ERGONOMIC REDESIGN OF ABLUTION AREA IN MOSQUE USING AN ANTHROPOMETRIC APPROACH AND DESIGN THINKING METHOD

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ABSTRACT

A mosque is required to have an ablution area, one of which is the Baitus Sholihin Mosque in Demak Regency. Muslims who use ablution facilities complain that the faucet is too low, especially for the elderly. So, it can cause fatigue in the waist and legs. This can be overcome by redesigning the ablution area using anthropometric approaches and design thinking methods. Anthropometric approaches are used to ergonomically design ablution area. Then the design thinking method is used to find out the needs of ablution place users with three stages. The first is Inspiration with the distribution of needs questionnaires. The second is the Idea of redesigning using normality tests, diversity tests, adequacy tests, and percentile calculations. Then the third is Implementation by redesigning the ablution area. So that it produces 8 dimensions, including the height of the faucet measuring 119 cm, the distance between the faucets 80 cm, the rack of goods (l = 25 cm, t = 158 cm), the width of the gutter 40 cm, the sewer divider (l = 9 cm, t = 21 cm), the iron grille (slope 30◦ with a net distance of 6 cm), the handrail (d = 5.3 cm, t = 129 cm), and the ceramic size of 25 cm x 25 cm. After that, a perception test was carried out with the Wilcoxon signed ranks test approach, resulting in increased comfort compared to the design of the previous ablution area.

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Keywords: ablution area, anthropometry, design thinking, ergonomic.

1. INTRODUCTION

Ergonomics is a branch of science that systematically uses information about human nature, abilities, and limitations to design work systems where people can live and work appropriately, that is, achieve desired goals effectively, and comfortably [1]. Ergonomics also studies all aspects of humans in the work environment, which are studied from engineering, anatomy, psychology, physiology, and management to design [2]. Ergonomics is done by assessing posture in workers, such as neck, back, arms, and legs. If worker facilities are not ergonomically designed, this can cause problems such as complaints and muscle injuries [3].

In designing a facility or product can use the basic principles of design ergonomics. Design ergonomics is designing by considering human factors as users with different individual limitations [4]. A mosque or musola is a public facility that has many users, especially Muslims. So in designing these facilities need to be considered. The mosque is one of the most important buildings for Muslims,

the main function of the mosque is as a place of worship for Muslims, and the additional function of the mosque is as a social means for educational activities, recitation, recitation, community meetings, celebration of Islamic holidays and other social activities [5].

The mosque in Rejosari Hamlet, Kedondong Village, Elephant District, Demak Regency only has 1 mosque, namely Baitus Sholihin Mosque. The location of this mosque is on the side of the highway. Therefore, many visitors such as people who are traveling long distances stop resting or performing prayers. The most important element in determining the level of comfort and security of a mosque or musola, is the place of ablution, which includes the dimensions of the ablution place, or the conditions of the ablution place itself [6]. In designing ablution places for bidet/standing models have certain standards [7]: PUPR; 14 / PRT / M (2017)).

The difference in the size of the ablution place at the Baitus Sholihin Mosque with the standard size is in Table 1. next.

Table 1. Wudu Place Comparison

Kind	Standard Size of Wudu Place [7]	Size of Baitus Sholihin Mosque Wudu Place
Tap Height	80cm-109cm	64 cm
Distance between Taps	80cm-100cm	75 cm

Based on the size of the ablution place of Baitus Sholihin Mosque in Table 1. the height of the faucet and the distance between the faucets do not meet the standards of ablution places [7]: PUPR; 14 / PRT / M (2017)).

Figure 1. Conditions of the ablution place when used

Figure 1. is the condition of the ablution place when used. Results from 12 pre-questionnaires that have been randomly distributed to users. From the condition of the ablution place, 70% of respondents complained that the faucet was too low, especially for the elderly. Causes the waist and legs to feel tired quickly, and it is considered ineffective.

