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Geographical information system for garbage collection in sanggau city and shortest path using dijkstra's algorithm

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ABSTRACT

When trying to find the closest facility, citizens frequently encounter difficulties due to the dispersion of waste collection facilities at different areas. Therefore, it is essential to offer a tool that can help the general public locate the nearest rubbish collection site. The goal of this study is to create a geographic information system for garbage collection locations and to use the Dijkstra algorithm to find the fastest route to the closest facility in the city of Sanggau. For locals to have simple access to information, this system will employ freely available resources like the Google Maps API. The system development process will make use of prototyping. According to the results, Sanggau city residents can use a geographic information system to find garbage collection locations and to speed up their search for the quickest way to the closest facility.

Keyword: Geographic information system; garbage collection; sanggau city; shortest path; dijkstra's algorithm

1. INTRODUCTION

The Sanggau urban area and its buffer zone, which is made up of six sub-districts, namely Tanjung Kapuas, Tanjung Seikayam, Ilir Kota, Beiringin, Bunut, and one village, namely Sungai Mawang, are located in the Kapuas sub-district, which is where the city of Sanggau is located. The entire urban population of Sanggau is predicted to be around 45,338 according to data from the Kapuas District Central Statistics Agency (BPS) for 2020. According to data on Sanggau's urban population from 2014 to 2019, there was an annual rise [1].

A number of motivating causes as well as population expansion in metropolitan regions occurred, causing an explosion in that growth [2]. For those in charge of delivering infrastructure, amenities, and urban public services, such as trash management, which are falling behind in keeping up with the rate of population development, this phenomena poses issues [3].

Improved environmental and societal health is the goal of waste management in metropolitan settings [4]. Preventing polluting of water and other natural resources from waste. protecting the growth of other sectors from the risk of causing environmental harm and encouraging the development of other critical industries like tourism and the revitalization of slums, among others [5][6].

Waste is an ongoing issue, particularly in large cities [7]. This is taking place not just in Indonesia but everywhere in the world. The issue of trash has grown to be a significant one. Developed nations have made several efforts to address this issue, and local governments are also looking for ways to address the issue of processing waste [8].

The community still has a practice of leaving trash by the side of the road and close to their homes. This occurs as a result of the city's trash disposal system not being fully optimized in the garbage disposal facilities. In addition, maps indicating the location of the Seimeintara Shelter (TPS) are not readily available [9][10]. The cleaning staff is required to gather trash gathered at the TPS and transport it to the Final Disposal Site (TPA) [11][12].

The goal of this study is to create a Geographic Information System (GIS) for Temporary Shelter Places (TPS) in Sanggau City that can inform the general public and the Sanggau Regency Environmental Service about the locations of these TPS and determine the shortest route to them. The author hopes to create a system that will provide geographic data on the Seimeintara Shelter in Sanggau City.

2. LITERATURE REVIEW

There will be a connection between the writing of this research and a number of prior investigations, including the one described above. The concerned studies are listed below.

Dijkstra's algorithm application in AndroidThe objective of this research, which is based on mathematical learning games, is to create a kid-friendly instructional game [13]. To discover the quickest route to a destination in the game, Dijkstra's method is employed in this study as an artificial intelligence system [14]. 18 students from grades 5 elementary to 1 junior high school completed surveys as part of this research, which led to the creation of a maze game that utilized Dijkstra's algorithm. This game can be used in place of traditional classroom instruction.

This study, "Implementation of Location Based Security based on Android for Searching for Tourism Accommodation on the West Coast," was conducted in order to help travelers locate tourist lodging on the West Coast by implementing Location Based Security (LBS), which makes use of Global Positioning System (GPS) technology [15]. By implementing Location Based Security (LBS), which uses GPS technology, this study, "Implementation of Location Based Security based on Android for Searching for Tourism Accommodation on the West Coast," aims to assist tourists in finding tourist lodging on the West Coast.

The objective of this project is to create a web-based application that serves as a source of information for MSME reporting (Micro, Small and Medium Enterprises) utilizing a Geographic Information System in Pontianak City. By gathering data about MSME units, this program also helps to raise the caliber of their marketing. The outcomes of this study led to the creation of an MSME geographic information system in Pontianak that was created utilizing HTML, CSS, and Javascript technology for the display side and PHP programming for the back end [16]. The locations of MSME units in Pontianak are shown on this Weibo application. Similarities between the research that was studied and the literature review can be identified. They both describe the Geographic Information System, which is a shared characteristic.

