchers are expected to develop the following:

1. Alternative Solutions to Valenzuela's Project X
2. Prototype
3. Test Results and Suggest modifications

2. Literature Review

The Department of Health (DOH) established governance structures and operational policies that encompass the COVID-19 mitigation, one of which is the use of digital tools (DOH, 2020). The process of contact tracing starts when the Safety and Health Officer identifies a suspect or confirmed case. Tracing individuals from the contact area shall be initiated, and 70% of possible contacts will be identified within the day and 100% within two days (DOH, 2020). Still, the whole process of a manual contact tracing system takes up to 7 days, from detection to quarantine. Integrating digital technology into the contact tracing system may improve the process to strengthen the contact tracing efforts. Moreover, the Safety and Health Officer must notify the contacts of suspected cases, who will urge them to self-monitor and follow severe minimum public health requirements. If the suspicious case is probable or confirmed, their contacts will be placed under quarantine or isolation, if necessary.

Regarding public health policy response to address COVID-19 Philippines, the "Bayanihan I & II" law has been implemented to enhance healthcare facilities' capacity to detect, treat, and isolate COVID-19 infected people. This also includes mass testing, contact tracing, treatment, and isolation. Despite increased resources and a more significant number of trained contact tracers, the government is still tracing too few people exposed to COVID-19 infected people, particularly in Metro Manila. As a result, contact tracing is still considered one of the weakest components in response to the COVID-19 (David et al., 2020).

The UP COVID-19 Pandemic Response Team explained that Metro Manila's daily testing capacity should be at least 91,000. However, the DOH's data shows that the average number of daily tests is only 47,725, beyond the target testing capacity.

With these issues and challenges, the Philippine government advised that the country's contact tracing be strengthened. This includes: employing a large number of well-trained and committed contact tracers, ensuring that personal health information is correctly utilized and readily accessible to healthcare professionals, using big data analytics and automation, and replicating international best practices.

A study conducted by Tan & Liu (2020) used a face recognition system to detect and track infected individuals. The device used in the system is an RGB camera with a thermal imaging camera, where the RGB camera is used to detect the face and locate the user's forehead. The thermal camera measures the skin's temperature on the forehead. The device can function as a local fever monitor and face recognizer. When a patient is confirmed to have a virus, the device will recognize their identification. Hence, all the face images of infected individuals can be retrieved from saved images or the camera ID and time stamp. Lastly, this device can only recognize persons enrolled in the system. Otherwise, individuals who will be using the system are considered visitors. Registration can be done on the device or in the cloud. This kiosk device can determine an individual's temperature in less than a second. If their temperature is above or below average, the company can prompt action to prevent an outbreak in their building or operation.

Companies who work in the workplace use a contactless kiosk to trace employees who have been infected. LamasaTech has just introduced a line of cutting-edge sign-in kiosks that incorporate temperature monitoring and facial recognition. It keeps a record of who enters the building, but it also gives information on their date and contact information. This implies that if someone tests positive for the coronavirus, the employer may see who else was in the building that day and see if they came into contact with the infected person. This is an effective way to trace individuals in every organization, allowing healthy employees to work in a secure setting, knowing that the management is concerned about their health and well-being.

RFID can also provide a real-time system that can track all points of contact and then be analyzed to alert those who came into close contact with a known positive case. Using RFID tags, each person who interacts with another person may be detected, quickly notified, and transferred for testing and/or isolation. In the healthcare system, RFID provides a better solution. Infection control and worker and patient safety, the usage of tracking and alert systems, in particular, can help Healthcare workers' safety in high-risk environments. Furthermore, RFID technology can help healthcare providers quickly locate and contact affected people (Metha et al., 2020).

