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EDITED BY
Raymond Li,
University of Canberra, Australia

REVIEWED BY
Love Kumar,
University of Florida, United States
Chun Kai Leung,
City University of Hong Kong, Hong Kong SAR, China

*CORRESPONDENCE
Ihwan Ghazali,
ihwan@utem.edu.my

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The water tap design for ablution activities considering cultural influences: a design for sustainability

Ihwan Ghazali[1]*, Nur Wardah Sufina Padzil[1], Effendi Bin Mohamad[1], Layla Ahmed Al-Mashjari[2], Irianto Irianto[2] and Safarudin Gazali Herawan[3]

[1]Faculty of Industrial and Manufacturing Technology and Engineering, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia, [2]Faculty of Resilience, Rabdan Academy, Abu Dhabi, United Arab Emirates, [3]Industrial Engineering Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia

Water is a vital resource that should be utilized effectively. However, it is overused and squandered on a daily need, including the unrestrained use of water for ablution purposes. This condition can be due to a lack of awareness and the influences of peer cultural values. Therefore, the aim of this study is to develop a water-tap design that takes into consideration the influences of cultural value. Accordingly, confirmatory factor analysis and structural equation modelling (SEM) approach the significant correlation between cultural influences and user preferences on water-tap design by referring at the critical threshold output of each attribute. The result showed that collectivism and uncertainty avoidance dimensions were identified as the influencing cultural dimensions and the automatic water level-control float valve, mechanical water-taps with auto-stop function, and transparent water tanks are the most important considerations for water tap technical specification. Through the assessment of its applicability, the use of the prototype can reduce water usage by 54.6% compared to regular water-taps. Correspondingly, the approach of cultural value in the designing process is expected to give more insights to practices such as product designers when determining design specification while for knowledge, it extends the applicability of Hofstede cultural theory for product design and development.

KEYWORDS

sustainable development, product design and development, cultural value, water-tap design, design for sustainability, green product design, environmental protection

1 Introduction

Water shortage is a critical issue that has been created by water scarcity and the rapid increase in the world's population. Unfortunately, this issue is likely to be intensified in the future. Water shortage is already a reality in some areas, and one contributing aspect is excessive and uncontrolled usage including in Malaysia (Ismanto et al., 2023). Undoubtedly, sustainable urban water management is crucial to sustaining cities' global resilience and prosperity (Kumar et al., 2022). Therefore, it is critical to recognise the necessity of responsible water consumption and conservation, which requires all parts of society, including ablution activities. Ablution, or wudu, is a revered and necessary cleansing

ritual for Muslims before prayer (Osim and Gabriel Eteng, 2021). It entails cleaning specific body parts in a precise order, such as the hands, face, mouth, nose, arms, head, and feet. While ablution is an essential part of Islamic prayer, it has been noticed that water usage during this practice is excessive and uncontrolled in certain situations (Johari et al., 2013a). Some water-tap users may need to be made aware of how their ablution practices affect the water flow they use during ablution. According to Johari et al. (2013b), ablution comprises the face, hands, forehead to the crown of the head, and the feet. Based on the suggestion from Prophet Muhammad PBUH, the ablution per person should not be more than 1 L of water (Zaied, 2017). However, it stated that while the ordinary Muslim may use 5 L of water for ablution, up to 25 L of filtered raw water are necessary (Wijsen, 2023).

A study on developing water-taps to reduce water consumption during personal hygiene and ablution activities has previously been conducted (Husain, 2020). The study describes the automatic water tap with sensors. However, due to the automatic shut-off feature, which can interrupt the continuous flow of water that is required for ablution, a water tap with sensors may restrict Muslim ablution activities. Sometimes, this type of water tap may be complex, especially for individuals who are unfamiliar with the technology (Achilleos et al., 2023). The sensors may also require routine maintenance and calibration, and any malfunction or failure may require costly repairs or replacements (Gungor et al., 2009). The initial cost of installing water-tap sensors may be higher than a conventional manual water-tap, which may concern some mosques and Islamic centres with limited funds (Down and Read, 2020). These maintenance and cost concerns could further complicate implementing automatic water-tap sensors for Muslim ablution activities.

Hence, mechanical water-taps can be an alternative and provide several advantages for Muslim ablution activities (Zaied, 2017). This type of water tap provides a constant flow of water that is required for appropriate ablution under Islamic law. It enables the users to perform ablution comfortably and efficiently without fretting about the water supply being interrupted. Mechanical water-taps may also provide a higher flow rate control than water-tap sensors, allowing users to adjust the water pressure to their preferences, making ablution more comfortable and efficient. In addition to requiring less maintenance than water-tap sensors, mechanical water-taps reduce the likelihood of malfunctions or disruptions. However, cultural influences may affect the applicability of water-tap design as they will reflect the user's behaviour when using it. Due to cultural influences, the water-tap user still uses a substantial quantity of water during ablution to ensure spiritual purity and the efficacy of the purifying process (Johari et al., 2013a). This research noticed a limitation from previous studies to consider the cultural influences during the design process of water-taps. This gap is critical because, in this setting, design choices profoundly affect people's day-to-day lives, especially in areas where ablution is an essential element of culture and religion. This research contributes to the creation of more inclusive and sustainable water-tap designs that respect cultural practises, encourage water conservation, and improve overall user experiences by identifying and resolving these cultural impacts. Therefore, to fill this gap, the objective of this study is to focus on developing a water tap for ablution activities taking into consideration the cultural influences. The existing issues of water-tap design and research gap are illustrated in Figure 1.

The objective of this study is to develop a water-tap design that considering the user cultural influences. To achieve this objective, this paper is divided into three sections. The first section concerns the existing study review on ablution and water-tap design. In this phase, the importance of each aspect is identified. The second section discusses the potential correlation between cultural value influences and water-tap attribute preferences. In this section, the elaboration of cultural value preferences on water-tap design is elaborated and the water-tap design specifications are generated. The last phase concerns on the water-tap sketching, 3D design model, to the testing of the prototype. The conclusion section also explains the potential contribution of knowledge and practices.

