Redesign of wudhu facility for disabilities using integrated kansei method

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Abstract. The research is a wudhu place that is friendly to people with disabilities, especially wheelchair users. The purpose of this study is to find out and develop a design using integrated TRIZ, Kansei and anthropometry method. The first assessment wudhu facility using RULA method. The score of RULA is 5 which means changes required soon. TRIZ and Kansei method to defined solution the redesign wudhu facilities and anthropometry to define the dimension of design. The scope of research only redesigns, implementation not yet.

1. Introduction
Persons with disabilities have the same rights as others, but in reality, persons with disabilities based on research [1] bear the stigma of imperfection, making marginalized persons from social acceptance marginalized, and very far from fair, which is still there is a lot of discrimination related to the fulfillment of rights, education, public facilities such as transportation, places of worship, entertainment venues and the same position in public.

The design of the place of ablution is important for persons with disabilities because design errors can be fatal and the risk that can be caused increases as an accident when taking ablution water. Especially for persons with disabilities such as wheelchair users, improper design of ablution places such as height measurements that are unsuitable taps, then other supporting facilities such as putting feet and the distance that is too far between the floors used and the limiting floor can cause difficulties and potentially increase the danger and accidents for them, such as difficulties in accessing the ablution place due to limited space, then the difficulty in reaching the tap, the position of bowing during ablution water, the physical limitations that are the obstacles and fatal is falling from a wheelchair.

Based on these problems, it is certainly very necessary to design a place of ablution that is friendly to a disability, so that in designing the ablution place it can be done using an ergonomic approach and using the smart city concept approach. It is hoped that the proposed design improvements will be able to improve design not only in terms of aesthetic appearance of places of worship but are expected to be able to improve disability’s friendly ability from places of worship, especially places for ablution. This research has only redesign proposal scope. This design implementation not yet.

2. Literature Review

2.1. RULA
Rapid Upper Limb Assessment (RULA) is a method developed in the field of ergonomics which a subjective observation that investigates and assesses the work position performed by the upper body but includes the lower body [2]. This method is used to take the value of work posture by taking posture
samples from one work cycle that is considered to have a dangerous risk to the health of the worker, then held an assessment or scoring. After obtaining the results of the assessment, we can find out the posture of the worker is in accordance with ergonomic principles or not, if not then it is necessary to take corrective steps.

2.2. Theory of inventive problem solving (TRIZ)
TRIZ is a method developed by Altshuller in 1946 to solve contradictory problems based on logic and data [3]. There are three main steps in TRIZ, i.e. understand the problem and determine the objectives, determine the problem and formulate contradictory engineering using 39 contradiction tables, and formulate solutions with 40 inventive principles [4].

One example of a successful TRIZ is applied to an industrial problem. TRIZ was successfully used in designing an Ergonomic Milling Machine Control Knob to reduce occupational injuries and trauma disorders [5].

2.3. Kansei
Schutte (2002) says Kansei engineering is one of method to development product which as methodology for translating psychology human process to a current product or new concept design product [6].

2.4. Anthropometry
Anthropometric data is used to identify the physical size or dimensions of the workspace, work equipment, and clothing so that people can do their jobs properly. Anthropometric data is also used to avoid mismatching dimensions or sizes between equipment and products used with the size of the user or user [7].

Anthropometry will be widely used as an ergonomic consideration in the process of product design and work systems that will require human interaction. Anthropometric data that have been obtained will be widely applied, there are [8]:
- Designing a work area
- Designing work equipment such as machinery, equipment, tools and so on
- Designing consumptive products such as clothing, chairs, tables, and so on.
- Designing a physical work environment.

2.5. Percentile
Percentile is a value that shows a certain percentage of people who have a size in percentage or below a percentage [9]. For example, the 95th percentile shows that 95% of people are in or below value and can use the product. To determine anthropometric data, the normal distribution is used which can be formulated based on the average and standard deviation of the data obtained, percentiles can be determined if the data are normally distributed.

