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Self-service technology kiosk design for restaurants: An QFD application

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ABSTRACT

Self-service technology (SST) has been increasingly integrated into today's service industry. The ability to understand how customers perceive SST and improve its quality is therefore important for both researchers and practitioners. Applying the Quality Function Deployment (QFD) methodology, this research established an SST House of Quality (HoQ) structure for restaurants by synthesizing the inputs of consumers and restaurant industry experts, the managers. This HoQ presents a relationship matrix that allows restaurants to assess SST attributes in relation to SST technical design specificities in a measurable way. Such a relationship matrix can assist in designing restaurant SST to deliver better service and customer experiences. This research thus provides an illustration of how the QFD method can be a useful tool in SST service design in restaurants.

1. Introduction

Hospitality organizations have used various forms of information technology to help deliver their services to customers more effectively and efficiently while also improving the general quality of the services provided (Law et al., 2020). One recent trend in the hospitality industry is that some organizations are migrating away from traditional services delivered by human employees to the use of self-service technology (SST) where the services are co-produced by customers (Law et al., 2020; Kattara and El-Said, 2014). The use of SST allows hospitality firms to provide their services with fewer employees (Lin and Hsieh, 2011). The resulting cost savings due to lower personnel expenses can be quite significant benefits for hospitality organizations as the hospitality industry is traditionally human labor-intensive compared to other industries (Law et al., 2020).

This trend is illustrated by the use of cashless touch-screen kiosks or self-order and pay tablets in restaurants. This form of self-service has become increasingly popular after the two leading casual dining chains, Chili's and Applebee's, provided the option of ordering and paying for services using tablet-based touch-screen devices in 2014 (Hanks et al., 2016). A number of other restaurant chains followed suit (Ahn and Seo, 2018), and touch screen tablets have become a fixture on restaurant tables next to ketchup bottles and saltshakers (Filloon, 2017). Illustrating this trend, fast food chains such as Taco Bell are aiming to install self-service kiosks in all their locations by 2020 in order to reduce overall service transaction times and eliminate human cashiers (Papandrea, 2019). The use of SST in restaurants has led to increased profits, as customers purchase more food items and fewer human servers are needed (Hanks et al., 2016). It also serves as a valuable mechanism for gathering consumer consumption data (Filloon, 2017) and results in better customer service by increasing service flexibility and reducing the need to wait for service (Ozturk, 2016).

Most decisions to introduce SST appear to be driven by perceived operational efficiency related to labor savings as noted above. However, despite the growing enthusiasm from hospitality businesses for utilizing SST, not much is known about its impact on the delivery of service attributes and consumer experiences. Contrary to other industrial technologies that are mostly designed to improve retail revenue, SST in service-oriented industries is developed to have a significant impact on both service providers' balance sheet and customers' service experience (Banyan Hills Insights, 2018). However, SST is also subject to failures just like other types of service due to technology malfunction or user error. In spite of this, there is a lack of effort in developing SST functions and technical specificities to respond to such challenges. In addition, poor SST performance related to SST technology design or service design is known to result in one of the most dissatisfying incidents when customers are operating SST. This further underscores the need towards SST improvement (Meuter et al., 2000).

What is more, this topic has received very limited attention in the hospitality research literature (Ahn and Seo, 2018; Shin and Perdue, 2019). The existing literature has two major drawbacks. First, much of the existing studies on SST tends to follow the traditional service

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attribute-satisfaction research paradigm which treats SST as a service feature without considering how specific SST design elements affect the perceived service and consumer experience. Second, the existing studies regarding SST tend to separately examine the technology based on either the customer or the service provider perspectives (e.g., Ozturk, 2016; Law et al., 2015). Since these perspectives can differ significantly, this leaves a need to assess how specific technique or design elements impact service quality from both customer and servcie provider perspectives. In this regard, this research intends to address these current issues and contributes to the understanding of restaurants' self service technology by applying the Quality Function Deployment (QFD) methodology.

QFD is a method for developing design qualities through translating customer's demands into design targets (Akao, 1990). In other words, QFD identifies customers' needs and wants while converting them into a particular product or service design in order to meet those requirements. In doing so, service providers can prioritize the top design traits that best align customer needs and company goals. Therefore, QFD is often called as a "voice of the customer," as it has been an ideal product development methodology based on the analysis of customers' requirements. This customer-driven method is suggested to be applicable for not only tangible products but also nontangible products such as services (Paryani et al., 2010). Although there are a few scholars have previously suggested that QFD can lead to improvements in the delivery of services in the hospitality and tourim setting (Lehto and Lehto, 2019), the QFD method has received scare attention in hospitality setting.