2 Ablution and water tap design

Efforts to reduce water consumption during ablution activities have recently gained significant attention. One way to achieve this is through innovative water-tap designs that regulate the flow rate of water (Muslim et al., 2019). A study conducted by Barbier et al. (2019) has developed an automated water tap system that reduces water consumption during ablution by controlling the duration of the water flow. The system utilises a motion sensor that detects the presence of the user's hand and automatically starts and stops the water flow, thus preventing wastage. The study has found that the developed system reduces water consumption by up to 60% compared to traditional water-taps. Muslim et al. (2019) developed an intelligent water-saving system incorporating flow restrictors and timers in water-tap systems to reduce water consumption during ablution.

The system was found to be effective in reducing water consumption without compromising the efficacy of ablution. These studies highlight the potential of innovative water-tap designs in reducing water consumption during Muslim ablution, thus, promoting sustainable water use practices. However, despite the availability of these specific taps design, one critical issue remains, i.e., the need for more user awareness regarding water consumption during ablution (Fidar et al., 2016). Users often do not have a clear understanding or realisation of how much water they use when performing ablution. The absence of water usage indicators or meters on the taps makes it difficult for the users to measure the quantity of water being utilised. Without such a feedback, individuals are unable to comprehend the impact of their ablution practices on water conservation. However, in terms of the general perception of users in designing water-taps for ablution, four essential factors should be considered, i.e., design appearance, functionality, price, quality, and durability (Bakar et al., 2015).

The appearance of the water tap is the most significant factor. Whether it is in a mosque, a private residence, or a public building, people frequently seek water-taps that match the aesthetic of the ablution area. The design should be aesthetically pleasing, producing a serene and inviting atmosphere that enhances the overall ablution experience (Suratkon et al., 2014). Functionality is an essential

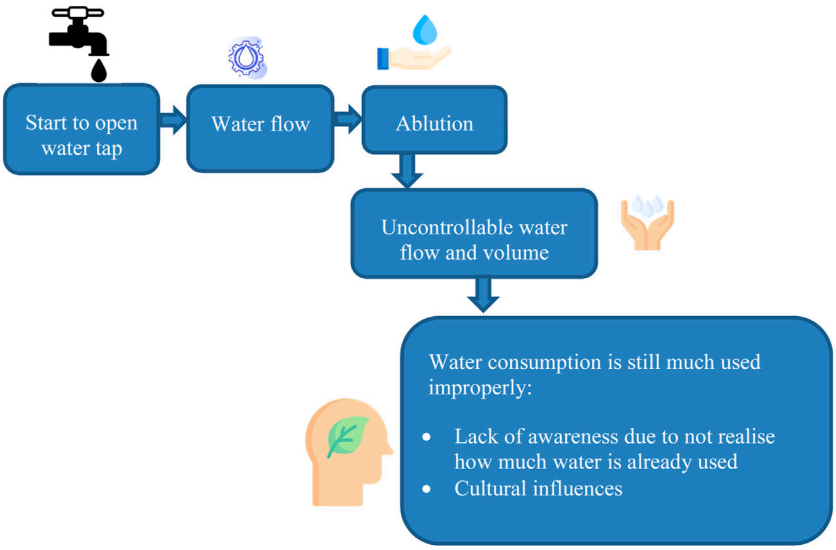

FIGURE 1
Existing water-tap issue.

aspect of the design of the Muslim ablution water-taps. People prefer user-friendly water-taps that facilitate a seamless and effective cleansing process. The water tap should provide precise flow control, allowing users to modify the pressure. As Islamic teachings highly value water conservation, the design should incorporate water-saving features (Suratkon et al., 2014). Price is also an essential factor for the general population. People typically search for water-taps that provide excellent value without sacrificing quality. They seek inexpensive and durable products that ensure a long-lasting and dependable solution for their ablution requirements. In summary, the design preferences of the general population for Muslim ablution water-taps are influenced by appearance, functionality, acceptable price, quality, and durability (Bakar et al., 2015). By addressing these factors, manufacturers can design water-taps that accommodate the requirements and preferences of the individuals performing ablution, enhancing their overall experience and adherence to Islamic rituals (Ghani et al., 2021).

3 Cultural value

Culture is a collection of learned and transmitted methods of thinking, feeling, and acting that represent the unique accomplishments of human groups, including their expression in artifacts (Ranger et al., 2018). According to Mironenko and Pavel (2018), it is an organisation of information, beliefs, procedures, attitudes, and artifacts that is shared among members of a community and is founded on traditional concepts and principles. Culture can be understood as the set of beliefs and behaviours that are required for an individual to be designated as a member of a particular society. (Hofstede, 1980) acquired data from the International Business Machines Corporation (IBM), a major global corporation, and analysed data from forty different countries about cultural studies. Individualism-collectivism, uncertainty avoidance, power distance, masculinity-femininity, long-term orientation, and indulgence are the six dimensions of Hofstede's theory (Agodzo, 2015).

Individualists are those who are concerned about not belonging to be members in a group and have a strong sense of self-reliance. (Steindl and Jonas, 2012). Individualism is a personality trait that is exhibited by individuals who prioritise their own interests over those of the community (Xiao, 2021). Individualists hold their own beliefs, whereas collectivist cultures prioritise group cohesion, cooperation, and collective objectives over individual pursuits, according to (Hofstede 1980). As men and women are referred to as masculine and feminine (Cheryan and Hazel, 2020), gender roles disparity is a crucial issue for all cultures and has numerous solutions. According to (Bojkowski, 2022), The values exhibit substantial variation across different countries, encompassing a spectrum that spans from assertiveness and competitiveness, goal-oriented behaviour, and the association of success with masculinity, to an emphasis on well-being, style, colour, social obligations, modesty, and attractiveness as attributes associated with femininity. Basabe and Ros (2005) defined power distance as the proportion of national cultures recognising and tolerating unequal societal power distribution. In general, power organisation in society is linked to the dimension of power distance, which includes distinct benefits for individuals at various levels of authority (Zheng, 2019). Moreover, in societies with a significant power differential, everyone can have a predetermined position in the social hierarchy (Mikhailov and Kornilina, 2013). In contrast, low-power distance beliefs adhere to the standard of upholding and respecting inherent equality in social interaction (Oyserman, 2017).