3. METODE

The Dijkstra algorithm method is employed in this study to look for independent routes. Both directed and undirected graphs with non-negative weights can use this approach. Dijkstra's algorithm finds the best route to a graph's vertices based on how far away they are physically from the specified source [17]. Finding the independent path from the source to the first independent node, then to the second independent node, and so on, is the first step in the process. Here is an illustration of a Dijkstra's algorithm implementation case for finding the TPS's nearest path to the map, which can be shown in Figure 1.

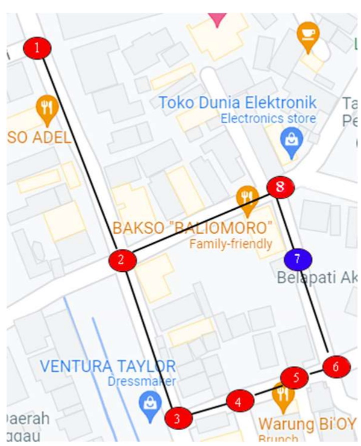

Figure 1. Map-based graph.

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The intersections or turns on the road that are related to one another on the map are considered auxiliary points. If it is weighted and turned into a graph, it will look like **Figure 2**.

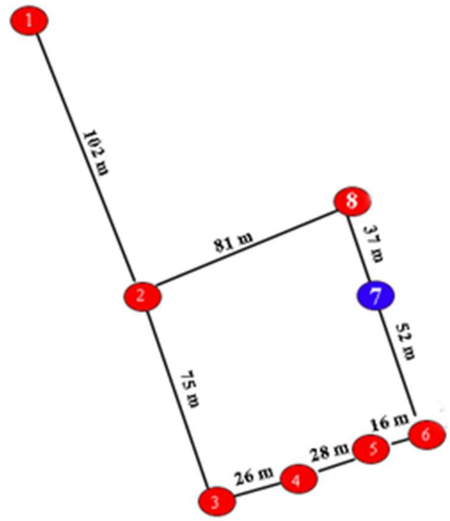

Figure 2. Graph with weights.

Using Dijkstra's algorithm, the following steps are taken to find the shortest route from node 1 to node 7.

a. Create a table with rows representing node positions and columns serving as places to record values or distances between nodes.
b. The first node's status is initialized with a weight of 0.
c. Determine the weights of the nodes that are directly connected to other node sources, such as from node 1 to node 2, which has a weight of 102 meters, whereas nodes 1, 2, 3, 4, 5, 6, 7, and 8 are initialized with "" since there is no path that is directly connected to node 1.
d. After testing all vertices, select the distance or value that is closest to all vertices.
e. Once all nodes have been checked and the destination node has been determined to have the best distance or index value, the chosen node will serve as the reference node for the following stage.

Table 1. Realization of the dijkstra algorithm.

V	1	2	3	4	5	6	7	8
1	Weight: 0 Knot: 1	102 1-2	∞	∞	∞	∞	∞	∞
2		102 1-2	177 1-2-3	∞	∞	∞	∞	183 1-2-8
3			177 1-2-3	205 1-2-3-4	∞	∞	∞	183 1-2-8
8				205 1-2-3-4	∞	∞	220 1-2-8-7	183 1-2-8
4				205 1-2-3-4	233 1-2-3-4-5	∞	220 1-2-8-7	
5					233 1-2-3-4-5	249 1-2-3-4-5-6	220 1-2-8-7	
6						249 1-2-3-4-5-6	220 1-2-8-7	
7							220 1-2-8-7	

Node 1 serves as the starting node and node 7 serves as the final node, or TPS, in Dijkstra's method, as shown in Table 1. The route that is chosen and has the most indexes when using Dijkstra's algorithm for the nearest TPS is 1-2-8-7.

3.1 Equipment and supplies

The following are some of the research resources and tools utilized in this study:

3.1.1 Hardware

The hardware used in this study is as follows:

a. A laptop with a Core i5 8th generation processor, 8 GB of RAM, a 250 GB solid state drive, and an NVIDIA GeForce GTX 1050 GPU for designing mobile and online applications for the TPS Sanggau application.
b. An Android smartphone running the designed mobile application with 4GB of RAM and the Lollipop version.