The employment of the QFD method allows the unveiling of the multi-faceted interactions between SST technical design characteristics, customer preferences, and the perspectives of servcie providers in diverse settings. In this regard, the current study utilizes the QFD method in an attempt to better understand SST attributes and their relationship with design factors (i.e. technical specificities) synthesizing input from both customers and service providers in the restaurant context. Specifically, this study intends to apply the QFD method in assessing (1) restaurant consumers' SST attribute perceptions; (2) Restaurant managers' goal perceptions associated with SST service provision; (3) The disparities between the viewpoints of customers and managers in SST attributes, and (4) The relationships between SST attributes and SST design characteristics. Therefore, this study is expected to both increase the understanding of how QFD can be used to improve services enabled by SST in hospitality settings and encourage further applications of the QFD method in hospitaltiy service design.

2. Literature review

2.1. SST and its applications in the hospitality industry

SST is a service that is provided by customers at the service encounter through the use of any technology facility without direct contact with frontline employees (Meuter et al., 2000; Beatson et al., 2006; Fan et al., 2020). Therefore, customers are considered co-producers and contributors to the general service delivery procedure (Lin and Hsieh, 2011). Thanks to the emergence of information technology as well as a revolutionized service landscape, several industries, including the hospitality industry, have signifiantly embraced SST. The banking and retail industries were among the first to adopt SST. The first automated teller machine (ATM) was introduced in the banking industry in late 1960s (Chris, 2016). Afterwards, the first modern SST gadget was utilized in grocery stores, a self-check out kiosk, was introduced in the early 1990s (Chris, 2016). Since then, SST has flourished in the hospitality industry due to the introduction of modern technology that enables rapid, convenient, consistent, and controlled service to its users (Beatson et al., 2006). More importantly, SST lessons the labor-intensive charateristics of the hospitality industry while reducing the significant amount of service prociders' costs by increasing the customers' involvement in the service process (Law et al., 2020). Not surprisingly, SST has been applied widely across the overall hospitality industry in a variety of forms. According to Shin and Perdue (2019), SST can be categorized by its purposes such as mobile SST (e.g., mobile hotel check-in and check-out), online SST (e.g., online flight check-in), onsite SST (e.g., self-service kiosks), transaction services (e.g., hotel and flight reservations), and self-help services (e.g., hotel SMART concerige systems).

Among different hospitality areas, SST has been enthusiasticly embraced in the restaurant industry. Today's restaurant customers can peruse menus, self-order, and customize their food through mobile apps, tableside tablets, and self-service kiosks. Since late 2013, when the restaurant industry introduced in-store iPads, SST such as tabletop multi-touch screens have been used to increase customer engagement in the service process (Ahn and Seo, 2018). Two major American casual dining chains, Chili's and Applebee's, have allowed their customers to order and pay their bill through tablet-based touch-screen devices since 2014 (Hanks et al., 2016). The CEO of Panera Bread, a bakery-café style causal restaurant, has also announced that their restaurants will provide self-service touch-screen stations for their customers (Hanks et al., 2016). In the similar vein, most of the 14,000 Mcdonald's locations and all Taco Bell's locations in the U.S. are planning to invest in self-service kiosks by 2020 in order to reduce the overall service transaction time (Papandrea, 2019).

SST applications in the restaurant industry is a trend that will be continually monitored. SST usage in restaurants have brought the higher check averages as well as increased marginal profits compared to when they offered traditional human service exculsively (Hanks et al., 2016). Providing empirical evidence, Papandrea (2019) notes that when customers complete their orders through SST, they tend to spend 20–30 % more at restaurants, because it is easy to add on extra condiments and drinks through SST devices. As a result, today's restaurant customers are highly encouraged or even forced to use SST (Beatson et al., 2006). According to Ahn and Seo (2018), there has been significant growth in the number of diners who use SST compared to the previous year. There are over 85,000 SST kiosks across the U.S., serving over 1 million restaurant customers each day.

This study found a few researchers have examined roles of SST on customers' service perceptions. Service received via SST is relatively more accurate and consistent than service by human employees (Williams and Savage, 2019). Therefore, higher levels of perceived service customization and greater control on the service delivery process due to customers' involvement are considered as crucial strengths of SST (Meuter et al., 2000). Bitner et al. (2002) insisted that SST increases customer satisfaction and loyalty as it successfully alters the traditional service provided by human employees. They also suggested that faster speed of the process and easier access to the service encourage customers to prefer SST over human service (Bitner et al., 2002). Similarly, Collier and Barnes (2015) found that hedonic aspects of SST such as perceived control can be a significant predictor of customer delight. In a more recent study, Kim and Qu (2014) suggested perceived usefulness, ease of use, and compatibility factors of SST will improve SST users' experience, satisfaction, and positive attitude.

