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Alternative use of the house of quality concept to rectify a faulty design in a last-mile delivery thermos container: A case study in Thailand

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ABSTRACT

This study explored how the House of Quality (HOQ) concept helps rectify a faulty-designed container within the unique context of food delivery in Thailand. The objective was to empirically discover what food delivery personnel (FDP) want from a food delivery container in Thailand. In this case, a local container manufacturer in Thailand just created a prototype, but it was not cost-effective and did not satisfy the FDP. Therefore, the HOQ approach was introduced to guide/educate the practitioners to translate the needs of FDP into optimum specifications for delivery equipment. The results showed that users needed sturdy, lightweight, inexpensive, well-insulated, easy-to-use, suitably sized, attractive, and easily cleaned containers. These preferences were converted to technical specifications including the types of materials, design, cost of materials, thickness, weight, volume, and thermal conductivity. The findings suggested that the containers made of vacuum insulated panels provided space for cooling packs, partitions for food and beverages, and strips for securing the container to the vehicle. Additionally, our study recommend that the price should not exceed 2,000 Baht/box, and the container should have a thickness of approximately 2.5 cm, a weight of 0.5-3 kg, a capacity of 55 litres, and thermal conductivity of about 0.02-0.08 W/m-K.

Keywords: food delivery personnel; last-mile delivery; delivery container; house of quality

1. INTRODUCTION

Fast-paced lifestyles, in worldwide urban areas, have fuelled the need for last-mile food delivery like never before. Consumer research has shown that city dwellers demand freshness, convenience, quick delivery, and operational effectiveness from last-mile delivery services (Kimes, 2011; Yeo et al., 2017). Therefore, last-mile food distribution of the temperature-controlled supply chain has gained significant attention to satisfy the growing customer demand. Last-mile delivery is typically categorized by a small volume within a short delivery distance and packed to fit in a small delivery container (volume of less than 55 litres in general) (Morganti and Gonzalez-Feliu, 2015).

Meal delivery is considered a revolution in the food industry since it reconciles two major rival sectors: food away from home and food at home. The lockdown situation due to COVID-19 in Bangkok tripled the adoption of the “food delivery to home” culture in just a few weeks (Promchertchoo, 2020). Many restaurants find themselves not needing to compete with food at home but have found a new business opportunity in the "be at home" segment to gain more revenue and recognition in the digital marketplace. In 2019, the volume of food delivery was about 33-35 billion Baht (KResearch, 2019). Small restaurants without their own online need to use channels partner with online food service intermediaries such as Food Panda, Get, Line Man, Grab Food, and Lalamove to boost their sales. On the other hand, well-established chain restaurants such as The Pizza Company, KFC Delivery, and S&P Delivery have their own delivery systems, need intermediaries. In Bangkok, the increasing trend in food delivery services and the insufficient supply of appropriate delivery boxes affect the quality of food being delivered. Unfortunately, many local food delivery container manufacturers fail to provide the right products to food delivery personnel (FDP).

1.1 The house of quality

The limited dissemination of house of quality (HOQ) among practitioners is the focal problem. Although the concept was invented in 1960, faulty design products can be found in various industries in different venues, including users' reviews and recalled incidents. Furthermore, the current utilization of HOQ is still limited to a few industries and regions. Two factors that inhibit dissemination are the lack of understanding of the concept and the hesitancy to adopt the concept. The adoption challenge is caused by human factors, which can be overcome by training and education. This study expects more adoption among practitioners by providing a real-world example.

Historically, the concept of HOQ originated back in 1972 at the Kobe shipyard of the Mitsubishi Heavy Industry (Hauser and Clausing, 1988) . This concept was further developed by Toyota and widely used by Japanese manufacturers in various industries (Hauser and Clausing, 1988). The HOQ concept is based on quality function deployment (QFD), which is a management approach to help design products effectively and efficiently (Hauser and Clausing, 1988). QFD was used in product development (Naspetti et al., 2014), service design (Khanna and Arya, 2015; Muda and Mat Roji, 2015; Tsoukalidis et al., 2009), and system development (Myers and Maani, 1995). The cost-effectiveness of QFD uses mathematical modelling to minimize cost and maximise customer value, subject to technical requirements (Prasad et al., 2011). The HOQ visually enhanced the QFD further by borrowing some QFD elements and categorizing them into "house" components, which makes this tool easier to understand for non-technical audiences.