3. Methods

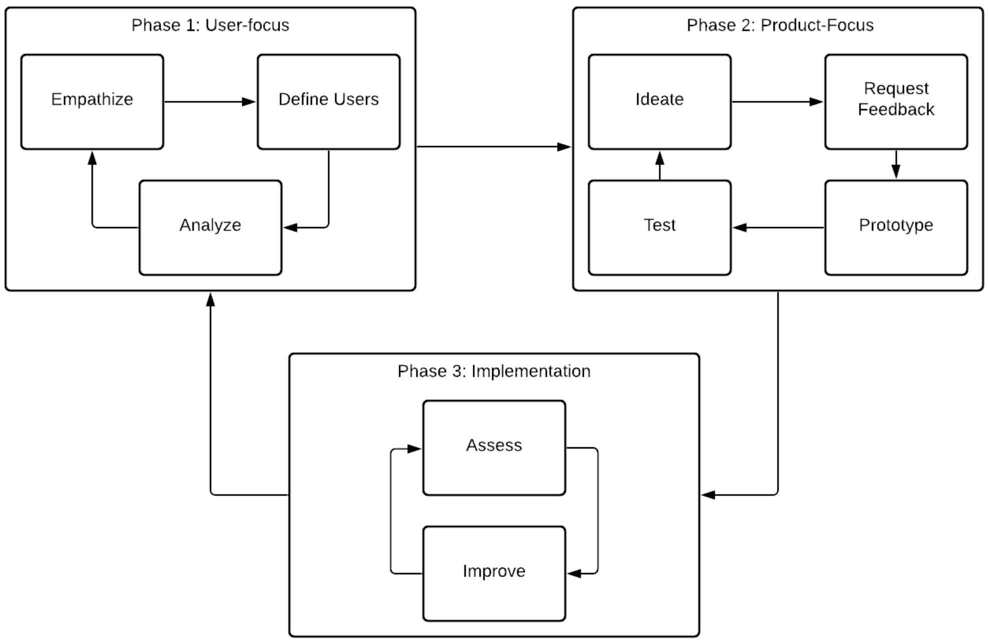

Figure 1. Chan et al. (2021)'s Three Phase Conceptual Framework

The conceptual framework focuses on three (3) phases. The first phase is called 'User-focus,' which consists of three steps: empathize, identify users, and analyze (Chan et al., 2021). First, the researchers characterized and understood the problem or difficulties that Project X users in Valenzuela experienced. Then, the researchers defined who the users are, their pain points, and their experiences in the current Project X using Persona Development. Lastly, following the defining point, the researchers looked into the user's behavior patterns and preferences concerning digital contact tracing through the Customer Journey Map.

From the mentioned study by Chan et al. (2021), this research focuses on the second and third phases of three phases, as shown in Figure 1. The primary focus of the second phase is the creation of initial designs and alternative solutions to the current digital contact tracing system of Valenzuela City from the input of Phase 1 and having it tested by the current users of Project X. This phase occurs in four stages: ideate, request feedback, prototype, and test.

a. *Ideate*: The researchers constructed a unified online service system that monitors and tracks COVID-19 cases through the Design Thinking approach to improve the system using the data collected in Phase 1. This also involved concept mapping, brainstorming, and flow diagrams.
b. *Request feedback*: The researchers asked the current users of Project X for their feedback on the initial designs created by the researchers and had them rated through Concept Scoring.

c. *Prototype*: The researchers built initial prototypes from the ideation from the first step, and the feedback received. Even though these prototypes are experimental and highly dependent on the ideation step, the researchers are still open to new ideas.
d. *Test*: The researchers then considered different factors and critical features that need improvement from the initial prototype and ran numerous trials to test whether the product/service is up for implementation. If it is not ready to be implemented yet, the ideation stage shall be redone to cover these shortcomings, and the cycle of Phase 2 repeats again.

In the product-focused, the formulation of solutions will be comprehensive, addressing all of the personas' pain points. Following that, Multi-Criteria Decision Making will be used to select the optimal answer. Once the optimal response has been identified, the researchers will create *n* models and solicit input from the users. The researchers will modify the models if the user mentions or experiences additional pain areas. If not, the research will move on to the last phase The third phase's primary focus is the assessment of the prototype made from Phase 2 through various testing and improving the product/service accordingly. This phase occurs in two stages: assessment and improvement.

a. *Assess*: After completing the prototype and the testing part of the framework, the researchers then assessed the current design if it complies with and encompasses the user's pain points through simulation in one establishment in Valenzuela City. The users' feedback on the prototype was considered through the Usability Test Questionnaire.
b. *Improve*: As the process of design thinking is a cycle, the prototype will be continuously improved according to the needs and pain points of the users according to the test results. And to be able to improve the system further, the designers will then go back to the Empathize stage in Phase 1, and the whole cycle of the framework shall be threaded again.