2.2. SST design methods and current challenges of SST

Due to several significant benefits of SST, approximately 88 % of service companies believe that SST will be one of the fastest growing areas in customer service (Bridgwater, 2019). In practice, there have been various methods of building and designing SST for service companies. For instance, one approach is using computer-aided design (CAD) for drafting the conceptual design or layout of SST gadgets. CAD can be productive and easy to use or modify the design as it is based on the computer-based system (Wu et al., 2015). Other SST providers conduct a competitive analysis to adopt strength while avoiding drawbacks of other companies where SST are already implemented in their service operations (Paryani et al., 2010). However, it is difficult to incorporate customers' perspectives via these approaches.

Overall, there are a few significant challenges of the current SST design that are noticeable. According to Dabholkar and Spaid (2012), due to the limitations of technology itself and potential errors of SST users, it is unlikely to avoid SST failures, especially when considering that not every customer has the required knowledge or skills to perform their tasks through SST. This leads to a higher risk of SST failures compared to the traditional employee service (Shin and Perdue, 2019). On the other hand, there is currently a lack of service recovery functions or technical specificities on SST to respond to this service failure (Fan et al., 2020). Meuter et al. (2000) made aware of SST failures two decades ago, the problem still remains today. This suggests that SST providers have not sufficiently considered customers' requirements (Robertson, 2012; Fan et al., 2020).

Additionally, as noted by Meuter et al. (2000), poor design represents a major dissatisfying incident when customers are operating SST. The study of Meuter et al. (2000) shows that technology design problems (e.g., customers accidentally bought the same item twice due to confusion resulted from using a SST system), as well as service design problems (e.g., customers cannot use certain coupons with SST) lead with 36 % of their respondents to not be satisfied with SST. Similarly, Oh et al. (2013) emphasized the need to make conscious efforts to address customers' concerns in SST design as current SST do not satisfy the customers' emotional side of their transaction goal. On the same note, using a tracking study, Robertson et al. (2016) discovered that the complicated design is the major source of customer dissatisfaction with SST as it hinders customers' ability to use such services.

In a nutshell, SST allows service providers to standardize their service delivery to reduce labor costs while expanding options for service delivery (Curran and Meuter, 2005). However, the challenges discussed here can lead to SST service failure and dissatisfaction. Therefore, it is critical to understand how best to design, manage, and promote such technologies from the perspectives of both the business and the consumers (Curran and Meuter, 2005).

2.3. SST quality measures

In contrast to the research done on traditional service provided by human employees, there is not much research on SST quality. Dabholkar (1996) recognized the necessity of systematic service quality measurements for SST at first, because he noted that some quality measurements for the traditional face-to-face service were problematic to apply in SST service quality measure due to its unique characteristics. Therefore, he proposed a new service quality construct which consists of five different service criteria: speed of delivery, ease of use, reliability, enjoyment, and control. However, he found that only three dimensions (i.e., ease of use, enjoyment, and control) out of the five have a significant effect on customers' SST perceptions and their satisfaction. Afterwards, Dabholkar and Bagozzi (2002) developed the SST quality scale for the fast-food restaurant context using scenarios with three primary key constructs: ease of use, performance, and fun. About a decade later, Yen (2005) proposed online self-service quality measurements that were defined by efficiency, ease of use, performance, perceived control, and convenience. Later on, Lee et al. (2009) suggested SST quality measurements in a retail context consisting of reliability, personal attention, comfort, and features. Similarly, Ding et al. (2011) developed e-SELFQUAL with four factors: perceived control, service convenience, customer service, and service fulfillment.

Lin and Hsieh (2011) suggested SSTQUAL through both qualitative and quantitative research making use of seven different dimensions: functionality, enjoyment, security, assurance, design, convenience, and customization. Compared to the previous studies, this SSTQUAL by Lin and Hsieh (2011) offers more complete coverage and understanding of SST customers in evaluating SST quality across different industries and contexts. This has resulted in SSTQUAL (Lin and Hsieh, 2011) being adopted by a number of researchers to examine perceived service quality of different contexts of SST. For example, Singh (2018) used the SSTQUAL scale to investigate customers' service perception of self-service check-in kiosks at airports. His results suggested that functionality has the strongest effect in terms of determining SST customer service perceptions. Considine and Cormican (2016) applied SSTQUAL to examine the different perception of SST in financial services based on industry experts' opinion. The result of this study indicated that security is the most important among SST attributes, whereas design and customization aspects are relatively less critical (Considine and Cormican, 2016). However, it was notable that the majority of the studies related to SST focus on either customer or service providers' perspective exclusively. Therefore, this research intends to bridge the dichotomy of the two perspectives by directly comparing and contrasting SST attribute preferences of consumers with those of service providers. Given SSTQUAL developed by Lin and Hsieh (2011) has been seen as a stable measure for SST related service quality, this research intends to adopt this scale to measure restaurant SST service quality as part of our QFD application.