The HOQ approach is a multidisciplinary design concept in product or service development that includes various perspectives regarding product or service requirements (Baran and Yıldız, 2015; Temponi et al., 1999). Seven main regions in the HOQ (Moradi and Raissi, 2015) are shown in Figure 1. The HOQ proposes that products should be designed and made to reflect customers' desires; therefore, marketing, product design, and manufacturing staff must work together to achieve the ultimate specification (Hauser and Clausing, 1988). The objectives of this study are to use HOQ to unearth the needs of the end users of food containers and to develop technical specifications based on these end-user needs.

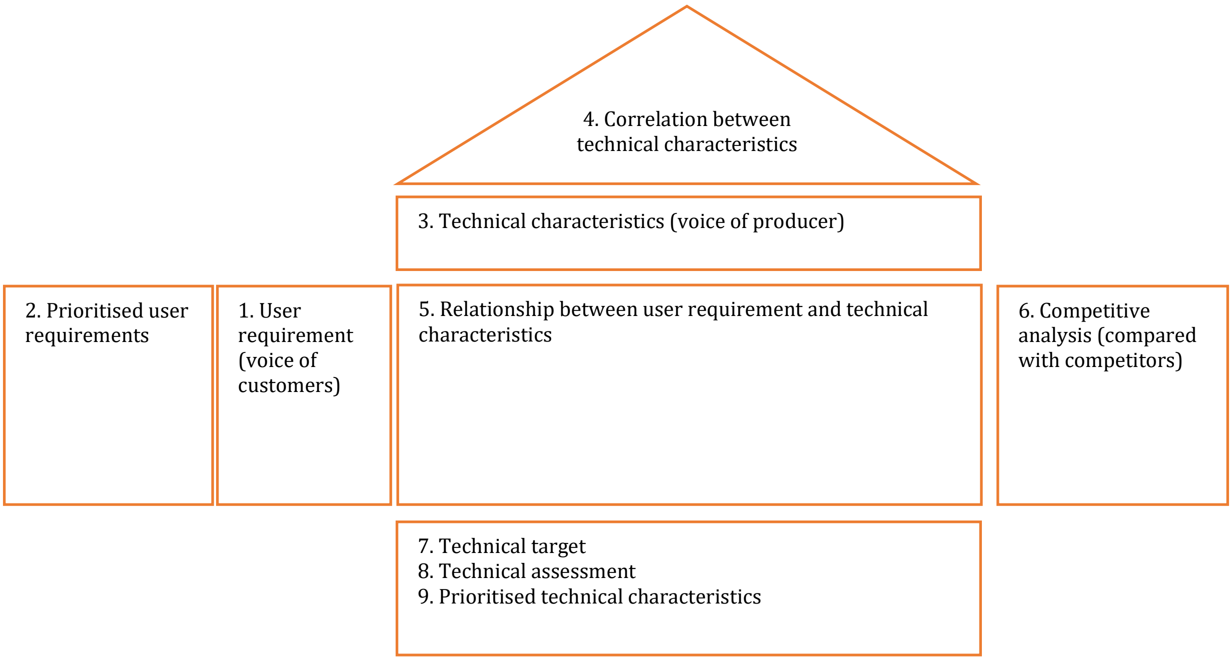


Figure 1. House of quality structure (Jaiswal, 2012; Moradi and Raissi, 2015; Temponi et al., 1999)

1.2 Background of the case

A food delivery company asked a local container manufacturer to create a temperature-controlled food delivery box. This food delivery company approached this group of researchers and asked them to evaluate the prototype before using it in mass production. The manufacturer built the prototype based on the availability of raw material in its cold storage box production line. However, the prototype was not cost-effective, and it did not satisfy the FDP. All key members of the design team were interviewed to determine the logic behind the faulty design. Then, instead of just pointing out the causes of failure, researchers walked the local manufacturing team through the whole design process using the HOQ approach. Their design team would learn more from the interaction with FDP during interviews and could master this concept to prevent the same problems in the future. In this case, the HOQ was introduced to solve the failed prototype design. FDP interview sessions and questionnaires were conducted. The results from the FDP survey reflected the multi-faceted nature of quality. The lack of understanding of what quality meant to FDP resulted in this faulty design. The failed prototype was proof that only involving design engineers and manufacturing staff is insufficient to create the right product for FDP.