Correspondingly, the uncertainty avoidance reflect to societies who concerned on the ambiguity, uncertainty, unpredictability of various condition and try to find a way to minimise that uncertainties situation (Hillen et al., 2017). In uncertain environments, individuals tend to be more emotional and driven

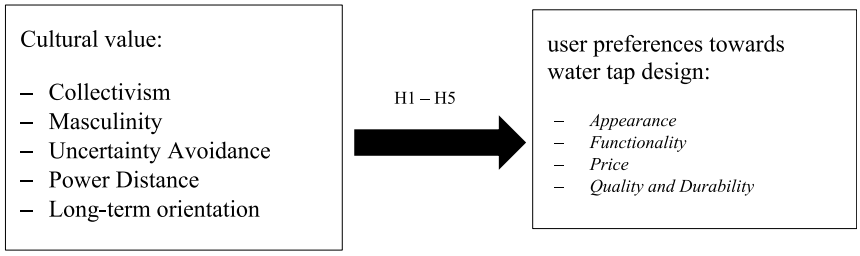

FIGURE 2
Hypotheses testing. H1 Collectivism provides significant influences on water tap preferences. H2 Masculinity provides significant influences on water tap preferences. H3 Uncertainty Avoidance provides significant influences on water tap preferences. H4 Power Distance provides significant influences on water tap preferences. H5 Long-term orientation provides significant influences on water tap preferences.

by their apprehensive energy. This reaction indicates how completely a culture has trained its members to feel uneasy or at ease in chaotic situations. Notably, Hofstede (1997) unstructured situations are distinctive, odd, shocking, and unusual characters. On the other hand, civilisations that embrace uncertainty are more tolerant of divergent viewpoints because they strive to construct as few laws as possible and are relativists who permit different philosophical and religious currents to coexist (Guala, 2022). When planning for the future, an individual is willing to forego immediate gratification in favour of long-term success, resilience, persistence, and advancement over the long term (Bissessar, 2018). On the other hand, a culture focusing on the short term is more concerned with leisure time, independence, short-term success, and individualistic or individualist principles (Bissessar, 2018). Short-term personalities emphasise the immediate result, the certainty of their beliefs, and the achievement of their current goals.

The knowledge and utilisation of water-taps during ablution activities might be significantly influenced by cultural value (Johari et al., 2013b). Cultural norms, traditions, and beliefs can shape individuals' behaviours and attitudes towards water conservation (Koop et al., 2019). In some cultures, there may be a strong emphasis on the purity and cleanliness that are associated with ablution (Fazli et al., 2022). Using more water to get cleaner results can lead individuals to prioritise thoroughness in the ablution process, which may affect the use of a substantial amount of water (Das et al., 2020). Moreover, cultural practices and societal expectations may influence individuals' perceptions of water usage (Lede et al., 2019). In certain communities, there might be a notion that using excessive water during ablution is a sign of piety or devotion. This cultural association between water usage and religious commitment can further discourage individuals from considering the conservation aspect of ablution practices. To identify the correlation between cultural value and user preferences on water-tap design the hypothesis testing is described in Figure 2.

4 Methodology

This study was divided into three phases: hypothesis testing, concept development, and prototyping. The hypothesis was verified to assess the relationship between five cultural value dimensions and the user's preferences for water-tap design. After confirming the hypotheses, the next stage was to generate design ideas and determine the water tap's design specifications. The design specifications were determined based on the structural equation modelling output of the outer weight. This outer weight was deemed more reliable than the questionnaire mean value, thus it was employed. This is because the outer weight results have been statistically validated and the measurement error assessed. Hair et al. (2016) used the outer weight to signify the absolute contributions of the indicators to the assigned constructs. After determining the design specifications, the final phase consisted of designing the design, transforming it into a 3D model for visualisation, and developing the prototype. After concluding the prototype, this study evaluated the applicability of a water tap to reduce the amount of water that was used for ablution activities through testing. The flow of methodology used in this study can be seen in Figure 3.

5 Data collection

The information required for this investigation was gathered from Malaysians' Muslim prayer. Utilising a questionnaire, the information was collected. The pre-test was administered to guarantee that the respondents would be able to answer the questions easily. To determine whether the respondents needed help in completing the questionnaire, the questionnaire was sent directly to the respondents with 30 number of pre-testing samples. Using the rule of thumb proposed by Cohen (1992), the minimum sample size necessary was determined. The minimum sample size (with 80% statistical power) was predicated based on the maximum number of arrowheads pointing to the structure of the developed model. In this investigation, five cultural dimensions pointed to the preferences of the water-tap users. The minimum sample size for these nine arrowheads was 120, with a minimum R^2 of 0.10. There was a total of 142 questionnaires. Twelve questionnaires were discarded due to insufficient responses. The quantity had exceeded the minimum requirement, hence the sample size was sufficient for the measurement. The details of data respondents can be seen in Table 1.