In all aspects of physical dimensions in designing, it is necessary to consider one of the basic things that are by the user's product. By focusing on all aspects of user characteristics, it can improve comfort, satisfaction, work safety, and productivity levels [4]. One part that supports ergonomics, especially when designing devices based on ergonomic principles is anthropometry. Anthropometry is a subset of ergonomics that specializes in the dimensions of the human body, including linear dimensions, weight, content, but also size, strength, speed, and other aspects of body movement [8].

This anthropometric approach was used by Anisah *et al* [9] in designing ablution places to suit the needs of its users. The original ablution place has changed as recommended and needed by its users. Especially on the shelves of goods that are redesigned models and dimensions tailored for users. Fitra *et al.* [4] also redesigned the ablution place related to tap height and distance between faucets with a user anthropometric approach.

Wahyudin *et al.* [10] researched redesigning the layout of play facilities using an ergonomic approach. In the design process, the design thinking method is considered more effective because it has three stages: 1) *inspiration* 2) *ideation, and* 3) *implementation* which is used as the basic basis for ergonomic assessment considering human needs as soon as possible so that they can accommodate.

A fundamental way to measure or assess perceptions of ergonomic musola design needs can be to perform the *Wilcoxon* difference test. This test is to determine the average assessment by comparing perceptions related to the old design and the new design of the musola, so that we can find out more precisely the needs and desires of musola users [11].

Based on previous problems and research that have been carried out and problems faced by the people of Dukuh Rejosari regarding the design of ablution places that are not comfortable, it is necessary to improve or adjust the design of ablution places for the surrounding community. So the redesign of the ablution place at the Baitus Sholihin Mosque can be done using *the design thinking* method step based on an anthropometric approach. Then comparing the design of the old ablution place and the design of the new ablution place, from public perception, *a Wilcoxon* difference test was carried out to determine the level of perception of the old and new designs. This study aims to redesign an ergonomic ablution place so that people who use it feel comfortable, and reduce the risk of injury resulting from the design of the ablution place that does not meet ergonomic standards.

2. RESEARCH METHODOLOGY

This research was conducted in January – March 2023. Research is quantitative. Quantitative data is an empirical-based research approach (concrete data) that studies data in numerical form [12]. There are 2 types of primary data collection and secondary data. Primary data is data taken through direct observation in the form of questionnaire distribution, object size, and user anthropometric data. While secondary data in the form of previous research is used as a theoretical reference or discussion of research results. The target of this study is to redesign the ablution place with an anthropometric approach and *design thinking* methods.

Anthropometry is a science that studies the relationship between the structure and function of the human body, including size and shape, as well as the design of tools used by humans [13]. According to Bryan Lawson [14], Design is an approach between problems and solutions obtained through a process of analysis, synthesis, and evaluation. Lawson also mentions that design results are heavily influenced by the relationship between designers, clients, and users. The stages of *the design thing* method are as follows:

Inspiration

The initial step of this research is to understand the problems and needs that are by the location of the case study. such as observations, interviews, or questionnaires.

Idea

At the stage of getting a solution obtained from inspiration, then designed with the following stages:

1. Normality Test

   To determine the normality of data distribution can be done using the *Kolmogorov-Smirnov* test using IBM *SPSS* 26 software. First, the test hypothesis is [15]:

H_0: Normal distributed data
H_1: Data is not normally distributed
Sig. > α 0.05 normally distributed data.

2. Uniformity Test

This uniformity test aims to assess whether the data taken is uniform. If the data is within the control range, then the data is said to be homogeneous [15]. Upper control limit (BKA) and lower control limit (BKB). Below are the steps to perform a uniformity test [16]:

The first step is to calculate the average of each observation, equation (1):

$$\overline{X} = \frac{\Sigma x_i}{n} \quad (1)$$

Information:
$\overline{X}$ = average observation results
x_i = i-th measurement result data
n = number of observations

The second step calculates the standard deviation, equation (2):

$$\sigma = \frac{\sqrt{\Sigma(xi-\underline{x})^2}}{n-1} \quad (2)$$

Information:
σ = standard deviation
x_i = i-th measurement result data
n = number of observations

