Redesigning Ablution Facilities in Malaysian Public Restrooms: A Hygienic and User-Friendly Approach

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Abstract. The current public restroom infrastructure in Malaysia often lacks dedicated ablution facilities, forcing Muslims to perform ablution at common sinks. These sinks are typically not designed to accommodate the ritual's requirements, resulting in water splashing that inconveniences user and creates slippery, dirty floors. This study aims to redesign ablution facilities in public restrooms to address these hygiene issues and enhance the safety and comfort of users. Using a human-centered approach, the study involves empathizing with users, defining parameters, ideating new designs, and analyze the flow of tap water to reduce splashing, which is the major concern for a hygienic ablution facility. A matrix evaluation process, which considers criteria such as user comfort, feasibility, and water splash reduction, is used to select the final design. The chosen design features two separate sinks: one for washing the face and hands, and another for washing the feet. This configuration minimizes water splashing and enhances hygiene with aims to fulfil $We < 2000$ and $Re < 1$. The placement of the faucet especially for the lower sink is important, which should be within 400mm – 600mm off the ground. The depth is suggested to be between 150-200 mm, width of 400-500 mm, length of 500-600mm with walls with a parabolic curve for smooth water flow. Drain Placement should be central with a slight slope towards the center. Ample space for foot washing will ensure efficient water drainage while minimizing water splashing in the ablution facility.

Keywords: Wudu, Human-centered design, Public toilet, Sinks, Water splash

1 Introduction

1.1 Background of Study

The Basic of Ablution or Wudu' Praying (or salah) and ablution (or Wudu') are considered as part of the daily activity that must be conducted wherever they are. World Muslim population in the world is estimated to be around 20-25% of total world population [1]. The religion of Islam is based on five pillars. One of the pillars is to pray five

times a day. Without ablution, the person is not allowed to perform the prayer [2]. Within the teachings of Islam, ablution is an act that involves both physical and spiritual, for body hygiene as well as to protect purity of the soul and spiritual than doing the wrongs [3]. The ritual purification with four compulsory acts consisting of washing the face and both arms including the tips of the fingers until elbows, wiping the head and washing both the feet including ankles with water and it is recorded in the Holy Book of Quran (5:6) [4]. The amount of water about half to 2 liters is enough to apply on the body [5], because certain hadith mentioned the Prophet Muhammad PBUH used to perform ablution with one mud of water (equal to 2/3 liter) [6]. Ablution ritual is compulsory for those who want to do praying activities. Without this ritual, prayers are not complete unless in an emergency with replacing ablution with tayammum ritual.

The design of ablution stations available in public toilets is often problematic, with issues such as poor ergonomics and water splashes. Users' clothes and the floor are often left wet after using standard ablution stations, which can cause discomfort to other users of the public toilet. In Malaysia, ablution sinks are rarely found in public toilets, with most of them only available in mosques. This absence poses a challenge for Muslims who are forced to perform ablution at available sinks in public toilets, which are not ergonomically designed for this purpose. This might cause discomfort to other users of the public toilet.

Ablution Facility Design Several studies have proposed novel designs for ergonomic ablution facility that ensure comfort, safety, and hygienic conditions for users, considering their anthropometric user preferences [7]. For instance, an innovative design development of an ergonomic ablution station for wheelchair users was explored to maximize accessibility with a focus on compact size and work surface adjustability [3, 8]. Since ablution is repeated many times daily, Zaied [9] studied water usage and time analysis for sustainability and to follow the sunnah of Prophet Muhammad PBUH who was using less than 1L of water for his ablution while Muslims nowadays use 2–10 L. Ghazali et al. [10] managed to reduce from 1 – 8L water when the designed water-taps consume an average of 1–3 L per ablution, whereas the standard water tap consumed approximately 3–9 L per ablution.

Ablution or wudu' is a ritual cleansing process that was mentioned in the holy Quran (5:6) to be carried out especially before performing salah. The basic compulsory procedure includes washing of hands, face, arms to elbow, and feet with water and gentle massage of head with wet hands. Water splashing problem occurs when the user washes his hands, face, and feet. A study discusses the issue of water splashing while performing wudu' explores the design considerations for ablution stations in mosques, particularly for elderly individuals, and highlights the importance of designing stations that minimize water splashing [11]. The study emphasizes the need for proper height and separation between the seating provision and the water faucet to reduce water splashing during wudu. Moreover, splashing at ablution area is important from the aspect of safety in mosques, particularly about slip-resistance and fall incidents [12].