Using the Partial Least Squares Structural Equation Modelling (PLS-SEM), Hierarchical Component Models (HCMs) were employed to evaluate the hypotheses and identify the water outlet preferences. HCMs, which are two-layered, higher-order structures, were intended to reduce the structural model's

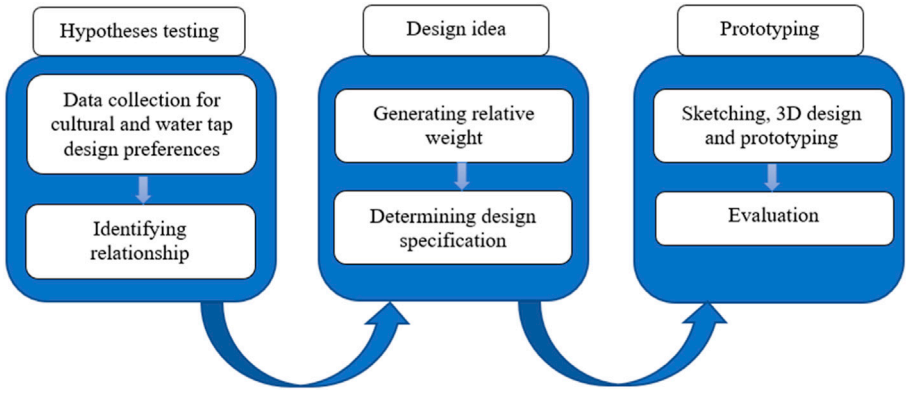

FIGURE 3
Flow of water-taps development.

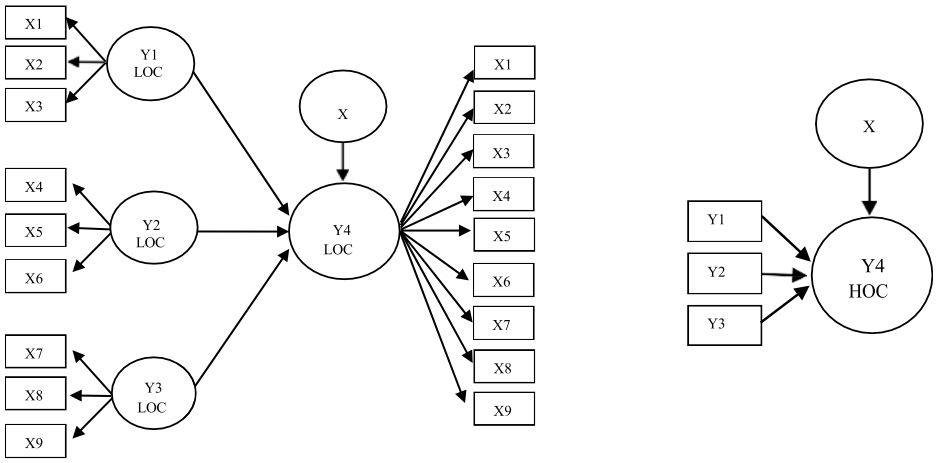

FIGURE 4
The two-stages approach for the HCM analysis (Hair et al., 2014).

complexity and facilitate a more concise comprehension of the partial least squares (PLS) path (Hair et al., 2014). There are two components within the HCM design: the lower-order component (LOC), which captures sub-dimensions of the abstract entity, and the higher-order component (HOC), which represents the more abstract entity. This approach uses latent variable scores of constructs in the LOC, then applies it as the manifest indicators in the HOC. The two-stage analysis is illustrated in Figure 4.

This study defines the HOC as "user preferences towards water-tap design," whereas the LOC includes product appearance, functionality, price, quality, and durability concepts. Four kinds of HCMs exist: reflective-reflective, reflective-formative, formative-reflective, and formative-formative. Reflective measurement reflect to the indicators are highly correlated, dropping the indicator will not alter the meaning of construct. For formative measurement, the indicators are perceived as fundamental attributes that define the concept, the removal of an indicator has the potential to modify the conceptual framework of the construct (Hair et al., 2016). The study employed a reflective-formative measuring technique to investigate the conceptions of cultural value and user preferences for water-tap design. The indicators pertaining to the five cultural dimensions were categorised as a reflective measurement model due to their strong correlation in predicting cultural dimensions. The removing to the indicators had no substantial impact on the conceptualization of the cultural components. The constructs of product appearance, functionality, price, quality, and durability were categorised as the lower-order control (LOC), whereas user preferences for the water-tap design construct were categorised as the high-order construct (HOC). Figure 5 depicts the categorization of construct measurement.

As illustrated in Figure 5, the constructs product appearance, functionality, price, and quality and durability are considered as formative in the LOC, with arrows pointing towards the water-tap preferences construct, which is also defined as formative in the HOC, to identify the preferences. Therefore, the paradigm is classified as formative-formative measurement. On the left side of the proposed model, the indicators for the five cultural dimensions are categorised as reflective because they assess the same

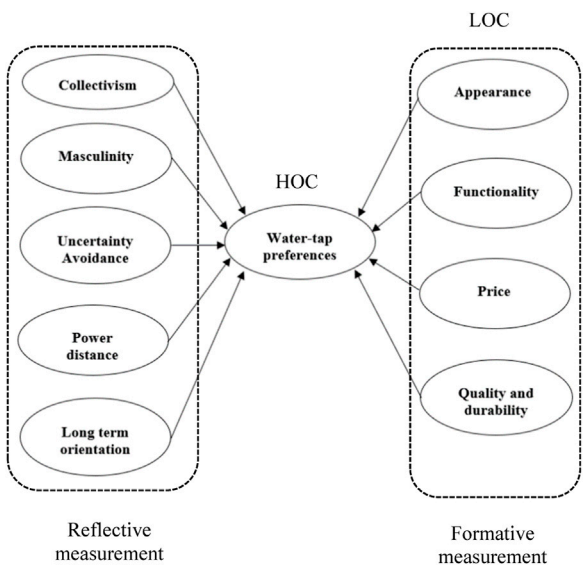

FIGURE 5
The categorization of construct measurement.

fundamental concept. Consequently, the elimination of an indicator has little effect on the interpretation of the designated construct. Before the HCM analysis, a confirmatory factor analysis (CFA) for reflective assessment and variance inflation factor (VIF) for formative measurement, sampling adequacy and reliability were assessed to evaluate the data quality for subsequent analyses.

Ensuring that the appropriate dimension allows for additional analysis during data collection is crucial. The sample size and reliability of the data can be evaluated using Cronbach's alpha, Kaiser-Meter-Olkin (KMO), and Barlett's sphericity test.