3.1.2 Software

The software used in this research is as follows:

a. Minimum system requirements for running the necessary software are included in Windows 10 as the operating system.
b. Android Studio as an IDE for building Android applications quickly because the IDE contains the Android SDK option and allows for testing on emulators.
c. Using Google Chrome as a web browser, testing the back-end design, and using https://graph.latcoding.com as a web application to help generate connected nodes and lines to aid in the search for dijkstra calculations.
d. Using Visual Studio Code as a code editor for creating back-end apps since it is simple to use and allows users to download effects that are helpful for creating applications.

3.2 Stages of research

By prototyping, a system model that can be swiftly expanded or improved upon is created [18]. When the client requires something but is unable to express specifics early in the project, this paradigm performs well. The customer is shown a scale model of the work system that has been balanced. Depending on the comments received, this initial system is occasionally discarded and other times it is expanded. Figure 1 shows the prototype process in phases.

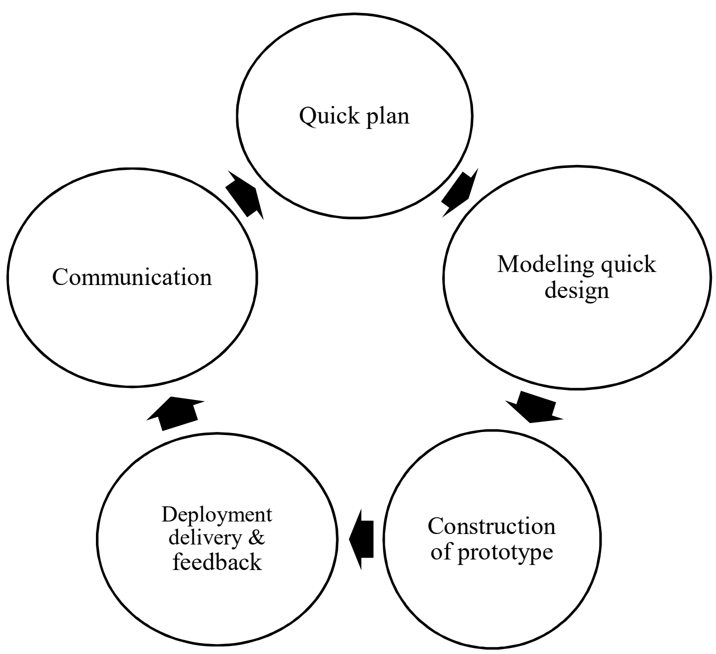

Figure 3. Prototyping stage.

The steps of the prototyping system balance model are shown in Figure 3 and include the following: communication, quick plan, modeling quick design, construction of prototype, deployment, delivery, and feedback [19]. The stages of prototyping are described in the paragraphs that follow.

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3.2.1 Communications

At this stage, it's important to speak with users or stakeholders to better grasp the objectives.

3.2.2 Quick plans

Planning is the next step, which entails outlining the estimated activities to be completed, any potential risks, the resources required, work scheduling, the goods to be generated, and monitoring the status of system work.

3.2.3 Modeling quick design

The design and modeling of the system architecture, including the design of database structures, user interfaces, and program algorithms to be employed, is the primary focus of this phase.

3.2.4 Database structure design

By documenting the data related to the database, an ERD explains the model that was used to create the database. Typically, after the ERD design is finished, the database physical design comes next. In other words, keep performance in mind when creating tables and indexes. Figure 4 illustrates the ERD Geographic Information System for Temporary Shelters in Sanggau City and the search for the shortest route using Dijkstra's algorithm.

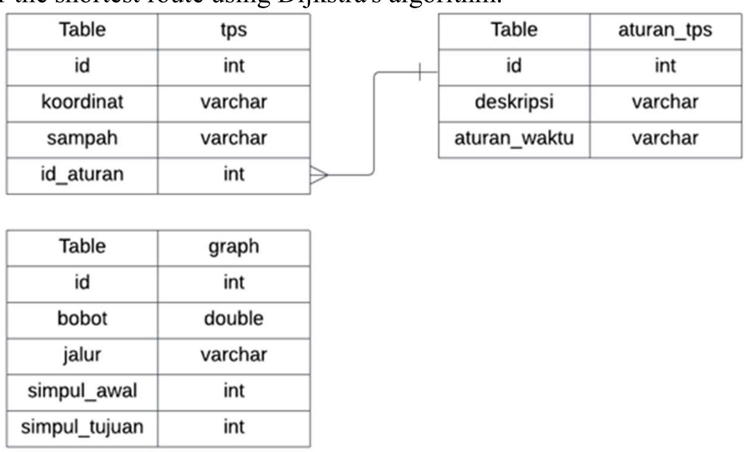


Figure 4. Entity relationship diagram.