3. Research Method

3.1. Subjects
The subjects in this study were 11 people with disabilities who use wheelchairs in aged 25 to 50 years. The location for observation is located in Darussalam Mosque, Griya Perwita Wisata, Besi, Sukoharjo, Kec. Ngaglik, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55581.

3.2. Method
The object of the research was to redesign the Darussalam mosque ablution facilities using the method of RULA, TRIZ, Kansei, and Anthropometry. This is intended so that persons with disabilities, especially wheelchair users can comfortably use ablution facilities without having to experience difficulties and of course to create safe facilities and reduce the risk of harm that exists. Based on the results of work postures analysis, contradictory problems in product re-design and inventive solutions are identified using TRIZ.
In its use, the Anthropometry method is used to adjust the shape of the place of ablution so that it is comfortably used by the user, while the use of the RULA method is used to keep the user's posture in a comfortable and safe.

4. Result and Discussion

4.1. RULA

The RULA method is used to investigate and assess work positions. The following is the RULA data operator that will be used as a measure of the proposed design of Wudhu place (Table 1).

| Respondent | Measured Angle |
|------------|----------------|
|            | Neck | Hips | Upper Arm | Elbow | Wrist |
| 1          | 119.76 | 220.32 | 333.37 | 229.09 | 228.03 |
| 2          | 55.82  | 447.94 | 115.72 | 662.55 | 440.18 |
| 3          | 99.48  | 229.86 | 335.7  | 84.6   | 118.4  |
| 4          | 338.93 | 331.02 | 52.2   | 52.2   | 214    |
| 5          | 88.47  | 443.38 | 44.81  | 75.52  | 38.23  |
| 6          | 118.56 | 444.71 | 47.89  | 15.06  | 15.01  |
| 7          | 223.27 | 339    | 40.33  | 82.75  | 32.82  |
| 8          | 337.17 | 663.67 | 44.97  | 33.59  | 37.57  |
| 9          | 22.18  | 330    | 22     | 54     | 62     |
| 10         | 119.98 | 33.2   | 30     | 37     | 32.96  |
| 11         | 222.57 | 447.56 | 21.82  | 71.69  | 10.83  |

It can be seen (Table 1) that the average value of Neck, hips, Upper Arm, Elbow, Wrist is 28.5; 46.4; 40.4; 44.5; 59.6; 30.5 degree it can be implied that the posture is not good state. Respondents demonstrate their position when they will perform wudhu, especially in the bending section, based on this, it can be seen clearly the angle produced from Wudhu. The data will be processed with Ergofellow.

It can be seen (Table 1) the score of the RULA angle is 5, it means investigation and changes are required soon, so the wudhu place must be applying change soon.

This can happen because when doing work, the operator's body position is not in an ideal and comfortable position. Deviation of body posture that occurs, among others, is found in the back, the arm averages occur between 20-40 degrees. In addition, respondents also did not feel comfortable in the legs because respondents were required to bend to reach the legs.

4.2. TRIZ and Kansei

Based on the results of RULA, it can be identified that the main problem is that existing ablution facilities are not comfortable to use. So that the re-design process is needed in accordance with the dimensions of the user. But if the ablution facilities are redesigned, then the design will become more complex. In this case, there are two contradictory parameters, i.e. Improving parameter: Productivity and Worsening parameter: Device complexity.

There are four alternative inventive solutions to the problem, i.e. equipotential (12), another dimension (17), intermediary (24) and mechanic substitution (28). In this case, the solution chosen is another dimension (17) using anthropometry.

The Kansei method is using users interview. The users are disability person who prays regularly in the location. The result of word Kansei method is flexible faucet. The faucet that can move on its own, elongate, and be shortened. Not only flexible faucet, but also water sensor that is useful for removing water when the user directs their body parts toward the faucet. This is useful to make it easier for persons with disabilities not to bend during ablution activities, especially on the legs so that users feel comfortable and avoid accidents when performing ablution activities.
The integrated TRIZ and Kansei are using inventive solutions from TRIZ and using Kansei words to support TRIZ result.