1.3 Contribution of this paper

Faulty design is a common mistake in various industries, including the food delivery sector. Its serious consequences have contributed to numerous waste and safety issues in our society. This is a contemporary problem, and fixing it could help all stakeholders avoid many issues. The common design practice of trial and error could not address this contemporary problem promptly; therefore, practical research is needed to promote the use of more effective and preventive approaches, such as the HOQ.

In addition, this pioneering study empirically highlights the voice of FDP in Thailand. Based on interviews with executives from major food delivery companies and box manufacturers, this study is the first to use HOQ with a customer-involvement approach to guide the design process of food delivery containers. Both contributions respond to the need to bridge the gap between theory and practice, which is critically needed in supply chain research (Garver, 2019; Goldsby and Zinn, 2016). This study not only provides business insight through this unique case but also shows how to use a practitioner-level theory to solve business issues (Garver, 2019; Goldsby and Zinn, 2016; Zinn and Goldsby, 2017). Therefore, this study adds to the body of knowledge in two primary aspects. The result showed that the HOQ concept helped this local company solve its specification issue reasonably well. The HOQ concept was also able to adequately address the challenges of the unique food delivery industry, extreme tropical climate, and heavy traffic in Bangkok, Thailand.

1.4 Why Thailand?

Although the scarcity of research within the region is a primary research gap, there are four other reasons Bangkok, Thailand, providing a unique opportunity to study last-mile food delivery. First, Thailand is one of the very few countries with an influential street food culture. In this culture, "food at home" and "food away from home" overlap more than in other cultures. Using last-mile food delivery, the lifestyle of "eating restaurant food at home" was widely and rapidly adopted among Thai people. Notably, during the COVID-19 lockdown, over one-third of the Bangkok population ordered food online, three times the number from before COVID-19. Second, in urban areas, Thailand has ubiquitous use of motorbikes as a mode of transportation. In our findings, public motorbike taxi drivers played a vital role in food delivery. Third, Bangkokians already embrace the digital lifestyle with activities such as using digital money and ordering products online. Ordering food online to eat at home is not new to them, so it was quickly adopted. For example, the COVID-19 situation accelerated the adoption threefold within a month (Promchertchoo, 2020). Fourth, Bangkok has many well-established digital facilitators like Grab and Line Man in the marketplace. Application familiarity and trust in these companies accelerated the adoption of ordering food online, thereby fuelling the last-mile food delivery operation like never before. Finally, the tropical climate of Thailand requires use of a "portable" temperature-controlled box year round. For these reasons, Bangkok, Thailand, is a prime location to conduct this study.

2. MATERIALS AND METHODS

Since COVID-19 disrupted both current demand and supply landscapes, previous research provided no relevant insights to this study. To effectively investigate this unexplored realm, a mixed qualitative and quantitative method was adopted (Brannen, 2017; Östlund et al., 2011; Yardley and Bishop, 2011). The qualitative approach in the mixed method helps improve the breadth and depth of findings, while the quantitative approach ensures empirical support for the findings (Fassinger and Morrow, 2013; Östlund et al., 2011; Pole, 2007).

Following the mixed method guideline by Brannen (2017), a focus group, with a panel of 10 experts, was conducted to gain insights for questionnaire construction. This multi-functional panel consisted of an engineering executive, a manufacturing executive, and eight FDP (six full-time FDP and two part-time FDP). The findings from the group interview revealed multi-dimensional qualities related to temperature-controlled food delivery containers. We used these insights to construct questionnaires.

After the same group of panellists validated the face validity of the questionnaire to ensure readability, the quantitative approach was then adopted by administering the final questionnaires with 100 randomised FDP. This short and precise questionnaire was conveniently administered in a paper–pencil format within 5 minutes. The researchers administered the questionnaires in person by handing them directly to respondents, clarifying any questions immediately, and collecting the completed forms. This face-to-face questionnaire administration resulted in 100% usable responses. Respondents were from all major delivery companies in Bangkok, consisting of 41% Grab, 22% Line Man, 14% Food Panda, 10% Get, 6% Lalamove, 4% Ginja, and 3% Scoota. This sample group consisted of 72% part-time and 28% full-time drivers, which reflected a similar 80:20 ratio in this industry, based on the executives' interviews. The questionnaire was constructed using a five-point Likert scale format, where 5 = very important, 4 = important, 3 = neutral, 2 = unimportant, and 1 = very unimportant.