Another study on ergonomic ablution facility addresses the issue of water splashing [13] and the importance of designing a proper drain. It proposed two designs for the ablution place: one with two steps, a wider platform, and seats constructed on the top

of the platform; and another with a single step, a bit narrow platform, and seats raised from the floor which were implemented and well-received in four mosques in Arar, Saudi Arabia.

Most studies such as shown in [2-13] are mostly for ablution areas within the mosques or musolla (prayer rooms/suraus) compounds. This poses a challenge for individuals who are working or studying and have limited time to go to the mosque to perform ablution. As a result, they are forced to perform ablution in the public restrooms of their respective workplace/school buildings. For example, they are forced to take ablution at the tap or toilet sink, which is not convenient and less ergonomic for performing the ablution ritual. Not only the person performing wudu' at a common sink is exposed to awkward posture and chances of hurting himself when he has his foot in the sink, water splashing will surely be everywhere and creates messiness, but also the visibility of someone performing wudu modifies social relations between the Muslim or people who already know about it and the non-Muslim and the ignorant or new to the rituals with associated concerns over how they may be perceived [14].

The current public restroom infrastructure in Malaysia often lacks dedicated ablution facilities, compelling Muslims to perform ablution at common sinks. These sinks are typically not designed to accommodate the ritual's requirements, resulting in water splashing that not only inconveniences users but also creates slippery and dirty floors. This situation not only poses hygiene issues but also safety hazards for all restroom users. This study aims to address these challenges by proposing an improved ablution sink design suitable for public use, focusing on ergonomic principles and user comfort while excluding considerations for a complete overhaul of public restrooms or specialized stations for users with visual impairments or body disorders. Fig.1 shows a common ablution facility available at musolla/prayer rooms. Similar setup can also be found in certain public restrooms in Malaysia, usually one faucet for one person at a time. At certain public restroom where there is no sink, people perform ablution in the toilet itself, although this act is not preferred. Most people will use the sink in the public restroom and even lift their legs to wash the feet as one of the compulsory body parts to be washed in the ritual.

Fig. 1. (a) common public ablution facility (b) performing ablution in the toilet where the floor vent is (c) performing ablution at common sink of public restroom.

The primary objective of this study is to redesign ablution facilities in public restrooms to mitigate the hygiene issues caused by water splashing while ensuring the safety and comfort of the users.

2 Methodology

2.1 Survey Questionnaire

This survey is to get an idea or voice of user on the preference and expectation of the ablution facility at a public restroom. The questionnaire was randomly given to some of university students and staffs. The questionnaire survey was created on the online platform which is Google Form for ease of distributions among respondents. The link was forwarded from one messaging applications group to another. Since the target audience are open to all users of public restroom, the approach of determining the potential subjects through simple random sampling.

2.2 Product Design Specification (PDS)

From the survey, items to be put in the PDS table as in Table 1 can be determined. General requirements are the common elements expected from a product. Based on Pugh, General requirements decided for this study includes Safety, Hygienic, Accessibility, Water Conservation, Ergonomic, Maintenance and Economic. A more rigorous validation process of determining the requirements for PDS was presented through Hierarchical Component Models [15].

2.3 Concept Generation and Sketches

Before one final design could be created, at least five concepts will be generated to allow for the best finalized detail design could be created. These five sketches will be a combination of existing technology and the PDS established.

2.4 Pugh-Matrix Concept & Weight Scoring Process

The Pugh matrix helps assess which products or possible solutions are more relevant or better than others. It is used after recording the customer's voice (VOC). It is a scoring matrix used for idea selection in which scores relative to criteria are allocated to choices. Based on the consolidated ratings, the selection of the final design is made.

In this process criteria, the weightage will be added so that the importance of criteria will be focused more on the comparisons of the concepts selected from the scoring process. For the scoring method process criteria, the weightage will be added so that the importance of criteria will be focused more on the comparisons of the concepts selected from the screening method.