According to the findings presented in Table 2, the Cronbach's Alpha coefficient exceeds the threshold of 0.7, showing a high level of internal consistency and reliability for the scale. Additionally, the Barlett's test of sphericity yields a p-value of less than 0.001, suggesting that the data is suitable for factor analysis. Furthermore, the Kaiser-Meyer-Olkin (KMO) measure surpasses the minimum value of 0.5, further supporting the scale's internal consistency and reliability. The findings suggest that the reliability is outstanding and falls within acceptable thresholds.

TABLE 1 Respondent demographic.

Demographic		Frequency numbers
Gender	Male	75
	Female	55
Age	16–19 Years old	25
	20–29 Years old	60
	30–39 Years old	25
	40–49 Years old	12
	50–60 Years old	5
	Above 60	3
Profession	Student	47
	Government staff	32
	Housewife	24
	Private sector	18
	Others	9
Education level	Senior high school	30
	University	85
	Others	15
Monthly Income	<RM 1.000	10
	RM1,000-RM2000	30
	RM2,001-RM3000	17
	RM3,001-RM4000	22
	RM4001-RM5000	13
	RM 5000>	5

TABLE 2 KMO testing for sample size and reliability test.

Measurement		
Kaiser–Meyer–Olkin (KMO) sampling-adequacy test		0.906
Bartlett's sphericity test	Sig	0.000
Cronbach's alpha		0.941

Ideally: KMO > 0.5; Bartlett's should be significant, $p < 0.001$, Cronbach's alpha >0.7.

6 Results

The CFA was conducted using the Partial Least Squares (PLS) method. The statistical analysis of the data was conducted using the SmartPLS software. The gauging strategy encompasses the utilization of both reflective and formative measurements. The application of Hierarchical Component Model (HCM) was utilized in order to establish the relationships between the design, functionality, cost, durability, and quality attributes of structures (referred to as the lower order construct or LOC) and the preferences of users for water-tap traits (referred to as the higher-order construct or HOC). Conducting convergent validity testing is necessary in order to ascertain the quality of the model. The assessment of convergence validity involves the examination of factor loading, correlation coefficient, and area under the curve (AVE). In order to meet the criteria for factor loadings, they should exceed 0.4 but remain below 0.7. Additionally, the average variance extracted (AVE) should surpass 0.5, while the composite reliability (CR) should exceed 0.7. Despite the fact that the coefficient of correlation (CR) falls within the range of 0.6–0.7, it remains within an acceptable range for further examination in subsequent stages of study.

Table 3 shows that the factor loading, AVE, and CR values were higher than the threshold levels. Therefore, having proved convergent validity, the calculation can move on to determining discriminant

TABLE 3 Compilation of factor loading, AVE and CR.

Cultural dimensions	Items	Loading	AVE	CR
Collectivism	COLL1	0.721	0.519	0.886
	COLL2	0.739		
	COLL3	0.822		
	COLL4	0.728		
	COLL5	0.758		
	COLL6	0.850		
Masculinity	MAS1	0.784	0.602	0.672
	MAS2	0.755		
	MAS3	0.787		
Uncertainty avoidance	UAI1	0.819	0.649	0.900
	UAI2	0.843		
	UAI3	0.829		
	UAI4	0.776		
	UAI5	0.759		
Power Distance	PDI1	0.819	0.662	0.871
	PDI2	0.843		
	PDI3	0.826		
	PDI4	0.743		
	PDI5	0.721		
Long-term orientation	LTO1	0.870	0.742	0.902
	LTO2	0.897		
	LTO3	0.904		
	LTO4	0.893		
	LTO5	0.767		

The average variance extracted (AVE) should be greater than 0.5, and the composite reliability (CR) should be greater than 0.7; 0.60 to 0.70 is appropriate for exploratory studies.

TABLE 4 Heterotrait-Monotrait Ratio (HTMT) for discriminant validity.

	Collectivism	Long time orientation	Masculinity	Power distance	Uncertainty avoidance
Collectivism					
Long time orientation	0.483				
Masculinity	0.178	0.090			
Power distance	0.272	0.174	0.091		
Uncertainty avoidance	0.126	0.080	0.565	0.142	

The HTMT, value for data was determined to be < 0.85 based on the obtained values.

validity. It is important to confirm the critical threshold of reflective measurement. The degree to which a construct is actually different from the others according to empirical standards is known as discriminant validity. The discriminant validity was determined using the heterotrait-monotrait (HTMT) critical threshold <0.85. The result of HTMT can be seen in Table 4. The formative measurement, variance inflation factor (VIF) needs to be confirmed to avoid collinearity issues among indicators (Hair et al., 2014). The VIF score should be <5. The result of VIF is served in Table 5.

After the factor loading, AVE and CR, HTMT and VIF test the next step was to ensure that the five cultural value factors and the users' preferences for water-taps were put together in a way that worked well. In the study, the correlations are between the five cultural value dimensions and the outside loadings of the

TABLE 5 VIF value of user preferences construct.

Appearance	VIF	Functionality	VIF	Cost	VIF	Durability and quality	VIF
App1	2.800	Funct1	3.781	Cost1	2.434	Dnq1	2.614
App2	3.356	Funct2	2.733	Cost2	2.571	Dnq2	3.162
App3	2.277	Funct3	2.342	Cost3	3.172	Dnq3	3.015
App4	2.703	Funct4	2.252			Dnq4	2.584
		Funct5	2.647			Dnq5	3.755
						Dnq6	3.429
						Dnq7	3.769

VIF > 5 indicates collinearity issue.

TABLE 6 Results of the structural equation model.