The Implementation Phase will be covered in the final phase of the research/conceptual framework once the prototype has been tested. The researchers will study the system's current state and weigh its benefits and drawbacks during this phase. Finally, the researchers will examine the prototype's potential for improvement.

4. Data Collection

Due to strict quarantine protocols, the researchers collected data from the survey respondents of 112, who are all Project X users, for the scorings in Analytical Hierarchy Process (AHP), Concept Scoring, and Usability Test. Online platforms such as Zoom Meetings, Google Meet, and Google Forms were utilized to conduct surveys, one-on-one interviews, and focused-group discussions. The researchers ensured that all participants' consent was asked regarding their willingness to participate in the study and recorded each session. Ethical considerations such as their right to refuse to participate without penalty were also explained. Furthermore, all data gathered was kept confidential and used solely for research purposes in reference to the Data Privacy Act of 2012. No activities in any part of the study could harm the participants.

For the Analytical Hierarchy Process, the researchers interviewed respondents from the previous 112 in the empathize stage to compare and rate the criteria based on their importance, using Table 1 as their reference for scoring. After the prototype was built, the researchers randomly selected 40 participants from the previous survey respondents to test the prototype. The Usability Test Questionnaire was answered by the participants and scored accordingly. The researchers classified the respondents into two categories in this questionnaire: those who agree and those who disagree.

5. Results and Discussion

5.1 Graphical Results

Analytical Hierarchy Process

Multi-Criteria Decision Making, specifically Analytical Hierarchy Process (AHP), was used to determine the criteria' priority weights, which will be used later in the Concept Scoring. AHP is a technique developed by Saaty (1980) used to analyze decisions by ranking and providing weights from a given set of attributes using an intensity scale from 1 to 9, with higher intensity means higher performance.

Table 1. Intensity Scale for Criteria of Pairwise Comparison

Relative Intensity	Importance	Description
1	Equal	Both criteria are equally important
3	Moderately	One criterion is moderately important than the other
5	Strong	One criterion is strongly more important than the other
7	Very Strong	One criterion is very strongly more important than the other
9	Extreme	One criterion is extremely more important than the other
2, 4, 6, 8	Intermediate Values	Compromise is needed

The criterion with the most weight is Cost Efficiency, 38.94%, while the criterion with the least weight is the Ease of Use, which has 7.44%. For the solutions, RFID received the highest rating with respect to Accessibility, Ease of Use, and Cost Efficiency. At the same time, both RFID and Kiosks have the highest rating in terms of Availability of Resources. Using this result, the researchers were able to identify the overall rating of the three solutions, as shown in Table 2. In addition, the block diagram of the AHP Model is also provided in Figure 2. Looking at the overall rating, it is apparent that the rating for RFID and Kiosk is the highest. The researchers conducted another decision-making process called Concept Screening and Concept Scoring to verify the accuracy of the ratings.