The concept which was at the highest rank in the previous method will be used as a reference in the scoring process. The reference will be compared with the other

concepts in this method to find the best concept. The concepts will be rated from one (lowest rating) to four (highest rating).

2.5 Framework for Product Testing

Several analyses will be done after the final design is set, which are:

Water Flow Analysis Analyze the flow of water in the sink to ensure it meets the requirements for ablution. This involves calculating the water flow rate, distribution, and ensuring the design allows for effective and efficient use of water during the ablution process. This analysis can help optimize water splashing on the floor or user's clothes while performing ablution rituals such as while washing hands.

Stress Analysis and Material Resistance Stress analysis on materials used in sink construction, especially those subjected to repeated loads or stresses during normal use can be conducted. However, this analysis is excluded from this paper.

3 Results and Discussion

3.1 Survey Result

An online survey was created using Google Forms. The questionnaire was answered by 58 respondents consisting of students and staff at the National Defense University of Malaysia (NDUM). The survey contains 16 questions that are very important to know their opinion on their experience using the ablution sink. The questionnaire is also divided into seven sections, among which are user demographics, current ablution experience, ergonomics and comfort, accessibility for all users, hygiene and cleaning, the ablution sink requirement from user survey and suggestions for improvement. As shown in Table 1, the 58 participants were 80% students and 20% staff. All of them were recreated randomly through WhatsApp group. Their height groups showed that the respondents are from the 50^{th} and 95^{th} percentile groups [16]. This data will help determines the placing of the faucet for the ablution. The majority performed ablution more than 3 times in a month at public restrooms. Their current experience was between satisfied and least satisfied. Table 2 clearly shows that they feel that the water splashes out when performing ablution (hence wet their clothes as well as the floor), followed by difficult to wash feet. The same number of subjects thought that the sink is too high, and the faucet design is inappropriate.

Table 1. Survey respondents

Demographic	N= 58	Frequency %
Gender	Male	39
	Female	61
Age	18-24	76
	25-35	24
Height	150 – 169cm	22

	170 – 189cm	78
Experience of performing ablution in public toilet per month	1 – 2 times	20
	3 – 4 times	46
	5 times	32
Current ablution experience 1-least satisfied to 5-most satisfied	1 – 2 least satisfied	42
	3 - 4	57
	5 most satisfied	1

Table 2. Aspects of the current ablution sink design that is most inconvenient or uncomfortable to the subjects.

Relative Performance	Frequency n (%)
The sink is too high	21 (36.2)
Difficult to wash feet	36 (62.1)
Water splashes out	41 (70.7)
Inappropriate faucet design	20 (34.5)

The suggestions given by the respondents are as depicted in **Fig. 2**. Most respondents (46.6%) suggested adding handles to increase stability while washing feet, while 41.4% suggested providing feet sinks and non-slip surfaces. 31% of respondents suggested designing height-adjustable sinks, while 15.5% suggested inclusive designs for different abilities. 13.8% suggested incorporating water-efficient features, while 8.6% suggested enhanced privacy features. Only 1.7% suggested increasing the depth of the feet sink to prevent water from flowing onto the floor. All the respondent's voices will be translated into the Product Design Specification.

Fig.3 shows the customer requirements for the ablution sink from the survey. Each respondent is required to choose the 3 most important criteria from their opinion. The result will be used as reference for scoring method for the selection of final design. The weightage (%) was referring to the 58 respondents. The result indicated that safety as the most important factor, with 72.4% responses followed by hygienic factors (55.2%) and accessibility (46.6%).