According to the HOQ procedure, the voice of the customer was the starting point of building the house, followed by defining technical characteristics, quantifying their importance and relationship, calculating the correlations of technical aspects, and comparing the container with those of competitors as follows.

2.1 Identify the FDP's need

To identify the FDP's desire, the questionnaire was designed to prioritise those feasible user requirements, based on an importance rating, using a five-point Likert scale, where five is very important and one is not important.

The survey results were derived from the 100 usable responses from FDP through randomised sampling.

2.2 Identify the user requirements

The user requirements derived from the FDP were filled in the HOQ in zone 1 in Figure 1. Next, a weight was determined based on the result of average importance score of the survey results. Then, a relative importance score was calculated using the importance score divided by total importance scores. Finally, zone 2 was filled in.

2.3 Identify the technical specifications

The user requirements, from brainstorming sessions, were used to establish feasible technical specifications and fill in zone 3. A group of two FDP spokesmen, a design engineer, and a container manufacturer helped define technical features of containers, such as the type of material and thermal conductivity. It is important to note that the two FDP spokesmen were invited to be involved in the whole HOQ process. These FDP spokesmen were the two full-time drivers from the questionnaire formulation group. They were recommended by the two executives to be "spokesmen" to provide active end-user voices through the whole HOQ process. These two spokesmen had over five years of experience in their job and still perform this job daily. Both were quite outspoken and not shy when sharing their thoughts. The two FDP spokesmen, an engineer, and a manufacturer helped conduct feasibility evaluations for each requirement.

2.4 Identify the correlations among technical characteristics

The correlations among technical characteristics were determined and categorised into five different levels: strongly positive correlation (+++), positive correlation (+), no correlation ( ), negative correlation (−), and strongly negative correlation (▼). Then, zone 4 was filled in.

2.5 Identify the correlations between user requirements and technical characteristics

Correlation factors of each relationship between user requirements and technical characteristics were categorised into three levels: strong (Θ), moderate (O), and weak (▲), using the symbols represented in the parentheses, which are equal to a score of 9, 3, and 1, respectively. Then, zone 5 was filled in.

2.6 Analyse competitors

Competitive analysis was performed with five competing containers against the prototype design, ranking each entry with a score ranging from 0 to 5, worst to best, respectively. To evaluate if the prototype was feasible, it was compared to five existing food delivery containers. Prototype A was designed and built by a refrigeration company using polyurethane. Five existing containers were then selected for comparison purposes. These boxes are currently used in Thailand, Taiwan, and Germany, as shown in Figure 2. The containers B, D, and E were obtained from a trade exhibition in Thailand; container C was from the Industrial Technology Research Institute in Taiwan (ITRI); and container F was purchased from a delivery rider for a food delivery company in Thailand. Then, zone 6 was filled in.

2.7 Establish the technical target

The technical target was established for all technical requirements. Then, zone 7 was filled in.

2.8 Assess the technical characteristics

The technical assessment was performed by determining the difficulty of incorporating the technical requirements as targeted. It ranges from 0 to 10, defined as easy to accomplish to extremely difficult to accomplish. Then, zone 8 was filled in.

2.9 Prioritise the technical characteristics

The technical characteristics were prioritised by computing the technical importance score. This score is the summation of the products obtained by multiplying the relative user requirement importance score and the relationship score of the user and technical requirements for each container. Then, relative technological importance scores were computed from the individual technical importance scores divided by the total technical importance scores. Then, zone 9 was filled in.

Figure 2. The current delivery containers in the market. (A) the prototype, (B, C, and E) containers from a trade exhibition in Thailand, (C) a container from ITRI, (F) a container from a food delivery

3. RESULTS AND DISCUSSION

It is important to note that keeping the customer's voice involved in all HOQ stages is helpful and should be modified for all HOQ practices. Instead of leaving the customer's voice as initial input, having one or two end users involved in the whole HOQ process provided great benefit to the design and manufacturing teams because of interactive communication. In this case, the two FDP spokesmen involved in all steps of the HOQ process provided deeper insight to prevent a faulty design than the passive customers' voices alone. The two following discussions are good examples of the value of the customer insights.