The third step determines the upper control limit (BKA) and lower control limit (BKB) which aims to limit the data that must be discarded with equations (3) and (4):

$$BKA = \overline{X} + k\sigma \quad (3)$$
$$BKB = \overline{X} - k\sigma \quad (4)$$

Information:
$\overline{X}$ = average observation results
σ = standard deviation
k = confidence index coefficient:
The confidence level of 0% - 68% is 1
The confidence level of 69% - 95% is 2
96% - 99% confidence level is 3

3. Sufficiency Test

Data adequacy tests are used to determine whether the data obtained is sufficient for processing. Before the data adequacy test was carried out, the degree of freedom s = 0.05 was determined which was the maximum deviation from the research results. In addition, a confidence level of 95%, k = 2 is determined to indicate the confidence of the meter in the accuracy of anthropometric data, which means that the average measured data can deviate by 5% from the actual average [15]. The data adequacy test formula is as follows:

$$N' = \left[\frac{{}^{k}/_{s}\sqrt{N\,\Sigma x_i - (\Sigma x_i)^2}}{\Sigma x_i}\right]^2 \quad (5)$$

Information:
k = confidence level
s= degree of accuracy
x_i = i-th data
N = amount of observational data
N′ = amount of theoretical data

4. Percentile Calculation.
Here are some commonly applied percentile values that can be seen in Table 2.

Table 2. Normal Distribution and Percentile Calculation [17]

Percentile	Account
1-st	$\bar{X} - 2{,}325\ \sigma x$
2.5-th	$\bar{X} - 1{,}96\ \sigma x$
5-th	$\bar{X} - 1{,}64\ \sigma x$
10-th	$\bar{X} - 1{,}28\ \sigma x$
50-th	$\bar{X}$
90-th	$\bar{X} + 1{,}28\ \sigma x$
95-th	$\bar{X} + 1{,}64\ \sigma x$
97-th	$\bar{X} + 1{,}96\ \sigma x$
99-th	$\bar{X} + 2{,}325\ \sigma x$

5. Wilcoxon Difference Test

This difference test can be done with the *Wilcoxon signed ranks test* approach using IMB *SPSS* 26 software. The difference in data values is intended to determine the acceptance or rejection of a hypothesis. In this *Wilcoxon* test, several rules apply to this test, namely accept Ho if sig > α(0.05) and reject Ho if sig < α(0.05) [18]. As for the steps to complete the *Wilcoxon* test [19]:

1) Research hypothesis
H0: μ1 = μ2: The comfort level of the old ablution place is not significantly different from the average comfort level of the anthropometrically designed ablution place.
H1: μ1 ≠ μ2: The comfort level of the old ablution place changed significantly from the design of the average ablution place equipped with an accessory rack.
2) Significant level α = 0.05
3) Conclusion:
Sig. ≥ α = H0 is rejected, which means that there is a significant average difference between the design of the old ablution place and the design of the ablution place.
Sig. ≤ α = H0 is accepted, which means that the design of the old ablution place and the average ablution place do not differ significantly.

Implementation

In the third stage of this research, the design results are presented to users who are expected to meet the needs of the community where the case study is located.

3. RESULTS AND DISCUSSION

Inspiration

At this stage, identify the needs of ablution site users and the author gets solutions or findings from the complaints of the ablution place user community at the Baitus Sholihin Mosque and observes directly the existing ablution place conditions. So that the needs and desires of users are found in Table 3. as follows:

Table 3. User Needs and Wants

No	Complaints	Needs and Wants
1.	The ablution faucet is too low	The height of the ablution faucet is appropriate and convenient
2.	The ablution place does not have a shelf of goods	The ablution place has a rack of goods
3.	The ablution place has no *handrail* or handle	Ablution places have *handrails* or handles
4.	The gutter is too narrow and shallow so that the water flowing from the foot comes out of the collate	Gutter width adjustment with gutter divider
5.	The distance between the taps is very close	Adjustment of distance between taps for convenience

Idea

In this research process, the right solution has been obtained, then continued by redesigning the ablution place. Here are the stages of the design process:

Normality Test

This normality test uses the *Kolmogorov-Smirnov one sample* type, this data processing uses the help of IBM 26 SPSS software. The following to find out the results of the normality test can be seen in Table 4.