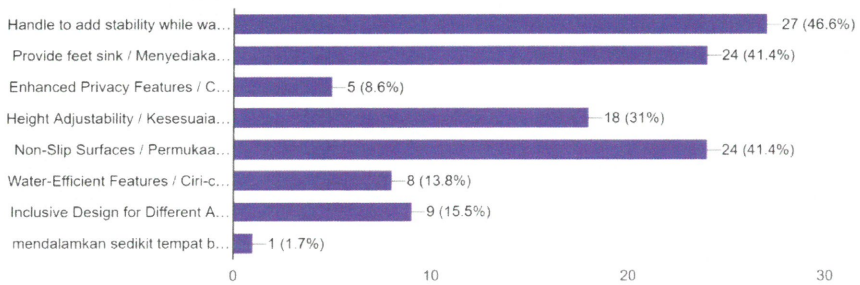


Fig. 2. Suggestions for Improvement of Ablution Facility Design at Public Restroom

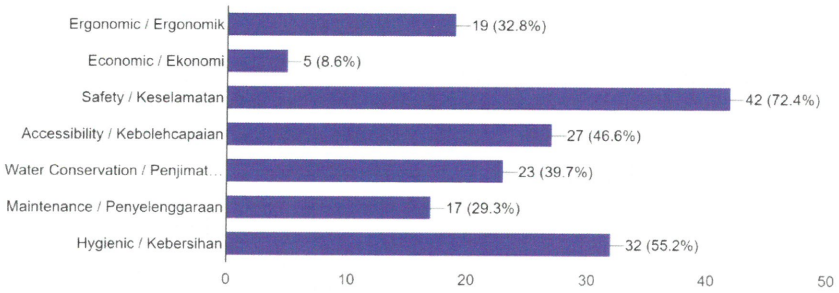


Fig. 3. The Customer Requirements for the Ablution Facility

The total responses received were 165, so to calculate the weightage for example for Safety factor, $\frac{42}{165} x\ 100 = 25.4 \approx 25\%$. The weightage for the rest of criterion is shown in Table 3.

Table 3. Weightage for each criterion of the PDS

No	Criteria	Weightage (%)
1	Safety	25.5
2	Hygiene	19.4
3	Accessibility	16.4
4	Water Conservation	13.9
5	Ergonomics	11.5
6	Maintenance	10.3
7	Economic	3.0

3.2 Product Design Specification (PDS)

In terms of safety, there should be no sharp corners and it is expected that users might lean on one side or both side of the sink, and it should be able to withstand it. If the weight of a 95th percentile male is approximately 93.45 kg [17], it is assumed the load of his body leaning on the sink is half of his weight, the sink should be able to support up to 50kg. Aman [3] suggested that the upper sink is designed with slope of 100° to reduce wet experienced by users and prevent water accumulation which is unhygienic. The feet sink is designed with 50° slope to allows water to flow naturally towards the drain, making it easy to clean and dry. The material chosen for the sink is from stainless steel with weight (±1.5 kg) for maintenance and hygiene in existing public restrooms.

The accessibility refers to sink distance to users refers to shoulder elbow length at 383mm from and sink width is refer elbow to fingertip at 354mm at 95th percentiles [17].

The sink height refers to the standing elbow height which concluded to be 95cm from the floor. The foot shower should not exceed the dimension of the knee or poplit-eal height. This is to allow users to wash their feet comfortably with the dimension of 650mm from the floor and the shower head is flexible to give extra comfort to users.

Water conservation includes using low-flow faucets at 5 L/min or less to decrease water splashes wile ablution [9]. Tap control that use for this design is quarter-turn wall-mounted taps because it can help reduce water waste by providing a quick and easy way to turn the water on and off, thus minimizing the risk of leaving the water running [18]. Aerators can be installed on low-flow faucets to further reduce water usage can save up 30% of water [19].

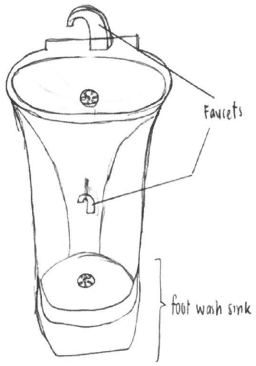
The height of the upper and lower sink is an important in ensuring ergonomic and comfortable use of the ablution facility. The upper sink should be 950mm from the floor, while the lower sink should be 650mm from the floor [3]. To reduce water splashes, the distance between the water tap and sink should be 450mm based on forearm-hand length [3] however further detail calculations based on water flow analysis is shown below. It is important to ensure users can perform ablution comfortably without water splashing onto the floor or their clothes. This ablution sink will be installed in existing public restrooms, hence, it should feature a simple, easy-to-clean design, avoiding complex mechanisms and economically competitive.