The designed system's ERD is shown in Figure 4, where the TPS table maintains information about coordinate locations in the form of latitude and longitude and is linked to the TPS rule table, which holds information about TPS disposal rules. To store path information or related nodes' weights on a meter scale in the graph table.

3.2.5 Interface design

The Splash Screen and the Main Page of the proposed application provide the fundamental framework for presenting application pages that will be balanced.

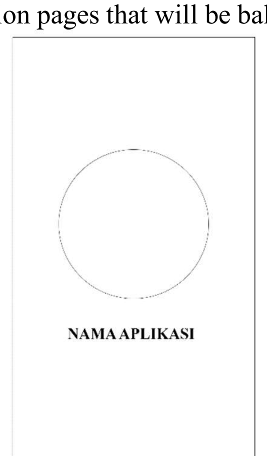


Figure 5. The splash screen page.

Figure 5 shows the application's splash screen, or the first screen that appears once the user launches it.

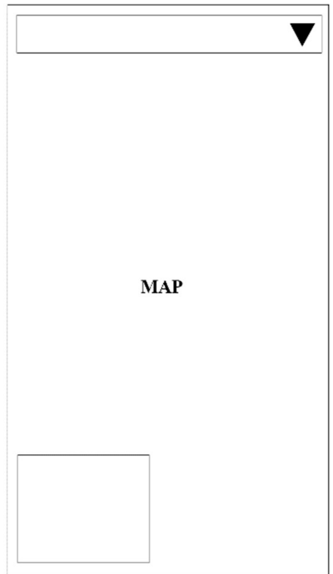


Figure 6. Main page.

After the splash screen page has been shown, the main page is shown in **Figure 6**. The user can select the TPS they want to visit on this page.

3.2.6 Construction of prototype

The system coding process comes next. The system is tested once the code is finished.

3.2.7 Deployment delivery dan feedback

The delivery of the system to users or stakeholders and the provision of feedback or commentary on the proposed system constitute the last stage.

4. RESULTS AND DISCUSSION

4.1 Testing the program

The goal of this program's testing is to evaluate the applications created for this study. Figure 7 details the test results.

Figure 7. Splash Screen.

The application's splash screen, or first display, is seen in **Figure 7**. Following that, the user will be taken to the home page, where they can select the display TPS as illustrated in Figure 8.

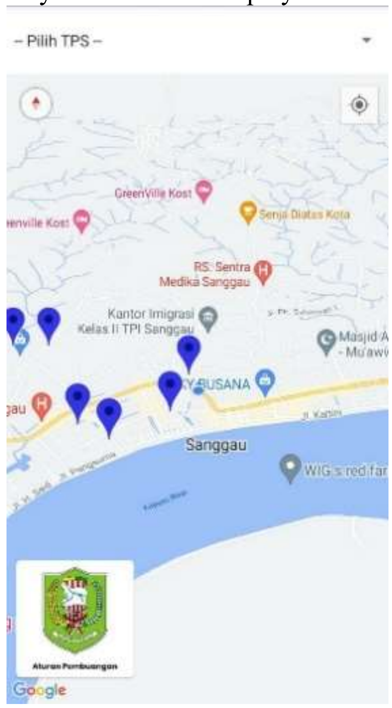


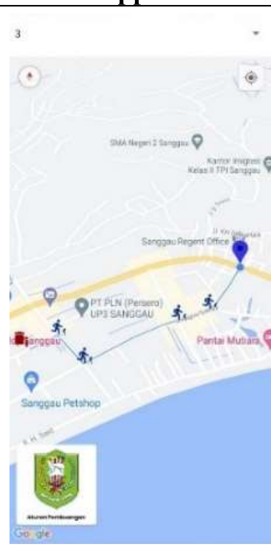
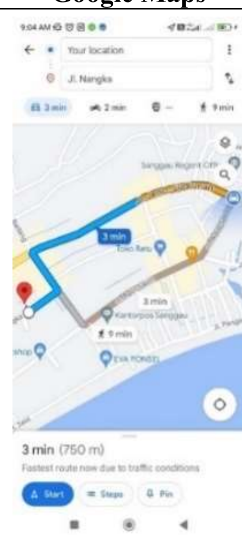
Figure 8. Main page.