2.4. QFD and its applications

QFD is a "systematic approach mapping the customer's needs into definable and measurable product and process parameters, using matrices and other quantitative and qualitative techniques" (Bickness and Bicknell, 1995, p.28). QFD was introduced by Mitsubishi Heavy Industries Limited in the Kobe Shipyard, Japan in 1972. In the early 1980s, automobile companies such as Ford Motor and manufacturing companies such as 3 M Company introduced QFD concepts in the United States (Chan and Wu, 2002). Since then, many other companies have realized the remarkable benefits of QFD, and consequently, this tool continues to grow in popularity beyond Japan and the United States. QFD is generally considered as a larger process with four different phases: product planning, deployment, process and manufacturing planning, and production planning (Michael et al., 1999). However, the most basic core design tool of QFD is the House of Quality (HoQ) which showcases the summarized product planning matrix (Kurtulmuşoğlu and Pakdil, 2017; Cohen, 1988). This study further discusses HoQ in-depth within the methodology section.

According to Chan and Wu (2002), there are two major components of QFD development: to improve the quality of design and to provide manufacturing with the planned quality control chart before the initial production. Consequently, QFD has been predominantly applied in manufacturing and civil engineering industries. For example, Wang (2017) applied QFD to identify key features of smart phones in order to forecast the future trend because electronic gadgets are characterized by its marketing requirements and technical specificities. Similarly, Homkhiew et al. (2012) utilized the QFD technique to produce the new prototype of furniture characteristics based on customers' desire. Meanwhile, Benner et al. (2003) identified how the food manufacturing industry has adopted QFD into food products. In another example, Dolgun and Köksal (2018) conducted a case study of plain yogurt that used QFD to gather hedonic ratings of potential new products based on taste, odor, and texture to better understand what customers prefer.

QFD can be of importance for the hospitality industry as it defines what is the especially critical service factor that determines customers' service attribution. According to Paryani et al. (2010), QFD is a profitable tool for the hospitality industry as it determines an effective development target for the prioritized product and service characteristics. What is more, as per Crick and Spencer (2011), QFD is the most promising approach to evaluate customers' service perceptions in the hospitality industry since it measures customers' expectations and actual experience evaluation of the received service at every service stage. QFD can be a desirable tool to align customers' voices with business priorities and goals. In addition, it allows the development of a holistic view of the service delivery as well as the design process. However, QFD has not been utilized as much as it can be despite of the acknowledgement in the literature.

We found two notable applications. Jeong and Oh (1998) applied QFD methodology to examine which hotel service attributes are particularly important for hotel customers and its relationship with service design requirements. To do so, they examined the link between SERVQUAL by Parasuraman et al. (1985) which is the service quality scale as customer requirements and hotel service characteristics based on several departments: fronts desk, housekeeping, and food and beverage. In a similar vein, Kurtulmuşoğlu and Pakdil (2017) applied QFD in the lodging industry in order to seek improvement of service attributes through the mixture of managers and customers' viewpoints. It is noticeable that QFD applications in the hospitality industry is lacking, evident from not only the limited number of studies but also the limited research contexts.

In this regard, this study applies QFD into an SST design in a restaurant setting to understand how restaurant customers face SST at the service encounter and increase their service experience through the relationship between SST attributes and SST design characteristics. According to Hauser and Clausing (1988) it is challenging to design a product or service that satisfies every customer at once. Therefore, it is essential for service providers to learn from customer experiences to reconcile the priority of the product design to make their customers happier and enhance its advantages. Especially, a number of today's restaurants have invested high technologies including SST while minimizing the customer-employee's face-to-face interactions. Considering restaurants are one of the service-intensive hospitality industries, unlike other manufacturing technologies that are mainly developed to increase retailers' bottom line, SST in restaurants should have ways to improve both restaurants and customer experiences better (Banyan Hills Insights, 2018).

3. Methodology

Although traditionally there are four phases in QFD including product planning, deployment, process and manufacturing planning, and production planning (Michael et al., 1999), this research concentrates on the initial phase: product planning. Specifically, product planning consists of translating customer requirements into engineering characteristics which is the main objective of this study. The main focus here is developing a relational matrix framework known as the HoQ. HoQ is a core vehicle to translate customer requirements into engineering design specificities. In other words, HoQ is a part of the QFD that appears as a diagram with a house shape and it is utilized for product development purposes. HoQ captures how certain engineering characteristics of products or services affect different aspects of its attribution (e.g., Jeong and Oh, 1998; Michael et al., 1999; Paryani et al., 2010). Not surprisingly, it includes various pieces of information such as customer needs, service design/management requirements, target design goals, and service evaluations, but they are organized in an orderly relational framework (see Fig. 1). For this reason, Hauser and Clausing (1988) described HoQ as a "road-map" or "navigation chart" that becomes a conceptual map providing the means of inter-functional product planning. The baseline argument for HoQ is that any product or service should be designed based on customers' desires and requirements that reflect QFD's customer-driven characteristic (Hauser and Clausing, 1988).