Hyp	Description	Path coefficient	Std. error	*t*-value	Result
H1	Collectivism → Water-taps preferences	0.131	0.108	2.223**	Supported
H2	Masculinity → Water-taps preferences	0.019	0.124	1.417	Not supported
H3	Uncertainty avoidance → Water-taps preferences	0.321	0.083	4.017***	Supported
H4	Power distance → Water-taps preferences	0.060	0.103	1.585	Not Supported
H5	Long-term orientation → Water-taps preferences	0.066	0.111	0.057	Not Supported

*$p < 0.01$, **$p < 0.05$, ***$p < 0.1$.

constructions of appearance, functionality, cost, as well as quality and durability. These may be due to the repeated hints of formative-formative measures for the builds of appearance, functionality, cost, and quality and durability of the water-taps attributes. Based on the t-value, the importance of the relationships can be figured out. The t-value is the standard way to figure out how important a number is. The link between the cultural value factor and water-taps preferences was identified. For the 1%, 5%, and 10% significance levels, the important t-values were 2.223, 1.417, 4.017, 1.585, and 0.057. The result of structural modelling is presented in Table 6.

The t-value can be utilised to evaluate the significance of the correlations. The recognised criterion for determining the significance of a coefficient is the t-value. The recognised criterion for determining the significance of a coefficient is the t-value; the calculation of the relationship between the dimension of cultural value and the concept of water-taps preferences. The critical t-value was 2.223, which is a significant level. Collectivism (path coefficient = 0.131, $p > 0.05$) and Uncertainty avoidance (path coefficient 0.321, $p < 0.1$) substantially affect the water-tap preferences construct, as shown in Table 4. The path coefficient values for collectivism, masculinity, power distance, and long-term orientation are less than the significant critical threshold, thus they do not significantly affect the construct of water-tap preferences.

7 Discussion

This study considered the cultural value influences on the development of water-tap design for ablution activities. Hofstede's cultural dimensions, such as collectivism, masculinity, uncertainty avoidance, power distance, and long-term orientation, were used to the test to see whether or not there is a link between those qualities and preferences for the design of water-taps. Structural equation modelling approach was used to evaluate the correlation between cultural value dimensions and user preferences on water-tap preferences. According to the study's findings, collectivism and uncertainty avoidance provided evidence in favour of the hypothesis on water-taps design preferences. Collectivist societies place a high value on interpersonal connections, interdependence, and community harmony. They strongly emphasise shared accountability, communal decision-making, and adherence to social standards (Agodzo, 2015). This correlation was shown to be statistically significant. This finding is in line with Hofstede's cultural dimension index where Malaysia has a collectivist cultural dimension (Taghipoorreyneh and de Run, 2020). This shows that people who live in collectivist societies prefer designs that encourage appropriate water consumption, considering the overall health and longevity of the group and prioritising group harmony and cooperation, which reveals a positive link with a preference for water-tap designs that encourage water saving.

In addition, the design of water-taps takes on significance when it is considered in the context of uncertainty avoidance, which is related to how cultures handle ambiguity (Hofstede, 2001). In order to lessen the confusion surrounding water use, the idea of water-taps with transparent, modest water tanks is crucial. With real-time visibility into water use, this design reduces uncertainty about water availability and allows the users to exercise better control over their usage. In order to accomplish these goals, the quality of such water-taps is

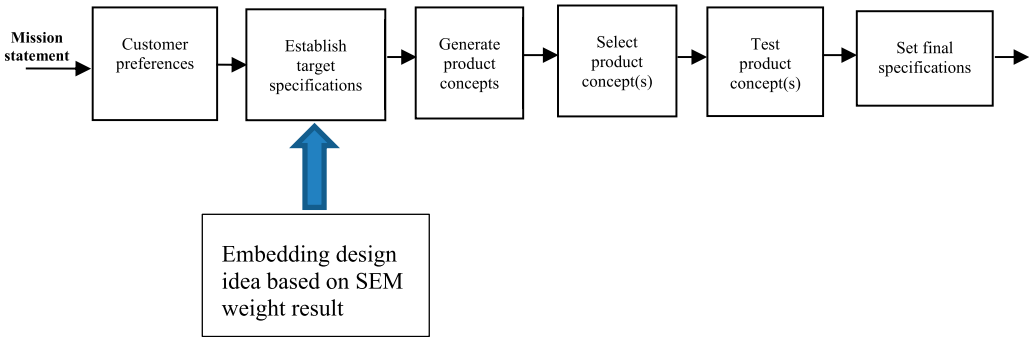

FIGURE 6
Use of the outer weight of SEM to establish technical specification of water-taps.

crucial, with leak-proof designs reducing waste and durable materials that ensure lifetime quality.

The other cultural dimensions were investigated, such as masculinity, power distance, and long-term orientation, did not reveal significant connections with the people's preferences for the design of water-taps that were used in ablution activities. However, it is essential to consider these dimensions in connection to the counterparts that they correspond to. For example, the opposite of masculinity is femininity; feminine user preferences may focus on appearance such softer aesthetics, style, colour and a more compassionate approach (Witek and Kuźniar, 2021). A low power distance suggests a preference for designs that are inclusive and accessible, and that aim to meet the requirements of all persons, irrespective of their position in any social hierarchy (Ghazali et al., 2017). A short-term perspective emphasises the immediate impact of water conservation initiatives, which may influence the design of systems that offer rapid visual feedback on water use.

It was believed that preferences for product design development could be considered as an abstract impression and altered by various reasons, such as the product's design, utility, and price (Bloch, 1995). Because the concepts that were used in product design development for all the phases were focused on the customer's or product users' preferences, the designers must determine the customer or user preferences at the beginning stages of the designing process (Ulrich and Eppinger, 2012). In this study the outer weight results from the Structural Equation Modelling (SEM) analysis were employed to identify the technical specifications of the water-tap design. SEM is a statistical technique that examines relationships between variables by utilising the outer weight results, which indicate the strength of the associations between the cultural dimensions and the users' preferences of the water-tap design. By reflecting on the outer weight rank, the designers can determine the most relevant technical specification and identify the design priorities of the water-taps.