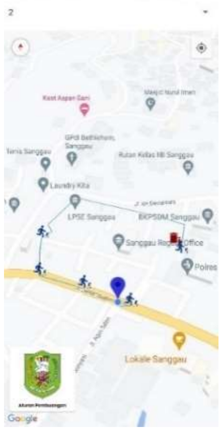
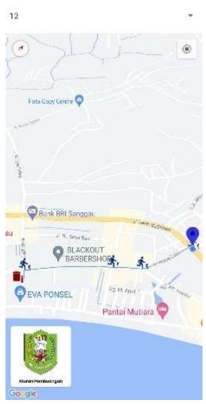
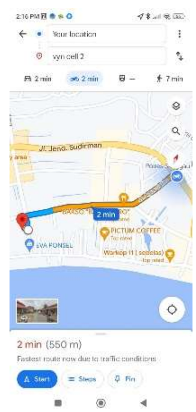
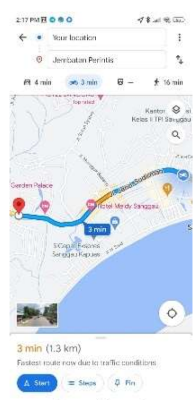
The home page is shown in **Figure 8**. The user can select the TPS they wish to visit on the home page, and it will then present the results of its search for the best route from that TPS so they can view the guidelines for garbage disposal.

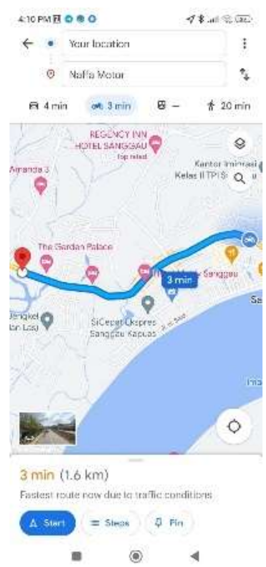
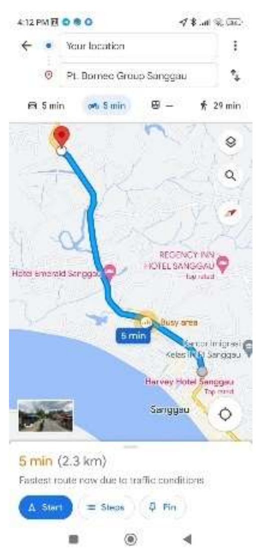
4.2 Validation of results

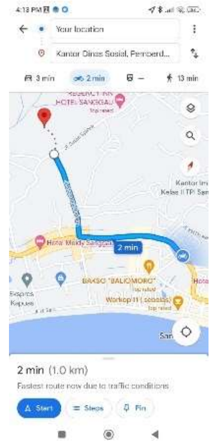
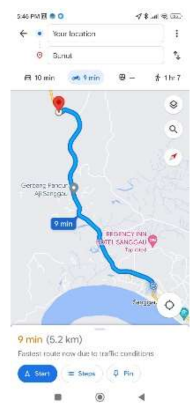
The goal of this test's results is to validate the application's design, confirm that it complies with the balance objectives, and determine whether it can adequately serve the demands of the research's users. **Table 2** compares the selected paths from Google Maps to the outcomes of the randomized path validation for temporary shelters (TPS) using Dijkstra's algorithm.

Table 2. Comparison test.

No.	TPS application	Google Maps	Test result
1.			The distinction is that although the developed application cannot read the traffic or traffic bottlenecks that are currently occurring, Google Maps can.

No.	TPS application	Google Maps	Test result
2.			Get the same shortest path results from 2 comparisons.
3.			The same shortest path is obtained from 2 comparisons.
4.			The identical shortest path outcomes from 2 comparisons.
5.			Get the same shortest path results from 2 comparisons

No.	TPS application	Google Maps	Test result
6.			Get the same shortest path results from 2 comparisons.
7.			The same shortest path is obtained from 2 comparisons.
8.			The identical shortest path outcomes from 2 comparisons.

No.	**TPS application**	**Google Maps**	**Test result**
9.			Get the same shortest path outcomes from 2 comparisons.
10.			Get the same shortest path results from 2 comparisons.

There are discrepancies in applications that are built to be unable to read the current traffic jams, as seen in Table 2's comparison of applications created with Google Maps. In ten trials, compatibility with the Google Maps app was achieved nine times, with only one inconsistency. The designed application can be said to be 90% compatible and 10% incompatible with Google Maps.