The first step in developing a HoQ is to identify customer needs and wants. These needs and wants are corresponding to *Customer Requirements* (WHATs). These requirements are also known as the voice of the customer, and in the current context would reflect what customers expect from their service providers. This study adopted Lin and Hsieh (2011) SSTQUAL measurement for customer requirements. For QFD, researchers can either develop customer requirement items from scratch or use findings from previous studies to determine customer requirements (Lehto et al., 2007). Since SSTQUAL was developed in the SST context, it perfectly fits for this study. This SSTQUAL measurement consists of seven aspects of SST attribute, including

- *Functionality: functional characteristics of SST systems*
- *Enjoyment: perceived enjoyment during SST procedures*
- *Security: perceived safety during SST procedures*
- *Assurance: perceived confidence during SST procedures*
- *Design: overall design of SST systems*
- *Convenience: accessibility of SST services*
- *Customization: the degree of SST fitting customers' preferences*

Functionality and enjoyment consisted of four items each, while other service attributes consisted of two different items each. The planning matrix also included several sub-items related to assess customers' opinions, service providers' opinions, and the combination of both (Kurtulmuşoğlu and Pakdil, 2017). Since this information was obtained from both customers and service providers, two different sets of surveys were developed. One was for customers and the other was for service providers. In-depth interviews were also conducted with service providers.

The next step in developing the *Planning Matrix* was to collect customer importance ratings (IR) and customer performance ratings (CR) for each of the seven SST attributes. This was done by using the Amazon Mechanical Turk (MTurk). Even though MTurk has been a

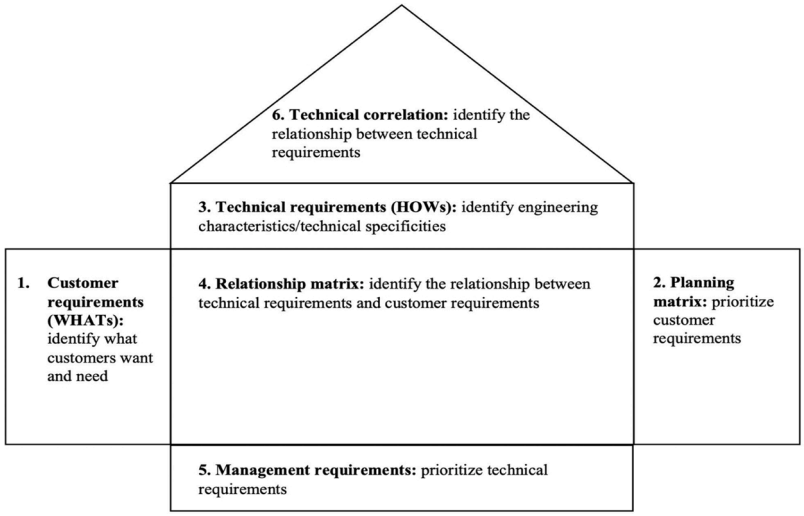


Fig. 1. Framework of HoQ.

debatable data collection method among researchers (e.g., Paolacci and Chandler, 2014; Goodman et al., 2012) due to a potential difference with the general population, it is easy to approach specific and diverse sample. Nonetheless, the reliability of MTurk data is not significantly different than other data collection means (Buhrmester et al., 2011). Accordingly, it has been commonly used and accepted in many psychological/social science studies recently (Chandler and Shapiro, 2016). Since MTurk is a convenience sampling method, this study provided a screening question "I have used a self-service technology kiosk (e.g., self-ordering or paying kiosk) at restaurants in the U.S. within the last six months." to make sure the sample can represent the overall SST users at restaurants. Then the respondents were asked to rate each of the seven SST attributes with a five-point importance scale (i.e., 1 = not at all important to 5=extremely important) for revealing IR. Participants also evaluated CR based on their actual SST experiences in a restaurant that uses SST. Consistent with the IR, CR items were rated on a 5-point scale (i.e., 1=extremely dissatisfied to 5=extremely satisfied).

The third step in developing the planning matrix was to collect a similar set of inputs from service providers. Again, this was accomplished by using MTurk via the worker requirement function as it is efficient to approach such a specific sample of this study (Chandler and Shapiro, 2016). Also, an additional screening question: "I am currently working as a manager in a restaurant that uses self-service technology kiosks" was applied. Managers who responded with "yes" were then asked to answer following questions such as the type of a restaurant they work for. They then were asked to rate the seven SST attributes: functionality, enjoyment, security, assurance, design, convenience, and customization. Specifically, they evaluate performance goal ratings (PG) with a five-point scale of how important each SST attribute is to them (i.e., 1 = not at all important to 5=extremely important). Manager respondents, followed by, evaluated priority factor ratings (PF): a potential capability of each SST attribute to increase the total sales of the restaurant in the near future are by a 3-point scale (i.e., 1 = no improvement possibility, 1.2=medium improvement possibility, and 1.5=strong improvement possibility).