Table 4. Product Design Specification for Ablution Facility in Public Restroom

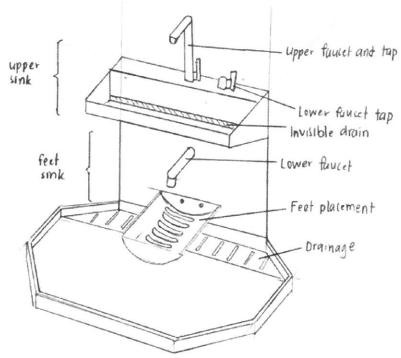
No	General Requirement	Specific Requirement	Acceptable Performance
1	Safety	safe to use	• No sharp corner • Can support weight > 50kg
		Handrail to support awkward standing.	The sink act as a handrail to support. Material: stainless steel (1.5kg ±) (Stainless Steel Undermount Kitchen Sink Single Bowl 65cm x 45cm x 22.5cm [20])
2	Hygienic	The sink sloped toward the drain easy to clean.	The slope of upper sink is 100 and lower sink is 50 [3].
3	Accessibility	Enough space range of adult users.	Sink distance to user; shoulder-to-elbow length = ±38.30 cm (95th percentiles) Sink width; elbow-to-fingertip = ±35.94 cm (95th percentiles) [17]
4	Water conservation	Low-flow faucets Tap control Water saving devices	The flow rate of faucets is 5 L/min or less [9] Quarter-turn wall-mounted taps Aerators can be installed on low-flow faucets to further reduce water usage. Can save up 30% of water [19]
5	Ergonomic and comfort	Has a suitable height for upper and lower sink based on ergonomic considerations.	Range of height: Upper sink: 95 cm from floor. Lower sink: 65cm from floor. [3]
		Reduce water splashes	Distance between water tap and sink: 45cm based on forearm-hand length.[3]
6	Maintenance	Easy to do maintenance	• No complex mechanism • Easy to clean
7	Economic	Competitive for market Low-cost manufacturing	< MYR1000 [20]

3.3 Conceptual Design

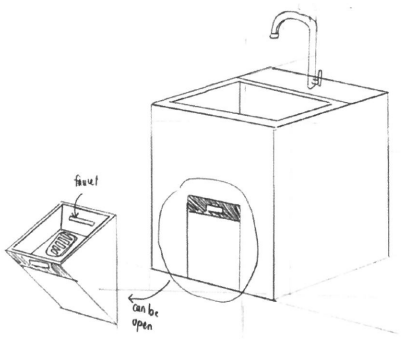
A total of 5 sketches were generated as shown in Fig. 4 and will go through the selection process to get the final design. The design ideas are based on the project objectives; reduce water splashing and ergonomic.



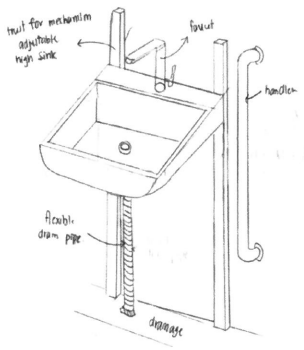
Concept A



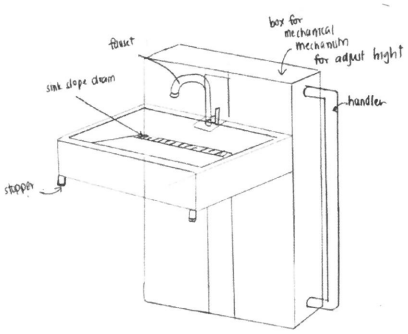
Concept B



Concept C



Concept D



Concept E

Fig. 4. The five conceptual designs

3.4 Finalized Design

Those sketches will be evaluated using scoring method. The systematic approach evaluates and ranks different design alternatives based on the PDS in Table 4.

The weightage percentages from Table 3 are used to prioritize the design criteria for an ablution sink, ensuring that the most important factors are given the most attention during the evaluation process. To obtain the weight score (W.S), the rating (R) must be put first. The rating is based on the relative performance that has been discussed in subtopic **2.5** where 1 is the least performance and 4 is excellent performance. After the rating has been added, then it must be multiplied with the weightage that has already been assigned according to important characteristics. Table 5 shows how the selection of the designs were finalized.