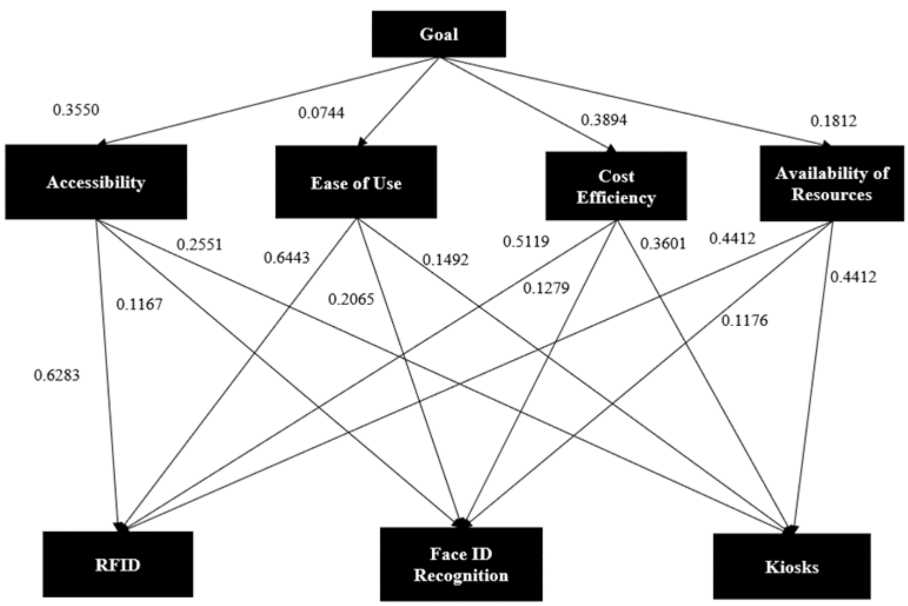

Figure 2. Block Diagram of the AHP Model

The table 2 shows the summary of the AHP model with each criterion weight and the overall scores in a tabular form.

Table 2. Tabular Summary of the AHP Model

	Accessibility	Ease of Use	Cost Efficiency	Availability of Resources	Overall
Criteria Weights	***0.355***	***0.074***	***0.389***	***0.181***	
RFID	0.628	0.644	0.512	0.441	**0.550**
Face ID Recognition	0.117	0.206	0.128	0.118	**0.128**
Kiosks	0.255	0.149	0.360	0.441	**0.322**

Concept Screening
The researchers used the Pugh Concept Selection (Pugh, 1980) as a concept screening method to select the best solution between the two previously discussed solutions. The solutions are rated according to the four criteria with the Current Project X as the reference. Concepts or solutions that meet the criteria are marked as + with a value of positive 1, not meeting the criteria are marked as - with a value of negative 1, and the reference criteria are all marked as 0. These values are then summed to determine the rank of the solutions and whether they will proceed to the Concept Scoring or not. In this case, according to the concept screening results, the Current Project X and RFID will be continued, as shown in Table 3.

Table 3. Concept Screening

Concept Screening		
	Reference	Concepts
Selection Criteria	Current Project X	RFID
Cost efficiency	0	-
Accessibility	0	+
Ease of use	0	+
Availability of Resources	0	+
Sum +'s	0	3
Sum 0's	4	0
Sum -'s	0	1
Net Score	0	2
Rank	2	1
Continue?	Yes	Yes

With RFID as the alternative solution to Project X based on the Concept Screening, the researchers have developed three different models: card, keychain, and bracelet. These three models are subjected to Concept Scoring and will be further elaborated on and discussed in detail in 5.2.

Concept Scoring
From the result of the concept screening, the researchers then used the relative performance in Table 4 as a reference to rate the Current Project X and RFID. These ratings are multiplied by their corresponding weights, which the researchers computed using the Analytical Hierarchy Process (AHP) priority weights in the previous step.

Table 4. Relative Performance Rating

Relative Performance	Rating
Very Unsatisfied	1
Unsatisfied	2
Neutral	3
Satisfied	4
Very Satisfied	5

In the following table, Concept Scoring for RFID Designs shows that the RFID Keychain is the concept that should be developed with an average score of 4.64. The researchers generated this score by conducting a one-on-one interview with the previous respondents and asking them to score the Current Project X and the RFID Designs concerning the four criteria given. Then, the researchers computed the mean of all the scores to summarize the respondents' scores. With these taken into consideration, RFID is the best solution among the three proposed solutions, with RFID Keychain being the best design.