The objective of this dual-survey data design was to allow the perceptions of customers be compared with service providers regarding all seven SST attributes. Ideally, PG should be aligned with the gap between IR and CR as it reveals the disconfirmation of customers' service expectation and their actual experience (Kurtulmuşoğlu and Pakdil, 2017). Ratings of level up (RL) reflect the improvement potential of each SST attribute based on CR by customers and PG by service providers. Therefore, it explicitly identifies the possibility of the extent of what a certain service attribute can be improved as it shows the gap between service providers' future aims and customers' current service perceptions. In other words, RL is a weighted value of required improvement by customers (Jeong and Oh, 1998), and it is computed as follow:

$$RL_i = PG_i \div CR_i,\ i = 1, 2, 3, \ldots, n$$

As noted earlier, the surveyed managers were also asked to assign PF to each of the seven SST attribute based on their experiences and knowledge. PF identifies whether each SST attribute has a potential capability to increase the total sales of the restaurant industry in the near future or not (Kurtulmuşoğlu and Pakdil, 2017). This value was used to calculate the planning matrix's absolute weights (AW) for each SST attribute. AW specifically identifies the rank of customer requirements using the combined assessment of the IR, RL, and PF:

$$AW_i = IR_i \times RL_i \times PF_i,\ i = 1, 2, 3, \ldots, n$$

The relative weight (RW) measured based on the AW for the normalization:

$$RW_i = AW_i \div \sum_{i=0}^{n} AW_i,\ i = 1, 2, 3, \ldots, n$$

The next step was to decide design *Technical Specificities* (HOWs). Therefore, this stage particular reflects how SST delivers a desirable service to customers in a measurable way. The technical design element requires specifications of service characteristics, product characteristics, and engineering characteristics (Paryani et al., 2010). Therefore, this study reviewed SST specificities using academic and trade journals (e.g., Meuter et al., 2000; Beatson et al., 2006; Shin and Perdue, 2019) and conducted in-depth interviews with industry experts. To recruit industry experts, snowball sampling was utilized. Snowball sampling is especially helpful for research that less feasible and accessible targets like this study, since it uses participants' social network to conveniently approach the specific population (Browne, 2005). Specifically, to participate in the interview, respondents should meet the following criteria: (1) currently working in an SST-adopting restaurant, (2) holding a managerial position at the time of the interview, (3) having three years or more of managerial experience in the restaurant industry, and (4) considering themselves familiar with SST in restaurants. This study initially invited five experts for an in-depth interview via email, but only three of them accepted. Each interview strongly affected the relationship matrix as well as the technical correlation matrix; Accordingly, it is critical to include the correct sample rather than the quantity of samples. An average interview time was around 30−40 min and all interviews were transcribed. These interviews help researchers to develop measurement items pertaining to technical specificities. This step is important in order to align technical specificities with SST attributes in QFD, since the major aim of QFD is capturing customer requirements and translating them into service characteristics (Paryani et al., 2010). A total of 16 technical specificities of SST design were utilized for this study:

- *Eye-catching kiosk body: visually appealing SST kiosk body*
- *Eye-catching screen display: visually appealing and neat display of the screen*
- *Screen protector: protected from being seen by other customers*
- *All-encompassing touch screen: offering all-encompassing touch screen*
- *Multi-language support: offering multi-languages that customers can choose*
- *Showing product images: providing products' image that customers can refer*
- *Showing product prices: providing products' price that customers can refer*
- *Search engine function: available for searching products*
- *Customizable function: offering customizable options of every order*
- *Additional communication support: offering virtual help by service employees*
- *Confirmation before transactions: confirming orders before transactions*
- *Variety payment options: offering various payment options including cash, credit cards, gift cards, and coupons*
- *Secure credit card transactions: offering a high-security system*
- *Print receipt option: ability to choose paper receipt, digital (e-mail) receipt or no receipt based on their preference*
- *Easy to go back, continue, and quit function: no hassle to go back to the previous screen, continue or quit transactions*
- *Sensitive screen response: providing a spontaneous response*

The next step is constructing the *Relationship Matrix* (r) between customer requirements (WHATs) and engineering characteristics (HOWs). In other words, this stage measures the correlations between customer SST attributes and its technical specificities. Similar to the technical specificities' determination process, this relationship matrix is determined based on restaurant managers' experience and knowledge via in-depth interviews. The association between a pair of SST attribute and technical specificity is assigned to three different symbols, and each of them contains a different numeric value. Specifically, ▽ (weak relationship) = 1, ○ (moderate relationship) = 3, and ● (strong relationship) = 9 as per Akao (1990).