Table 5. The Scoring Results

Ablution Sink		Qualify Concept									
		Concept A		Concept B		Concept C		Concept D		Concept E	
Selection Criteria	Weight (%)	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Safety	25.5	3	0.76	4	1.02	3	0.76	2	0.51	2	0.51
Hygienic	19.4	2	0.38	4	0.77	3	0.58	3	0.58	3	0.58
Accessibility	16.4	4	0.65	4	0.65	3	0.49	3	0.49	3	0.49
Water conservation	13.9	3	0.41	3	0.41	3	0.41	2	0.49	2	0.49
Ergonomic	11.5	3	0.34	3	0.34	3	0.34	4	0.46	4	0.46
Maintenance	10.3	4	0.41	4	0.41	4	0.41	3	0.30	3	0.30
Economic	3.0	4	0.12	3	0.09	3	0.09	3	0.09	3	0.09
Total Score		3.07		3.69		3.08		2.95		2.92	
Rank		3		1		2		4		4	
Continue?		No		Develop		No		No		No	

3.5 Engineering analysis

Water splashing. An engineering approach to estimate water splashing from a faucet designed for ablution, principles from fluid dynamics can be used. One important aspect to consider is the impact of the water jet on a surface, which can be described by the Weber number (*We*) and the Reynolds number (*Re*). The Weber number is a dimensionless number that represents the ratio of inertial forces to surface tension forces. It is given by:

$$We = \frac{\rho v^2 L}{\sigma} \tag{1}$$

where:

ρ is the density of water (kg/m^3)
V is the velocity of water (m/s)
L is the characteristic linear dimension (m)
σ is the surface tension of water (N/m)

While the Reynolds number is given by:

$$Re = \frac{\rho VL}{\mu} \quad (2)$$

where:

D is the inside pipe diameter

μ is the viscosity of the water Pa.s

To control splashing, the kinetic energy of the water impacting surfaces must be minimized. One key approach is to adjust the faucet design to control the flow rate and velocity. The impact force, F can be estimated using:

$$F = \dot{m} \cdot v \quad (3)$$

where:

$\dot{m}$ is the mass flow rate (kg/s),

v is the velocity of water (m/s).

To achieve minimal water splashing, the Weber number (*We*) must be less than 1 and the Reynolds number (*Re*) must be less than 2000. The *We* ensures cohesive water stream and surface tension (σ), and *Re* indicates stable, laminar flow with minimal disruption upon impact or splashing. Calculations can be made with water density (ρ) of 1000kg/m^3, surface tension (σ) of water 0.072N/m and the typical controlled water (L) estimated at 0.01m, the *We* can be < 1 if the velocity of water (v) is about 0.085m/s. This value (0.085m/s) will also satisfy the Reynolds (*Re*) < 2000 number condition since with viscosity (μ) of 0.001 Pa.s will give v < 0.2m/s.

Since the target of velocity (v) to minimize splashing is < 0.085m/s, the corresponding height (h) of the faucet from the ground can be calculated with the following formula:

$$v = \sqrt{2gh} \quad (3)$$

where:

g is the acceleration due to gravity (9.81 m/s^2)

h is the height m.

Using the value v = 0.085 m/s, h must be 0.37mm, which is too low and impractical. In designing an ergonomic, comfortable and user accessible ablution facility, the faucet should be at a height that allows users to comfortably place their foot under the stream without bending excessively or lifting their foot too high. A typical comfortable height for foot washing is around knee height or popliteal height. For popliteal height, it could be from 360mm (5th percentile female) to 508mm (95th percentile male) [16-17]. In

addition, to minimize the water splashing, flow restrictor or aerator must be used to get gentle flow typically around 0.1 to 0.15 L/s.

Water splashing. Another intervention is to design an effective sink/basin to catch and direct water, reducing splashing. A slightly sloped or curved surface helps manage water flow and reduces splash-back. Fig. 1 illustrates the finalized design for an ablution facility suitable for public toilet or non-dedicated ablution area commonly adjacent to prayers room.