4.3. Anthropometry

Researcher using anthropometry disability data with age range 20 to 50 years old. Table 2 is the anthropometric data from the measurements of the operator's body dimensions that will be used as a measure of the proposed wudhu.

| No | TBD  | PPO  | JT   | TL   | PTI  | LI  |
|----|------|------|------|------|------|-----|
| 1  | 22.5 | 40.5 | 67.5 | 47.4 | 24.5 | 9   |
| 2  | 19.8 | 35.3 | 78.5 | 40.8 | 23.5 | 10.4|
| 3  | 23.4 | 40.5 | 79   | 47   | 24.6 | 9.4 |
| 4  | 27.8 | 45.6 | 74.5 | 45.5 | 23.2 | 9   |
| 5  | 22.1 | 37.6 | 87   | 46.1 | 22.3 | 9.7 |
| 6  | 22  | 29   | 75   | 44   | 25   | 11  |
| 7  | 22  | 50   | 73   | 41   | 22   | 12  |
| 8  | 31  | 37   | 76   | 45   | 27   | 11  |
| 9  | 29  | 37   | 58   | 38.5 | 24   | 12  |
| 10 | 16  | 37   | 57   | 41   | 22   | 9   |
| 11 | 18  | 42   | 97   | 45.5 | 26   | 10  |
| 12 | 22  | 43   | 83   | 41   | 23   | 11  |
| 13 | 20.3| 41.6 | 68.4 | 48.1 | 24.5 | 10.3|
| 14 | 18  | 38   | 67   | 46   | 24   | 11  |
| 15 | 23  | 37   | 72   | 45   | 23   | 10  |
| 16 | 25  | 32   | 93   | 51   | 23.5 | 11  |
| 17 | 21  | 44   | 71   | 45   | 23   | 10  |
| 18 | 24  | 45   | 69   | 45   | 24   | 6   |
| 19 | 19  | 41   | 70   | 43   | 26   | 13.5|
| 20 | 24  | 48   | 74   | 45.2 | 23   | 11  |
| 21 | 23  | 44   | 76   | 45.4 | 25   | 12  |
| 22 | 16  | 44.5 | 89.2 | 41   | 22   | 11  |
| 23 | 24  | 36   | 78   | 50   | 23.4 | 10.5|
| 24 | 21  | 34   | 74   | 48   | 25.5 | 11.5|
| 25 | 19  | 41   | 72   | 43   | 23.3 | 10  |
| 26 | 20  | 41   | 80   | 44   | 18   | 10  |
| 27 | 22  | 42   | 77.5 | 48.5 | 24.2 | 10.8|
| 28 | 23  | 46   | 79   | 48   | 25   | 11  |
| 29 | 18  | 33.5 | 67   | 45   | 22   | 10  |
| 30 | 21  | 40   | 67   | 40   | 23   | 9   |

The results of the measurement of the Anthropometry is Percentile, it can be calculated using the formula:

\[ P = \bar{X} \pm Z_x \cdot SB \]  \hspace{1cm} (1)

\( Z_x = \) Normal standard value, where (+) if \( P > 51 \), and (-) if \( P < 50 \)

SD = Standard Deviation

The selection of dimensions used is based on the design requirements for ablution sites. The dimensions used are as follows:

- Sitting shoulder height (TBD)
The choice of dimensions of TBD (Sitting Shoulder Height) is useful for the height of the tap so that in this dimension the percentile used is percentile 5. The reason for using the 5th percentile is for someone who has a low or small posture to be able to use the ablution tap comfortably. Then based on the percentile calculation the TBD value is 16.34 cm. This size is used as a high size tap that will be designed.

- Popliteal butt (PPO)
The choice of the PPO dimension (Popliteal Butt) is useful for determining the distance of the ablution place, so that in this dimension the percentile used is the 50th percentile. Then based on the percentile calculation, the PPO value is 40.1033 cm, this size is used as a high measure of the tap to be designed.