The following step is revealing *Management Requirements*: AW and RW of each SST technical specificity based on the relationship matrix

and the RW of the aforementioned planning matrix. Hence, this step is heavily relying on the previous stages. The AW of management requirements is computed with the cell value of the relationship matrix and the AW from the planning matrix:

$$AW_j = \sum_{i=1}^{n} (r_i \times AW_i),\ j = 1,\ 2,\ 3,\ \ldots,\ k$$

Similar to RW in the planning matrix, RW of management requirements is determined by each AW and its row sum for the standardization purpose:

$$RW_j = AW_j \div \sum_{j=1}^{k} AW_j,\ j = 1,\ 2,\ 3,\ \ldots,\ k$$

The last step of this study is to construct the *Technical Correlation* matrix which represents the degree of functional relationship of each technical specificity. Specifically, every technical specificity either has no effect or provides a negative/positive impact. This functional relationship of technical specificities is also determined by industry experts via in-depth interview. Each pair of technical specificities relationship was labeled by three different symbols which reflect the degree of correlation from none to strong (i.e. = null relationship, + = positive relationship, and - = negative relationship) as per Akao's (1990) study. See Fig. 2 for the flowchart that summarizes how each phase of HoQ was determined.

4. Results

4.1. Respondents' profile

This study conducted two sets of self-administered web-based survey: one from customers (i.e., IR, CR) and one from restaurant managers (i.e., PG, PF) through MTurk. Table 1 summarizes two different samples' (i.e., customers and restaurant managers) demographic profile. QFD is not a methodology that heavily relies on the statistical evidence. Also, since this study used a convenience and non-random sample, there is no solid formular for estimating the right sample size (Baki et al., 2009). Therefore, this study targeted the advised minimum sample size for CFA which is 200 (Anderson and Gerbing, 1984). This study preliminarily collected 280 respondents, but 13 responses that have straight-line answers or the same IP address were dropped for the data quality assurance purpose. Of the 267 participants, restaurant customer respondents are composed of 64.42 % of the respondents were male, and 35.58 % were female. The majority of the respondents were between 26 and 40 years old (68.16 %) and the next largest group were between18−25 years old

Table 1
Samples' Demographic Profile.

	Customers' profile		Managers' profile	
Demographic Variables	Frequency	Valid Percentage	Frequency	Valid Percentage
Gender				
Male	172	64.42	19	45.24
Female	95	35.58	23	54.76
Age				
18−25	41	15.36	11	26.19
26−40	182	68.16	22	52.38
41−55	35	13.11	7	16.67
56 or older	9	3.37	2	4.76
Education				
High school or less	20	7.49	12	28.57
Associate degree in college (2-year)	42	15.73	14	33.33
Bachelor's degree in college (4-year)	163	61.05	9	21.43
Postgraduate	42	15.73	7	16.67
Ethnicity				
Caucasian	169	63.30	23	54.76
African American	22	8.24	5	11.90
Asian Pacific	47	17.60	9	21.43
Hispanic	23	8.61	4	9.52
Other	6	2.25	1	2.38

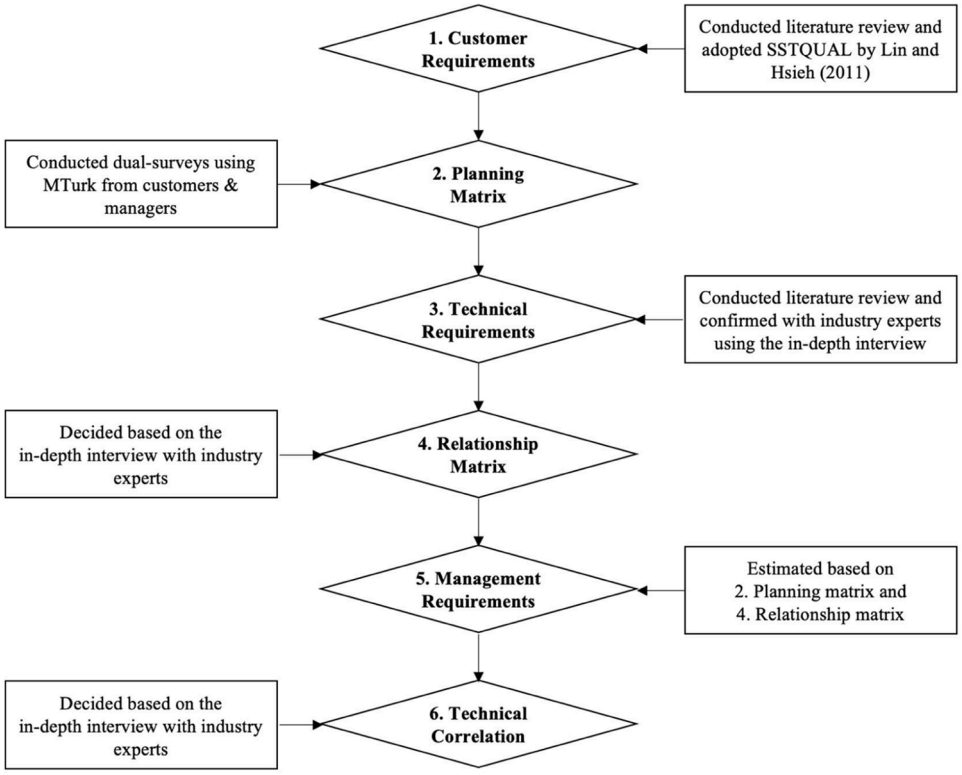


Fig. 2. Flowchart of HoQ.