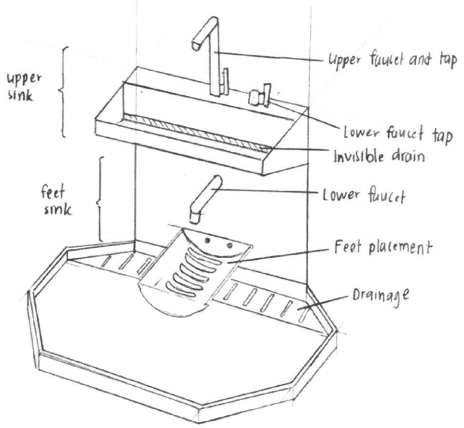


Fig. 1. The finalized design concepts from Concept B

Slope Angle A gentle slope between 10° and 15° helps guide the water flow smoothly into the drain. Steeper slopes may cause water to hit the surface with more force, increasing the chance of splashing.

Curvature A parabolic or gently curved basin ensures that water is directed towards the center and down into the drain without splashing back.
The curvature should be designed to allow water to follow the contour naturally.

Basin Depth A deeper basin reduces the likelihood of water spilling over the edges. A depth of around 150-200 mm (6-8 inches) is typically effective [3].

Drain Placement Centrally placed drains with a slight slope towards the center ensure efficient water drainage. Ensure the drain is large enough to handle the water flow without causing backups. Example of dimensions and design:

Width and Length A basin width of about 400-500 mm (16-20 inches) and a length of 500-600 mm (20-24 inches) provides ample space for foot washing without causing spillage.

Slope and Curvature Side walls can be curved with a radius that allows water to flow down smoothly. A parabolic curve is often ideal. The bottom should have a slight concave curvature to guide water towards the drain.

Commercial ablution sinks for upper body parts and feet are available on the market (mostly at hotels and mosques outside Malaysia), but they are often expensive and not robust enough for public use. The proposed design addresses these shortcomings by offering a practical, cost-effective, and durable solution. By separating the sinks for different parts of the ablution ritual, the design effectively reduces water splashing and enhances overall hygiene.

5 Conclusion

The final design emerged from a matrix evaluation process, which considered various criteria such as user comfort, feasibility, and water splash reduction. The selected design features two separate sinks: one for washing the face and hands and another for washing the feet. The faucet must be controlled to ensure $Re < 2000$ and $We < 1$. This configuration minimizes water splashing and enhances hygiene. The engineering analysis confirmed the design's technical viability. However, the detailed drawings and computer-aided visuals are not included in this paper. An effective basin design for reducing splash-back should include a gentle slope of 10°-15°, parabolic curved side walls, central drain placement. The dimensions around 450 mm (width) by 550 mm (length) by 175 mm (depth). These design elements ensure smooth water flow, minimizing splash-back, and providing a comfortable user experience for foot washing.

References

1. Mynatt, E. D., & Rogers, W. A. (2001). Developing technology to support the functional independence of older adults. Ageing International, 27(1), 24–41. https://doi.org/10.1007/s12126-001-1014-5
2. Al-Shahri, M. Z., & Al-Khenaizan, A. (2005). Palliative care for Muslim patients. J Support Oncol, 3(6), 432-436.
3. Aman, A. (2017). *Design and Analysis of Wudu' (Ablution) Workstation for Elderly in Malaysia* [M.E., University of Malaya (Malaysia)]. https://www.proquest.com/docview/2877960048/abstract/E8781C38C6124C A1PQ/5
4. Johari, N. H., Anwar, R., Hassan, O. H., & Kamaruzaman, M. F. (2013). Human behaviours influence framework of the ablution tub design. *2013 IEEE Business Engineering and Industrial Applications Colloquium (BEIAC)*, 750– 752. https://doi.org/10.1109/BEIAC.2013.6560233
5. Anom Besari, A. R., Zamri, R., Yusaeri, A., Palil, M., & Prabuwono, A. S. (2009). Automatic Ablution Machine using Vision Sensor. *2009 IEEE Symposium on Industrial Electronics and Applications (ISIEA 2009)*, *1*, 506 to509. https://doi.org/10.1109/ISIEA.2009.5356425
6. Loodin, N., Link to external site, this link will open in a new tab, Wolf, A. T., & Link to external site, this link will open in a new tab. (2022). Will Islamic Water Management Principles Be Included If the Helmand River Treaty Is Revisited? *Water*, *14*(1), 67. https://doi.org/10.3390/w14010067