As described in Figure 6, the outer weight that has been obtained from SEM will be used as the reference from the designer to identify the technical specification and give the weightage one to five value based on judgment and consideration of ability to produce the product, such as technical capability, capital, and human resources. This approach is adapted by several studies such as (Park et al., 2021), Karasan et al. (2022) who have performed the study on product design and used the weight that is given by design to determine design specification using the Quality Function Deployment (QFD) approach. Once all technical specifications are clearly identified, the next step is to multiply the weight from user preferences and weight from the designer. The result of this multiplication can be used as a relative weightage and to identify the priorities for the design of the water-taps. The users' preferences for water tap that are based on the SEM result and technical specification for water-tap design is described in Table:

Based on Table 7, most of the water-tap design prioritises an automatic refill water storage-to reduce water consumption and give a psychological impression of saving water, while the technical specification that relates to the user preferences is to use an automatic water level-control float vale, hence, implementing a mechanical water tap with auto stop function, and the use of a transparent water tank to indicate the amount of water being used during ablution.

7.1 Generating product concept

This research aims to create an ablution water tap that prompts users to pay closer attention to their actions. One novel way to raise users' awareness and encourage water conservation among Muslims is to incorporate a small, transparent water tank into the design of ablution water-taps. The two-layer layout features a 1-L reserve layer and a 1-L consumption layer. The top layer of spare water, which is not used, symbolises the water that may be conserved and remains untouched throughout the process. This see-through layer reminds the users to use only as much water as necessary throughout the ablution process. As the users can see the water level in the second layer dropping while they do ablution, it serves as a visual feedback mechanism to help them be more mindful of their water consumption. This design encourages the responsibility and awareness of water usage and helps people see how much water they need. According to Al-alawi et al. (2021), to raise the awareness of worshipers during ablution activities is an important strategy to minimise water usage during ablution activities. By incorporating small transparent tank in the water tap, the users can see how much water is available for ablution. In addition, the water level dropping after each use can be seen when they are using the water tap. Users

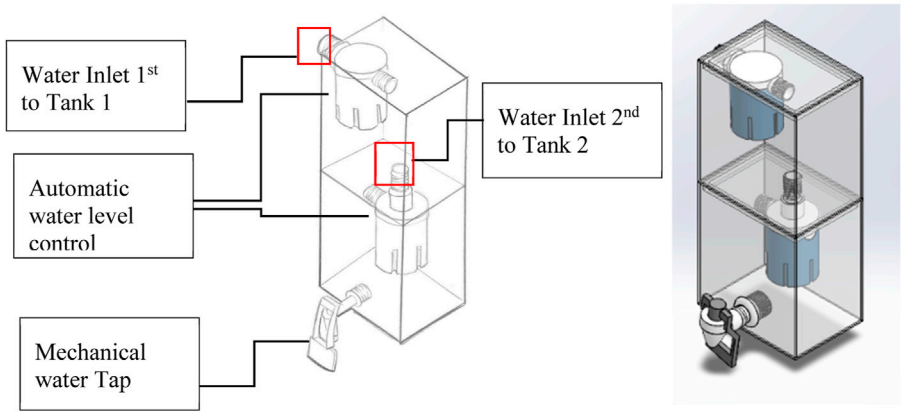

FIGURE 7
Design concept water tap.

TABLE 7 Water-taps design priorities.

User preferences on the water tap	Weight (A)	Technical specification	Weight (B)	Relative weight (AxB)	Design priorities
Reduce water consumption	0.373	Mechanical water-taps with auto stop function	4	1.492	2
Easy to use	0.368	Water tap function like water tap in water dispenser	3	1.104	6
Indicator to identify the water consumption	0.362	Water tank to indicate the water consumption	3	1.086	7
Automatically refill water storage	0.302	Automatic water level control float valve	5	1.51	1
Give a psychological impression of saving water	0.292	Transparent water tank	5	1.46	3
Long-lasting water tap	0.287	Consider durable material	5	1.435	4
Easy Maintenance	0.266	Users can perform self-maintenance and change the broken part	3	0.798	10
Comfortable	0.248	Water flow can be adjusted	3	0.744	11
Long-lasting system	0.246	Non-corrosion material	3	0.738	12
High quality	0.243	Consider durable material	4	0.972	9
Support high pressure	0.232	Automatic water level control float valve	5	1.16	5
Safety when performing ablution	0.211	Avoid sharp surface	5	1.055	8
The shape of water tap	0.174	Rectangular shape for water tank	3	0.522	14
Colour of the water tap	0.173	Transparent water tank	3	0.519	15
Texture of water tap	0.171	Non-slip surface	3	0.513	16
Spare parts can be obtained easily	0.171	Use water tap general water tap like a water tap dispenser	4	0.684	13
Low Price	0.167	Affordable price using	3	0.501	17
Low-cost maintenance	0.157	Easy to disassemble, the user can change the broken part	3	0.471	18

are constantly reminded to be aware of their use and minimise avoidable wastage by the evident decline in the water level. The concept designed of proposed water-tap design can be seen in Figure 7.

Inspired by water dispensers, the mechanical water-tap design can help Muslims save much water during ablution. To conserve water, mechanical water-taps might be modelled after water dispensers to dispense water in a measured fashion. A push-

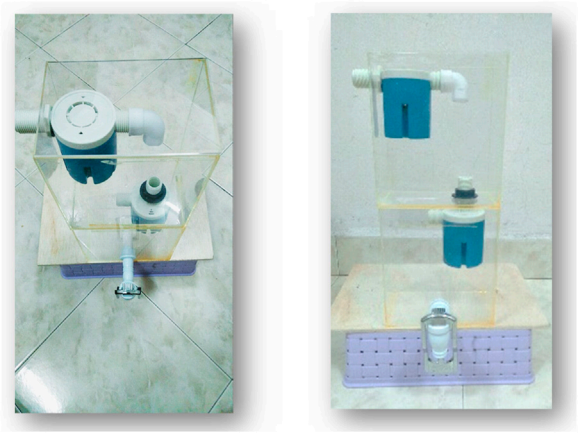

FIGURE 8
Water-tap prototype.

button or lever mechanism may precisely control the water flow, allowing the user to discharge the appropriate amount for each ablution step. Water stops flowing when the button or lever is removed, preventing any spillage even if the user does not want to waste any. This mechanical design encourages conservation by allowing the users complete control over the water flow and limiting the amount of water that is used in the ablution process. In addition to their already high efficiency, these water-tap may be outfitted with water-saving features such as adjustable flow restrictors or timers that further improve their efficacy and aid in developing more sustainable water practices. Mosques and other ablution facilities may actively encourage water conservation and provide a user-friendly and intuitive experience for Muslim worshippers by adopting a mechanical water-tap design that is influenced by water dispensers.