3.1 The operating conditions of food delivery

Delivery containers are mostly deployed for use on motorcycles. However, an inconvenience can be occurred during gasoline service stops since the container frequently blocks fuel service access. In some cases, a large food order can make the container heavy and unwieldy. Some combinations of food orders, like those with spillable contents, cause delivery riders to take extra precautions with the container, which has an impact on safety. Current food delivery boxes have trouble maintaining temperature, leading to reduced food quality. Besides, the exterior appearance and structure tend to fade and deteriorate too quickly. Riders need a container that is suitable for motorcycle seats, with a stable and secure base, and suitable for food and drinks. Also, the food delivery box should be light, yet still strong, and should be made from durable materials that are easy to clean.

3.2 User requirement in the HOQ

Failing to incorporate customers' voices into the initial design process was the main reason for prototype failure. The customers' voices are non-homogenous, and this multi-dimensional perspective creates a challenge to define optimum specifications (Zinn and Goldsby, 2017). Although the customers' voices is the term originally used in the HOQ process, the passive nature of "initial input" implies a lack of customer involvement in other stages of the HOQ. This study not only started with customers' voices as initial input but also employed two knowledgeable FDP (so-called "FDP spokesmen") in all stages of the HOQ. These two FDP spokesmen constantly communicated with the design engineers and manufacturing staff to provide deeper insight and more interactive communication to help the design and manufacturing teams thoroughly understand the practical use of the container. This study calls the approach HOQ with add-on customer involvement.

To fulfil the consumers' voices portion of the HOQ, the study started by recruiting the aforementioned panel of 10 experts, including eight FDP within this panel. This expert group participated in a group interview to construct the questionnaire and also helped rank the importance scores (I). Then, insights from the interview were used to construct questionnaires in a five-point Likert format, which were later administrated with 100 FDP. Respondents were from all major delivery companies in Thailand. As shown in Figure 3, the quality of the container was rated at 4.2 (important), or ranked no. 3; therefore, the container undeniably plays an important role in the recruiting process. This ranking followed no. 1, "A popular career in Bangkok", at 4.5, and no. 2, "Company is trustworthy", at 4.30. The two food delivery executives in this group also said companies provided the containers and uniforms with or without a 1,200-1,600 Baht deposit collected from the FDP.

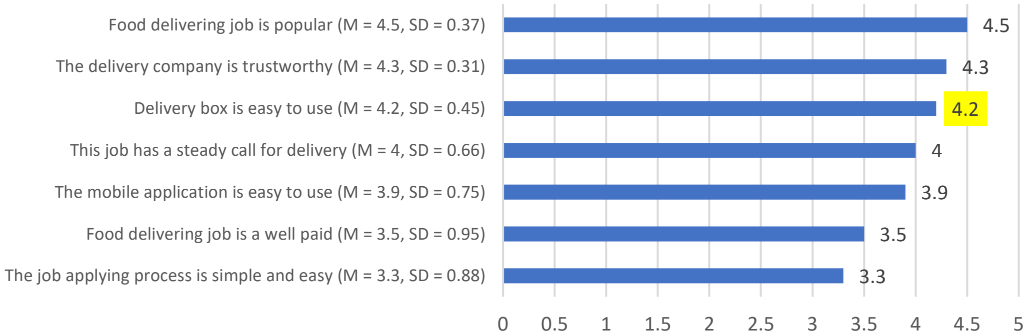


Figure 3. Importance of the studied factors in choosing a food delivery job

When asked about problems during delivery under the same five-point Likert scale format, containers were the top major issues (7 out of 12) for many FDP, as shown in Figure 4. The findings showed that the eight factors (keep temperature, easy to clean, suitable size, easy to use, lightweight, inexpensive, nice appearance, and durable) are the top issues during the delivery process. The open-ended question also recommended one more FDP desire - "antibacterial coating" - to be added to the list since seven respondents indicated "antibacterial coating" as an additional desire. Therefore, the initial critical features of a delivery container are keep temperature, easy to clean, suitable size, easy to use, lightweight, durable, inexpensive, nice appearance, and antibacterial coating. However, the antibacterial coating did not pass the feasibility evaluation and was dropped from the list. Only feasible user requirements were maintained after this process. In summary, the container is important for FDP in both choosing the job and avoiding problems during the delivery.