Table 4. Data Normality Test Results

One-Sample Kolmogorov-Smirnov Test

		TTH	LB	TB	PSJ	DLG
N		30	30	30	30	30
Normal Parameters[a,b]	Mean	127.8333	43.9667	158.0000	42.7667	7.4000
	Std. Deviation	3.78822	2.85854	7.26826	2.16051	1.30252
Most Extreme Differences	Absolute	.139	.126	.133	.139	.154
	Positive	.139	.126	.133	.139	.154
	Negative	-.116	-.089	-.126	-.083	-.144
Test Statistics		.139	.126	.133	.139	.154
Asymp. Sig. (2-tailed)		.142[c]	.200[c,d]	.183[c]	.146[c]	.068[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.

Based on the results of table 4. Normality test with *Kolmogorov-Smirnov one sample* can be found that the signification value of each dimension is more than 0.05, then the data is declared accepted or normally distributed.

Data Uniformity Test

This data uniformity test is carried out to determine the homogeneity of the measurement data and the data can be within the control limits. Here are the results of the data uniformity test recapitulation.

Table 5. Data Uniformity Test Recap

Dimension	Σx_i	$\bar{X}$	σ	BKA	BKB	Information
TTH	3835	127,833	3,78822	135,409	120,257	Uniform
LB	1319	439667	2,85854	49,6838	38,2496	Uniform
TB	4740	158	7,26826	172,537	143,463	Uniform
PSJ	1283	42,7667	2,16051	47,0877	38,4457	Uniform
DLG	222	7,4	1,30252	10,005	4,79496	Uniform

Data Sufficiency Test

This study conducted a data adequacy test using a confidence level of 95% (k = 2) indicating confidence or confidence that the measurement results meet the requirements, and this 5% degree of accuracy (s = 0.05) shows the maximum deviation of the measurement from the actual completion time. The selection of confidence levels and degrees of accuracy allows the average measurement result to deviate 5% from the actual average and the chance of success in achieving that value is 95%. This adequacy test is to find out whether the data used is sufficient or not. If then the data is considered sufficient. The following is a recap of the adequacy test results in Table 6. $N' < N$

Table 6. Data Sufficiency Test Recap

Dimension	N	k/s	Σx_i	$\Sigma {x_i}^2$	$(\Sigma x_i)^2$	N'	Information
TTH	30	40	3835	490657	14707225	1,358243992	Enough
LB	30	40	1319	58229	1739761	6,53791	Enough
TB	30	40	4740	750452	22467600	3,27298	Enough
PSJ	30	40	1283	55005	1646089	3,947296	Enough
DLG	30	40	222	1692	49284	4,791819	Enough

Percentile Calculation

The calculation of this percentile is from respondents' anthropometric data expressed in the form of percentiles. This percentile calculation is used to design by grouping data based on the smallest to largest percentage. The selection of percentiles must be adjusted to the flexibility in designing. The equation used is listed in Table 7.

Table 7. Recap of Percentile Calculation Results

Dimension	$\bar{X}$	σ	Percentiles								
			1	2,5	5	10	50	90	95	97	99
TTH	127,833	3,7882	119	119	122	123	128	133	134	135	137

Dimension	$\bar{X}$	σ	Percentiles								
			1	**2,5**	**5**	**10**	**50**	**90**	**95**	**97**	**99**
LB	43,9667	2,85854	37,3	38,4	39,3	40,3	44	48	49	50	51
TB	158	7,26826	141,1	144	146	149	158	167,3	170	172	175
PSJ	42,7667	2,16051	38	39	39,2	40	43	46	46,3	47	48
DLG	7,4	1,30252	4,4	5	5,3	6	7,4	9	9,5	10	10,4