After identifying the users' preferences and technical specifications, the next stages involved sketching and creating 3D drawings. Sketching permits rapid investigation of various design concepts, whereas 3D drawings provide a more detailed visual representation of the tap's design. This phase allows designers to refine the design, make any necessary modifications, and ensure that the water-tap's functional and aesthetic aspects are considered.

7.2 Prototyping and testing

After the design has been finalised, the next step is to generate prototyping and testing the applicability of the designed water tap. Designers can evaluate the tap's functionality, ergonomics, and performance through prototyping. This iterative process identifies any design defects or improvement opportunities. During the trial phase, the prototype's water consumption efficacy is evaluated and compared to standard water-taps. The prototype of the designed water tap can be seen in Figure 8.

A water flow metre was incorporated into the testing procedure so that water consumption could be accurately measured. This device enabled accurate monitoring and recording of water flow during ablution. These water flow metres were installed in each of the thirty samples, including the designed and standard water-taps to measure the water that was used during ablution.

To evaluate the applicability of the designed water tap, this study performed a comparison of water consumption between the designed water tap and normal water tap. The result of the designed water tap and normal water tap can be seen in Figure 9.

As depicted in Figure 9 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 or a reduced 1–8 L. From the 30 samples that were used, it was found that 76.8 L of water were used for the designed water tap and 169.4 L for the normal water tap. By percentage, the designed water tap can reduce water usage by 54.6%. This result was similar to the water tap that was designed by Besari et al. (2009).

Cultural value influences are an important factor in determining the design specification. According to Bloch (1995); Salmi and Sharafutdinova (2008), culture should be considered during the design phase because it may affect the customer's or user's preferences when choosing the product. In this study, the technical specification of the water tap that corresponds with the user's preferences encourages water conservation, and adapts to the

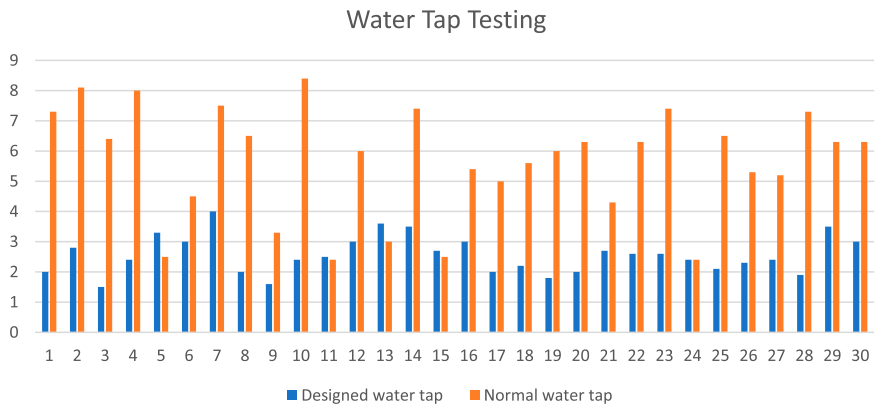

FIGURE 9
Testing result of prototype.

unique cultural context of ablution activities that have been performed after the significant hypotheses and the outer weight are identified from the structural modelling result. Based on this generated information, the technical specification can be focused (Ghazali et al., 2023). However, another specification also needs to be considered after the primary priority preferences.

8 Conclusion

This study emphasised the importance of incorporating the nature of users' behaviour through their cultural values into the design of water-taps. Five cultural value dimensions have been tested to identify the significant influences on the users' water-tap preferences. The approach of using outer weight from the structural modelling result has been performed and considered as a new approach to determine the design specification of water tap. By considering the cultural value, the design process of water-taps not only meets functional needs but also aligns with the cultural norms, beliefs, and traditions of various users' communities, thus, acknowledging their varied effect characters. User acceptance, adoption rates, and overall satisfaction have been positively impacted through the integration of cultural preferences. In addition, the incorporation of cultural consideration promotes inclusiveness, accessibility, and responsible water utilisation by water-tap users, thereby matching wider sustainability goals. The design process facilitates the promotion of pleasant relationships and trust between the designers and users, which helps to evaluate potential conflicts and misunderstandings in determining design specification. The cultural-centric approach plays a crucial role in enhancing the market success of water-taps by showcasing a genuine recognition of the cultural diversity that binds our global community.

This study contributes to both knowledge and practice. For knowledge, this study extends the application of Hofstede's cultural theory specifically in product design development. As for practice, to support the sustainability concern, the approach used in this study also can be adopted to identify green attributes in a product design. For instance, the designers have a list of green attributes in their product design to fit the user preferences such as light material usage, using non-toxic material, easy-to-disassemble design etc; the designer may adapt the approach of this study to get more insight and set a priority of green attributes based on customer cultural preferences. This study is limited to five of Hofstede's cultural dimensions, thus, a further study can elaborate on the dimension of indulgence-restraint to obtain a deeper analysis of cultural study for product design.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

IG: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing. NP: Project administration, Visualization, Writing–review and editing. EM: Supervision, Writing–review and editing. LA-M: Funding acquisition, Writing–review and editing. II: Funding acquisition, Project administration, Writing–review and editing. SH: Funding acquisition, Project administration, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2023.1281318/full#supplementary-material

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