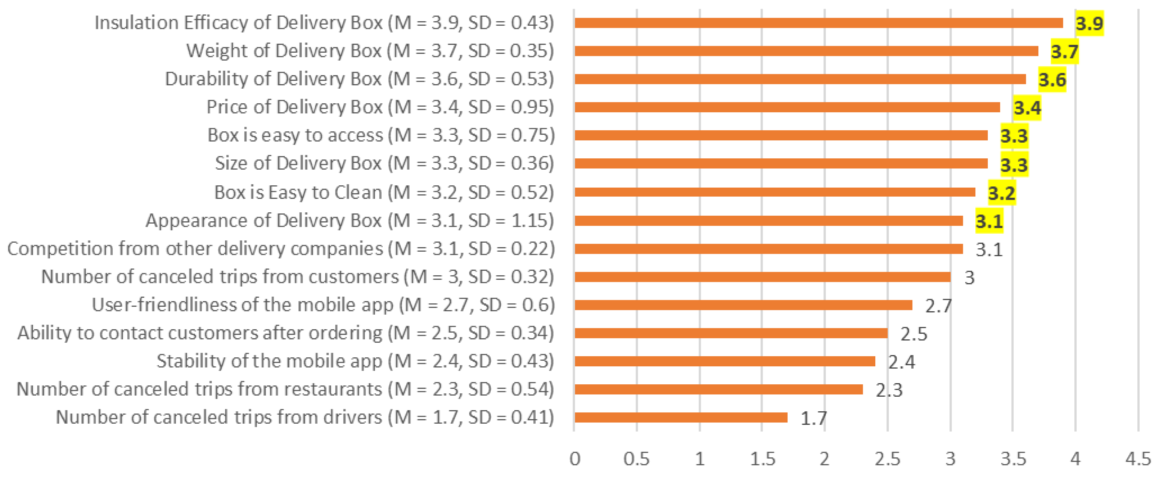


Figure 4. Importance of Studied Factors daring delivery issue

3.3 The rating and ranking of user requirements

During the rating and ranking process, the researchers ensured the group of 10 experts considered all critical aspects, including functionality, ergonomics, and sanitation. FDP who were using non-insulated food delivery containers raised the concern of deliveries being rejected due to food quality (e.g., melting of ice cream products, blooming of chocolate). The sanitation aspect was emphasised during the ranking to ensure awareness of the critical role of the "keep temperature" factor. The requirement characteristics were analysed to establish the weight of importance of each characteristic. The relationship between the user and technical requirements is from the importance rating (I), and relative importance (RI) can be calculated by Equation (1), as shown in Table 1.

$$Relative\ Importance\ of\ Requirement\ i\ (RI_i) = \frac{I_i}{\sum_{i=1}^{n} I_i} * 100 \quad (1)$$

where n is the number of requirements.

For example, the importance of "lightweight" equals to 5/34 *100 = 14.7%. The importance showed that the highest value is the most important criterion for the users of the delivery container. Lightweight, durable, inexpensive, and keep temperature all have the same weight. Suitable size and easy to use are ranked second. The least important are nice appearance and ease of cleaning. If we survey consumers who order food delivery, then the nice appearance may have a higher importance score.

Table 1. Importance score (I) and relative importance score of the user requirements

Desired quality (Customer requirement)	Importance score (I_i)	Relative importance score (%)
Lightweight	5.0	14.7
Durable	5.0	14.7
Inexpensive	5.0	14.7
Keep temperature	5.0	14.7
Suitable size	4.0	11.8
Easy to use	4.0	11.8
Nice appearance	3.0	8.8
Easy to clean	3.0	8.8
Total	34	100

3.4 Technical characteristics and their correlation

The HOQ, with all values, is shown in Figure 5. User requirements, from brainstorming sessions, are used to establish feasible technical specifications. There were seven technical characteristics: type of materials, design, cost of materials, thickness, weight, volume, and thermal conductivity. Next, the correlation among these technical characteristics was determined. For example, design has a positive correlation with other characteristics, whereas the type of materials is strongly positively correlated with thermal conductivity, cost of materials, and weight.