4.3 Black box testing

To determine whether functionality is appropriate, the Black Box approach is tested. Table 3 lists the outcomes of the tests used in this study.

Table 3. Pengujian *black box*.

No	Tested function	Test Scenario	Tested results	Status
1.	Get User Location	Utilize the Android smartphone's internet and GPS to determine the user's position	Displays the user's position marker	Valid
2.	Get TPS Locations	On an Android smartphone, turn on the internet and GPS to obtain the TPS position	Displays the TPS position marker	Valid
3.	Displays TPS Shortest Path	By choosing the TPS you want to go to, you can get the shortest route	Displays the shortest path	Valid
4.	Displays TPS Disposal Rules	By clicking the Disposal Rules button, the guidelines for TPS disposal are displayed	Displays TPS disposal rules	Valid

The Black Box tests that have been run, all of which function as intended and are error-free, are described in **Table** 3.

4.4 User acceptance test

In this study, the User Acceptance Test (UAT) was utilized to gauge how well the built-in system was received by users. composing responses to questions with a Likert scale. The summenteid rating scale is another name for the Likert scale. A person or group's attitudes, views, and perceptions toward phenomena or social phenomena are gauged using this scale. Table 4 provides the answer scale and weights for this study questionnaire.

Table 4. Questionnaire answers and weights.

No.	Answer	Answer
1.	SB (Very Good)	5
2.	B (Good)	4
3.	CB (Good Enough)	3
3.	KB (Not Good)	2
4.	TB (Not Good)	1

The following formula can be used to calculate the Likert Scale:

$$P = \frac{f}{n} x\ 100\% \quad (1)$$

Information:

P = Percentage

f = Number of Response Frequency

n = The total number of Alternatives in Answers as a Sample

100% = Fixed number of presentations

The following are the findings and analysis of the questionnaire given to various citizens of Sanggau City after they used the application that was built in **Table 5**.

Table 5. Data for answers to the UAD community questionnaire

No	Question	Frequency		Answer		
		SB	B	CB	KB	TB
1.	Can you install the application on your device?	4	5	1	-	-
2.	Is it intriguing that the TPS geographic information system application has now appeared in Sanggau?	-	10	-	-	-
3.	Is it simple to grasp the TPS geographic information system application in Sanggau City?	2	6	2	-	-
4.	Is the TPS geographic information system being used in Sanggau City in accordance with what the community needs?	3	3	4	-	-
5.	Does the city of Sanggau's TPS geographic information system application benefit the locals there and the Sanggau district environmental service?	2	8	-	-	-
6.	Are the outcomes of the TPS geographic information system application's search for the shortest path in Sanggau adequate and accurate?	3	5	2	-	-
7	Is Sanggau's TPS geographic information system application	1	7	2	-	-

No	Question	Frequency SB	B	Answer CB	KB	TB
	up to the task of locating the most precise routes?					
8	Will you too make use of this application?	1	7	2	-	-
	Total	16	51	13	0	0

The results of the community questionnaire were then examined by computing the average response based on the respondent's response score. It is possible to calculate it using the provided score.

- Total score of SB answers = 16 x 5 = 80
- Total score for answer B = 51 x 4 = 204
- Total score of CB answers = 13 x 3 = 39
- Total score of KB answers = 0 x 2 = 0
- Total TB response score = 0 x 1 = 0

Total number = 323

The highest and most lovely values can then be determined from the responses of the 10 respondents.

- Highest score = 10 x 8 x 5 = 400 (if the respondent answers SS).
- Lowest score = 10 x 8 x 1 = 80 (if the respondent answers SS).

Based on the calculations, the highest value, which is 400, is the percentage.

$$P = \frac{323}{400}\ x\ 100\% = 80{,}75\% \quad (2)$$

Based on the results, it can be concluded that, with a percentage of 80.75%, the community has responded well to the system that has been developed.

5. CONCLUSION

Based on the outcomes of the system's design and implementation, it generates mobile or android-based applications concerning geographic information and the use of Dijkstra's algorithm to find equivalent paths so that garbage can be disposed of in its spot. After a comparison test was conducted with Google Maps, there was a discrepancy where the designed application could not read traffic flow or road congestion, and the UAT test obtained an acceptance preference level of 80.75% for the designed application, meaning that it is good and practicable to use and the designed application has accuracy of 90% conformity and 10% discrepancy with Google Maps.

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