- Hand reach (JT)
The selection of the dimensions of JT (Hand Reach) is useful for determining the range of the user's hand with a tap, so that on this dimension the percentile used is percentile 5. The reason for using the 5th percentile is for someone who has a small posture to reach the tap comfortably and easily. Then based on the percentile calculation, the JT value is 60.55 cm. this size is used as the distance of the user's hand with the tap.

- Knee height
The selection of the dimensions of JT (Hand Reach) is useful for determining the range of the user's hand with a tap, so that on this dimension the percentile used is percentile 5. The reason for using the 5th percentile is for someone who has a large posture to make the tap comfortably. TL value is 49.7465 cm. this size is used to determine the distance of the tap movement.

- Foot length (PTI)
The selection of the dimensions of JT (Hand Reach) is useful for determining the range of the user's hand with a tap, so that on this dimension the percentile used is percentile 5. The reason for using the 5th percentile is for someone who has a large posture to make the tap comfortably. TL value is 49.7465 cm. this size is used to determine the distance of the tap movement.

- Foot width (LI)
The choice of LI dimension (Leg Width) is useful to determine the width of the footrest so that on this dimension the percentile used is the 95th percentile. The reason for using the 95th percentile is that someone who has a large posture can put his foot comfortably. 12.55 cm size is used to determine the width of the footrest.

4.4. Recommendation
The following is a recommended picture of the layout of the observation room based on TRIZ and Kansei method.

![Figure 1. Product isometric view](image)

The Product designed for disabled people using a wheelchair, with a moving tap so the user can wudhu without bent. Moving tap can move into four directions, Up, Bottom, Left and Right. It can be controlled with a blue box on the picture, it will give more capability to wudhu if the tap can move with
adjusting our movement. In the bottom there are some sensors that can turn on the tap, then the tap will release the water if foot area on the above. The hole in the last picture is another waterway that can get out beside tap. The user doesn’t need to wash his feet because it will automatically be washing.

5. Conclusion
The indicators needed to measure the form of ablution friendly ablution places with the smart city concept based on research are using human anthropometry, where dimensions are used namely sitting shoulder height (TBD), Popliteal Buttocks (PPO), Hand Reach (JT), Knee Height (TL), Foot Length (PTI) and Leg Width (LI). Each dimension has a purpose to determine the height of the tap at the top, to determine the distance of the foot to the place of ablution, then to determine the distance of the user's hand with the tap, then to determine the distance of the tap movement on the foot, then to determine footrest length and determine the width of the footrest. Then as a supporter of the redesign of the ablution place is done by taking the TRIZ method and the Kansei method by the voice of customer.

Results obtained based on the Anthropometry method in each dimension are sitting shoulder height (TBD), Popliteal Butt (PPO), Hand Reach (JT), Knee Height (TL), Footprint (PTI) and Leg Width (LI) are 16.34 cm, 40.1033 cm, 60.55 cm, 49.7465cm, 26.359 cm, and 12.55 cm respectively. Then, using the RULA (Rapid Upper Limb Assessment) method where the RULA method calculates the degree of slope of several parts of the user's body to be tested so that the researcher can find out what the RULA score obtained during the ablution process, whether or not a humped disability user is obtained. Immediate repairs need to be done, so that design changes will be made to places with special disabilities for wheelchair users, especially wheelchair users.

In designing the place of ablution proposal, the researcher uses the basis of Anthropometry and the standard size of the place of ablution in general which is obtained from the architect's data the size of the place of ablution. As for the innovations that we added based on user needs using the Kansei method, we found several innovations in the form of movable taps, self-moving taps, elongated taps, and long taps that can reduce size and water sensors that are useful for removing water when the user directs their body parts towards the water tap. The redesign is recommendation design that is useful to make it easier for persons with disabilities not to bend during ablution activities especially in the legs so that users feel comfortable and avoid accidents when performing wudhu activities.

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