3.5 Correlation between the user requirements and technical characteristics

Each technical requirement has a relationship with one or more user requirements, with importance ranked in three levels. First, a low relationship carries a value of 1. Second, a medium relationship carries a value of 3. Third, the highest relationship has a value of 9. For example, the "type of materials" and "keep temperature" metrics are strongly related and receive a score of 9, since the material properties almost completely define how well the container can keep temperature. However, the "easy to use" and "type of materials" metrics are less related and received a score of 1 since the ease of use depends on design and usage more than the type of material chosen.

3.6 Competitive analysis

Next, we compared the technical characteristics of sample (A) with five competitors (B-F). They were selected based on the current usage in Thailand, Taiwan, and Germany. The score of each technical characteristic of five competitors was ranked based on expert judgement. The relationship among the technical characteristics is called the technical correlation matrix and appears as the roof of the house. Each pair of technical characteristics is classified into five levels. For example, there is a strong positive correlation between the type of materials and the cost of materials. If the material is of good quality, then the cost will increase.

3.7 Technical target, technical assessment, and prioritisation of technical characteristics

The final part of the house is the base, which is the calculation of the importance of and interrelationship between the user requirement and technical characteristics, as shown in Equation (2). A higher score implies that the technical characteristic in question is more important for the users, and product developers should give higher priority to that factor.

$$Importance\ of\ Technical\ Characteristics\ j\ (T_j) = \frac{\sum_{i=1}^{n} \rho_{ij} * I_i}{\sum_{j=1}^{m} T_j} * 100 \qquad (2)$$

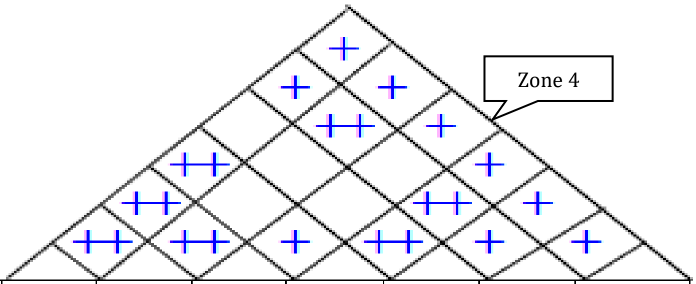
where ρ_{ij} is the correlation between the user requirement i and technical characteristics j, and m is the number of technical characteristics.

For example, the thermal conductivity importance score $= 9 * 14.7 + 9 * 14.7 = 264.7$, where the relative importance score is equal to $264.7/3185.2 * 100\% = 8.3\%$. The importance of technical characteristics is ranked in ascending order from the type of materials, design, cost of materials, thickness, volume, and thermal conductivity, as shown in Table 2. It showed that the most important factor that the developer of food containers should be aware of is the type of materials. It is involved in overall weight, durability, expense, and thermal properties. Hence, we suggested the insulated vacuum panel as the target material for food containers. Next, the design is also important in terms of suitable size, ease of use, nice appearance, and ease of cleaning. We suggested that the delivery container should have space to accommodate a cool/hot pack, a partition to separate the products, and a tie-down strip to attach the container to a motorbike. Then, the cost of materials is also the third key factor for the developer, since the FDP do not want to pay more than 2,000 Baht per box. Later, the dimensions of the box, such as thickness, weight, and volume, should be within certain ranges, as suggested. Finally, the thermal conductivity should be low or between 0.02 and 0.08 W/mC. Considering the difficulty associated with each target, the "inexpensive" target is the most difficult to accomplish, since it depends on the type of materials, design, and thermal conductivity needed by the FDP. The thickness, weight, and volume will be easy to accomplish once we determine the type of materials and design.