Table 5. Concept Scoring

Concept Scoring (RFID Designs)									
		Reference		Concepts					
Selection Criteria	Weight	Current Project X	Weighted Score	A RFID Card	Weighted Score	B RFID Keychain	Weighted Score	C RFID Bracelet	Weighted Score
Cost efficiency	35.50%	4.38	1.56	4.38	1.56	4.62	1.64	3.62	1.28
Accessibility	7.44%	3.69	0.27	4.15	0.31	4.38	0.33	3.77	0.28
Ease of use	38.94%	3.31	1.29	4.54	1.77	4.77	1.86	4.46	1.74
Availability of Resources	18.12%	4.15	0.75	4.62	0.84	4.54	0.82	4.15	0.75
Total Score		3.87		4.47		**4.64**		4.05	
Rank		4		2		1		3	
Continue?		No		No		Yes		No	

5.2 Proposed Improvements

Based on the personas created by Chan et al. (2021), the researchers have come up with three solutions to address the users' pain points: RFID, Face ID Recognition, and Kiosk. The RFID technology integrated into a device for digital contact tracing can provide a real-time system for probably exposed people. Another solution is Face ID Recognition, where people could have a lower risk of getting exposed because of its contactless system. Lastly, putting up a kiosk outside the establishment just beside the entrance where people could have the QR codes scanned and sign up for the HDF through hand gestures which a sensor could detect on the kiosk.

The AHP and Concept Screening resulted in RFID being the preferred design out of the three. The researchers have developed three alternative RFID models for the respondents to choose from: cards, bracelets, and keychains. The designs were presented to the previous respondents through one-on-one interviews with a sample size of 20.

The first design takes the form of a card. The form factor cue is taken from a conventional transportation card and an identification card used for payments, and the ID is used in timing in work and school. The card form specializes in the form factor of a typical identification card, and the resources used are Polyvinyl Chloride (PVC) Plastic and an RFID Chip. It is beneficial for people who prefer to put valuables in their wallets or use them as a typical ID hanging through lanyards for easy access. This design is inclusive because of its tap system, braille feature, web address, and hotline provided.

The second design is an RFID bracelet. It is classified as wearable technology. The resources used for this design are rubber and an RFID chip. It is beneficial for people who do not want to draw out the RFID device and those who do not usually wear watches and would prefer to use this as a substitute. This design is said to be inclusive because of its tap system, handiness, wearable, web address provided, and braille feature.

The final design is the RFID keychain which consists of plastic and an RFID Chip, a portable design that can be attached easily. It is suitable for forgetful people because it can be attached to an object they would most likely not forget. This design is also ideal for pediatrics and geriatrics because it would serve as an accessory always attached to them. Considering inclusivity, Braille is embossed on the design to allow visually impaired people to know the device, the hotline of the Valenzuela City, and the website of the Project X printed on the keychain. Additionally, this device is a tap system that is handy and detachable to objects.

With the RFID keychain being the preferred design in the Concept Scoring, the researchers provided the digital prototype of the keychain and the physical prototype of the proposed Project X system, as shown in Figures 3 and 4.

Figure 3. RFID Keychain Digital Prototype

Figure 4. Physical Prototype of proposed Project X System

The following table 6 shows the components of the physical prototype of the proposed Project X System that the proponents utilized. It shows the materials needed as well as the specifications. Additionally, the researchers will not be restricted to these materials once improvements and modifications are made.

Table 6. RFID Keychain Prototype Materials and Specifications

Figure	Material	Specifications
	RC522 RFID Module	Supports MiFARE Mini, 1K, 4K, Ultralight, DESFire EV1, and PLUS RF protocol
	RFID Keychain And Card	13.56MHz smart keychain standard
	Straight And Right-Angle Headers	Male Headers
	Jumper Wires	Male to Male Dupont Wire Female to Male Dupont Wire
	Mini Solderless Breadboard	Dimensions: 47 x 35 x 10mm 170 tie points
	Temperature Scanner	Accuracy: ± 0.2 Degress Response time: 0.5s Abnormal Automatic Alarm: Flashing + Voice
	Arduino UNO R3	Dimensions: 68.6 x 53.4mm Power supply: USB conection / battery / AC to DC adapter Operating voltage: 5V Recommended input voltage: 7V to 12V LED: In built
	5V Passive Buzzer	Max Rated Current: ≤ 32mA Min. Sound Output at 10cm: 85dB
	LCD Module	Alphanumeric LCD Module 16x2 (Two rows that can print 16 characters)
	LED Light	Dimension: 5mm Uniform light output Low power consumption