7. Sukadarin, E. H., Mohd Nawi, N., & Abd Ghani, A. A. (2021). Investigation on the Ergonomics Design of Wudhu' (Ablution) Station at a Mosque in a Higher Learning Institution. *Current Science and Technology*, *1*(1), 15–25. https://doi.org/10.15282/cst.v1i1.6442
8. Rohimi, R., Ismail, W. W., Yusra, A. I., Haizal, M. N., & Mohamed, S. (2020). Innovative design development of ergonomic ablution station for wheelchair user. PalArch's Journal of Archaeology of Egypt/Egyptology, 17(10), 1-15.
9. Zaied, R. A. (2017). Water use and time analysis in ablution from taps. *Applied Water Science*, *7*(5), 2329–2336. https://doi.org/10.1007/s13201-016-0407-2
10. Ghazali I, Padzil NWS, Mohamad EB, Al-Mashjari LA, Irianto I and Herawan SG (2023), The water tap design for ablution activities considering cultural influences: a design for sustainability. Front. Environ. Sci. 11:1281318. doi: 10.3389/fenvs.2023.1281318
11. Che Hasbi, S. A., & Hamat, S. (2020). The Ergonomics of the Islamic Ablution: Exploring Considerations for the Elderly in the Mosque. *Cultural Syndrome*, *2*(1), 59–77. https://doi.org/10.30998/cs.v2i1.323
12. Kim, I. J., & Omar, O. H. (2019, March). A Pilot Study on Ablution Space Safety in Mosques: Slip-resistance assessments of ablution floorings from a viewpoint of fall incidents. In 2019 Advances in Science and Engineering Technology International Conferences (ASET) (pp. 1-5). IEEE.
13. Nazeer, S. A. B., Randhawa, M. A., Alshammari, M. S., & Bawadekji, A. (2023). A Novel Design of Ergonomic Ablution Place at Mosques in Arar, Saudi Arabia. Ergonomics in Design, 31(2), 14-23.
14. Wigley, E., & Bibi, R. (2024). 'Why has this guy got his foot in the sink?': challenges, encounters and everyday geographies of practicing wudu. *Social & Cultural Geography*, 1-19.
15. Ghazali, I., Padzil, N. W. S., Mohamad, E. B., Al-Mashjari, L. A., Irianto, I., & Herawan, S. G. (2023). The water tap design for ablution activities considering cultural influences: a design for sustainability. Frontiers in Environmental Science.
16. Deros, B. M., Hassan, N. H. H., Daruis, D. D. I., & Tamrin, S. B. M. (2015). Incorporating Malaysian's population anthropometry data in the design of an ergonomic driver's seat. Procedia-Social and Behavioral Sciences, 195, 2753-2760.
17. Karmegam, Karuppiah, K., Sapuan, S., Ismail, M., Ismail, N., Md Tamrin, S., Gobalakrishnan, K., Palanimuthu, S., & Palaniandy, T. (2011). Anthropometry of Malaysian young adults. *Journal of Human Ergology*, *40*, 37–46.
18. Tap and faucet city. (2022, April 14). Mixer Taps vs Standard Taps. *Water Tap & Faucet Singapore - #1 Water Tap & Faucet Supply & Installation Service.* https://tapfaucetcity.com/articles/mixer-taps-vs-standard-taps/
19. Innovation Fields Co .Ltd. (n.d.). *The Benefits of Using Water-Saving Faucet Aerators* –Retrieved January 22, 2024, from https://ifl.sa/the-benefits-of-using-water-saving-faucet-aerators/
20. *CABANA Stainless Steel Undermount Kitchen Sink Single Bowl 65cm x 45cm x 22.5cm*. (n.d.). Retrieved January 22, 2024, from https://www.wowshop.com.my/cabana-stainless-steel-undermount-kitchen- sink-single-bowl-65cm-x-45cm-x-22.5cm-169179.html