Implementation

After conducting some data testing and percentile calculations, the next step is to redesign the ergonomic ablution place. This design also pays attention to the benefits and comfort of ablution activities. There are 8 parts in the design of ablution places which can be seen in Table 8. as follows:

Table 8. Size Data of ablution place redesign

No	Ablution Place Section	Dimension	Anthropometry	Percentiles	Size (cm)
1.	Faucet	Tall	TTH	P_1	119
2.	Distance between taps	Wide	LB	P_{99} (+29)	80
3.	Goods rack	Tall	TB	P_{50}	158
		Wide	-	-	25
4.	Gutter	Wide	PSJ	P_{10}	40
5.	Gutter divider	Tall	-	-	21
		Wide	-	-	9
6.	Iron grille	Mesh distance – net	-	-	6
		slope	-	-	30
7.	Handrail	Diameter	DLG	P_5	5,3
		Tall	TTH	P_1(+10)	129
8.	Ceramics	Long	-	-	25
		Wide	-	-	25

For ergonomic ablution place sizes can be seen in Table 8. The proposed ablution place design is in Figure 2.

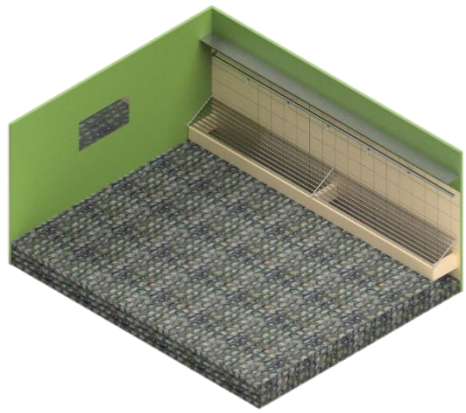

Figure 2. Redesign of Wudu Place

Testing Perception

This difference test uses the *Wilcoxon signed ranks test* approach to determine public perception regarding the design of the old ablution place with the proposed ablution place design. This perception assessment was obtained from the results of questionnaires from 30 respondents. The processing of the Wilcoxon difference test uses the help of IBM 26 SPSS software with variables of security, comfort, facilities, layout, and ease of access.

Table 8. Wilcoxon Difference Test Results

Test Statistics

	Safety of Use of New Wudu Place - Safety of Use of Old Wudu Place	Convenience of Using the New Wudu Place - Convenience of Using the Old Wudu Place	Facilities of New Wudu Place - Facilities of Old Wudu Place	New Wudu Place Layout - Old ablution place layout	Ease of Access to New Wudu Places - Ease of Access to Old Wudu Places
Z	-4,890[b]	-4.902[b]	-4.956[b]	-4.853[b]	-4,899[b]
Asymp. Sig. (2-tailed)	.000	.000	.000	.000	.000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Based on the results of the difference test with the *Wilcoxon approach, the signed ranks test* in Table 4.10 shows that all variables have *Asymp.sig values.* of 0.0000 which means *Asymp.* Sig. < α (0.05) was rejected, and the results showed that there was a significant average difference between the design of the old ablution place and the design of the ablution place.

4. CONCLUSION AND RECOMMENDATION

Conclusion

The result of the redesign of the ergonomic ablution place at the Baitus Sholihin Mosque using the Design Thingking method have different in size from the old ablution place design. The following measures of tap height (64 cm = 119 cm) have a difference of 55 cm, the distance between taps (75 cm = 80 cm) has a difference of 5 cm, and gutter width (21 cm = 40 cm) has a difference of 19 cm. The proposed ablution place design is also equipped with footrests, handrails, sewer divider freight

racks, footrests, and mirrors. Furthermore, the assessment of public perception of the design of the old ablution place was negative on each variable. While the design of the proposed ablution place in all variables is positive. The significant average difference between the design of the old ablution place and the design of the proposed ablution place increased comfort in the proposed design compared to the design of the old ablution place.

Suggestion

The research party can further refine the design that is found to be less good and can use other ways such as the selection of methods that can solve problems from different points of view to get more perfect results.

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