5.3 Validation

From the results of the Process part, 98% of respondents agreed that there are no delays in detecting RFID Keychain, 100% agreed that they are no delays in detecting their temperature, 100% find the process easy and fast, and 98% see the symbols helpful in navigating the scanner, and 100% can clearly read the text on display. In the RFID keychain's design, 100% found the RFID keychain easy to use, 100% found the device more convenient when entering premises, 95% found the device durable, and 100% found it handy and easy to carry. Overall, 98% of the respondents are satisfied with the simplicity and ease of the process. 100% also find the device user-friendly, 100% feel that the process should be implemented in all establishments, and 95% think PWDs can use the system.

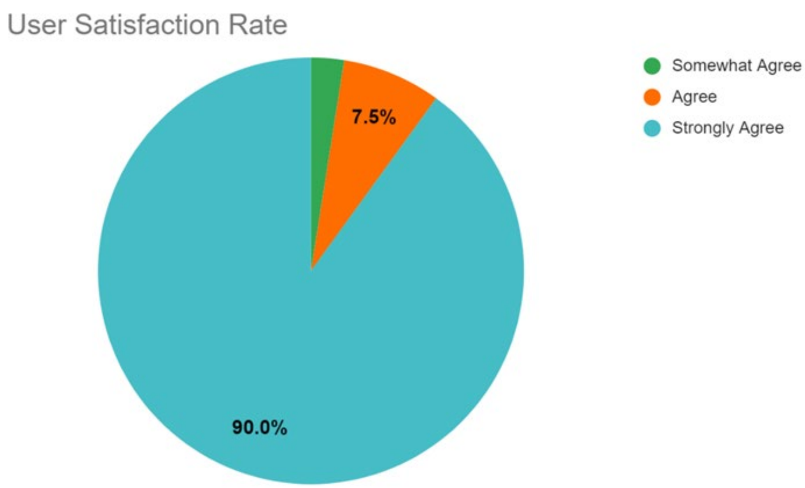

Figure 5. User Satisfaction Rate Chart

From Figure 5 above, although the users have different perspectives on the proposed system, they all agree that they are satisfied with the system. From the gathered responses from the 40 users, we can conclude that the prototype is successful in aiding a better contact tracing process. It also reduces the processing time it takes the users to declare information regarding tracing.

6. Conclusion

In the second phase of the study (Product-focus), the researchers came up with three designs for a more efficient digital contact tracing system that encompasses the users' pain points: RFID, Face ID, and Kiosk. In determining the optimal solution among the three, four criteria were considered: Cost-Efficiency, Accessibility, Ease of Use, and Availability of Resources. Subjected to their respective priority weights, Multi-Criteria Decision Making, specifically Analytical Hierarchy Process, was performed wherein RFID is the most preferred design. Concept Screening and Scoring were then executed to verify the results of the AHP with RFID as the proposed concept and Current Project X as the reference. The researchers designed three RFID models: card, keychain, and bracelet, with the keychain being the preferred design. Through Arduino UNO, the researchers devised a prototype for the users to test. The Usability Questionnaire shows that 100% of the 40 users are satisfied with the overall proposed Project X. These 40 users were able to suggest improvements and feedback on the prototype, such as the casing must be improved along with the connection of wires and how the devices were attached. There were also suggested improvements regarding the material used, such as the tape and the placement of the widgets in the casing. It was also recommended that the proposed system would not only be implemented in Valenzuela but also in other parts of the Philippines. With the inclusive designs taken into consideration, the Braille feature would require a braille printer device which will be used for mass production. Given this information, the project's proponents shall integrate the Braille feature when the system is implemented.

This study covered the objectives stated, such as proposing alternative solutions to the current Valenzuela's digital contact tracing system, devising a working prototype, testing this prototype with real users of current Project X, and suggesting improvements for further study.

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Biographies

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