The context in this case study was unique, and the findings need further investigation before they can be applied to other cases. For example, lightweight was the highest-rated characteristic for two main reasons. First, customers in Bangkok, especially those who live in high-rise buildings, preferred delivery to their doors rather than drop-off/pick up at the reception areas. Therefore, most FDP must be prepared to scale three to four stories of stairs to deliver the orders. Second, the FDP must carry the box and queue up at the restaurants due to limited parking availability in areas of old urban planning. Therefore, lightweight was rated as the top factor. However, during the COVID-19 pandemic, delivery to the door was prohibited to minimise community contamination. This lightweight ranking might change, and future research is required to investigate this change. Another example involves the low ranking of the "inexpensive" characteristic due to the unique "rental uniform practice" culture in Thailand. Based on the rental practice, the container and a uniform jacket are provided by the company, with a flat deposit fee of 1,200-1,600 Baht. To promote brand recognition, the company absorbs this cost into its advertising expenses. Therefore, the price of a container does not impact the company's FDP's perception directly as it does in other parts of the world. Unlike public for-hire drivers, who represented 5% in this sample and are estimated to be less than 7% in the population, they put more concern on the price of the container. As the public for-hire sector grows toward a projected 30%, more research will be necessary to address this change.

Table 2. The relative importance or weight of technical characteristics in ascending order

Technical characteristics	Relative importance (%)	Suggested values
Type of materials	24.9	Vacuum insulated panel (VIP)
Design	17.7	Have space for cool pack or hot pack/have partition/have a strip
Cost of materials	14.7	2,000 Baht/box
Thickness	13.0	2.5 cm
Weight	12.7	0.5-3 kg
Volume	8.6	35-55 litres
Thermal conductivity	8.3	0.02-0.08 W/mC



Row #	Relative weight	Weight or importance	Technical / User requirement (Zone 1, Zone 3)	Type of materials	Thermal conductivity	Cost of material	Weight	Volume	Thickness	Design
1	14.7	5.0	Lightweight	Θ		Θ	Θ	Θ	Θ	O
2	11.8	4.0	Easy to use				O	O		Θ
3	14.7	5.0	Inexpensive	Θ	Θ	Θ	Zone 5			Θ
4	14.7	5.0	Keep temperature	Θ	Θ	Θ			O	O
5	11.8	4.0	Suitable size	Θ			Θ	Θ	Θ	Θ
6	8.8	3.0	Nice appearance	Θ						Θ
7	8.8	3.0	Easy to clean	Θ		O				▲
8	14.7	5.0	Durable	Θ		O	Θ	Zone 7	Θ	O
	Zone 2		**Target or limit value**	VIP	0.02-0.08 W/mC	2000 baht/box	0.5-3 kg	55 lite	2.5 cm	Having strip and partition
			Difficulty (0=Easy to accomplish, 10=Extremely difficult)	7	7	8	3	3 (Zone 8)	2	7
			Weight or importance	794.1	264.7	467.6	405.9	273.5	414.7	564.7
			Relative weight	24.9	8.3	14.7	12.7	8.6	13.0	17.7

User requirement	**Competitive analysis** (0=Worst, 5=Best) Zone 6					
Containers	A	B	C	D	E	F
1	1	2	4	4	5	3
2	1	5	2	5	5	5
3	2	2	2	2	2	2
4	1	5	4	4	3	3
5	1	5	1	3	5	5
6	4	5	1	5	5	5
7	5	5	2	3	5	5
8	5	4	4	3	2	4

Zone 9

Figure 5. The HOQ for a food delivery container

4. CONCLUSION

The HOQ could be alternatively used as a correction tool if it was not used as a preventive tool to start a designing process. In this study, the HOQ effectively provided a step-by-step guideline to help correct the faulty design of food containers. The self-explained procedures in each HOQ component helped the design teams reveal the critical design mistakes, with very few arguments, and significantly improved communication flow. Through the HOQ approach with add-on customer involvement, this study revealed eight feasible characteristics of food delivery containers. FDP ranked them in order of importance: lightweight, inexpensive, durable, keep temperature, easy to use, suitable size, nice appearance, and easy to clean. These rankings were converted into technical specifications in terms of the type of materials, design, cost of materials, thickness, weight, volume, and thermal conductivity. Finally, a set of seven technical specifications met the feasible targets. The prototype failed the top three evaluation criteria because it was too heavy for actual usage, the lid was difficult to open, and it was too expensive. Besides, other existing containers in the Thai market met these criteria more than the prototype. Therefore, this prototype is not marketable for these reasons, and the company needed to make a major change if it still wanted to make this box competitive in the market. Although the competitors' products outperformed the prototype, none of them are perfect, based on the list of specifications from the HOQ. This set of specifications helps guide practitioners to achieve the optimum design of future containers. This scientifically derived measurement will eventually lead to improvement in this industry.

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