(15.36 %). In terms of ethnicity, Caucasians accounted for the largest percentage with 63.3 % among the respondents. Over 76 % of the respondents had at least a bachelor's degree. Apart from the demographic questions, a few additional questions were asked including respondents' previous SST experiences and the types of restaurants where they experienced using SST and thus controlling for potential influences of external factors on their responses. Over seventy percent of the respondents (70.41 %) used SST in fast service restaurants followed by casual service restaurants (23.22 %) and fine-dining restaurants (6.37 %).

Meanwhile, this study obtained a total of 42 restaurant managers participants. 54.76 % of manager respondents were female, while 45.24 % were male. In terms of age, over half of the managers were between 26−40 years old (52.38 %). Education level of manager respondents was relatively evenly distributed with associate degree holder as the largest group at 33.33 %, followed by people with education of high school or less (28.57 %) and four-year bachelor's (21.43 %). In term of race, the largest group were Caucasian (54.76 %), followed by Asian Pacific (21.43 %) and African American (11.90 %). Apart from demographic information, respondents were asked what type of restaurant they work for. The majority of the respondents were working in a fast service restaurant (57.14 %) followed by a casual service restaurant (28.57 %) and a fine dining restaurant (14.29 %).

In addition to two sets of survey, this study additionally conducted in-depth interviews with three industry experts (i.e., managers at an SST adopted restaurant). Of the three participants, two were male and one was female. Two were managers at casual service restaurants, whereas one was a fast service restaurant manager. All managers were between 26 and 40 years of age. Lastly, the three managers have five, eight and thirteen years of work history in restaurants.

4.2. Confirmatory factor analysis

In general, factor analysis for customer requirements in the QFD process is not required because researchers can use the list of customer needs and wants rather than factors or dimensions. However, this study adopted the seven dimensions of SST quality defined by Lin and Hsieh (2011) as customer requirements and each of the seven dimensions were measured by multiple items. Therefore, this study conducted CFA to confirm the seven-dimensional structure. Specifically, it was utilized based on CR by customers. Table 2 presents the details of the statistical properties of the customer requirements using CR. The overall goodness-of-fit statistics suggests that the SST quality construct fits the collected data reasonably well (chi-square = 252.197, p = .000, chi-square/df = 2.212, RMSEA = .068, CFI = .961, TLI = .947). Specifically, as per MacCallum et al. (1996) as well as Steiger (2007), if RMSEA value is less than 0.07, the data fits well in the proposed model. In addition, if CFI and TLI values are larger than .9, as is the case of this study, they indicate a satisfactory fit (Awang, 2012).

Table 2
CFA Results based on CR by Customer Sample.

Construct	Items	Standardized factor loading	Cronbach's alpha	Average variance extracted
Functionality	Functionality 1	0.80	0.86	0.612
	Functionality 2	0.81		
	Functionality 3	0.78		
	Functionality 4	0.82		
Enjoyment	Enjoyment 1	0.77	0.84	0.610
	Enjoyment 2	0.80		
	Enjoyment 3	0.74		
	Enjoyment 4	0.82		
Security	Security 1	0.79	0.63	0.653
	Security 2	0.64		
Assurance	Assurance 1	0.79	0.75	0.617
	Assurance 2	0.79		
Design	Design 1	0.78	0.76	0.568
	Design 2	0.80		
Convenience	Convenience 1	0.80	0.76	0.701
	Convenience 2	0.80		
Customization	Customization 1	0.84	0.74	0.790
	Customization 2	0.77		

The Cronbach's alpha values of all seven SST quality dimensions (ranging from 0.63 to .86) exceed the minimum of 0.60 threshold for reliability (Hair et al., 1998). Therefore, the measurement items of the study were deemed as reliable for assessing each SST attribute. In addition, convergent validity was assessed through factor loadings. Lastly, ranging from 0.61 to .79, the average variance extracted (AVE) values of all seven SST quality constructs were higher than the recommended threshold of .5 (Hair et al., 1998), suggesting satisfactory discriminant validity.

4.3. HoQ results

Fig. 3 shows the overall HoQ results. This study discusses the HoQ results based on three different perspectives: customers, service providers, and technical specificities focused.

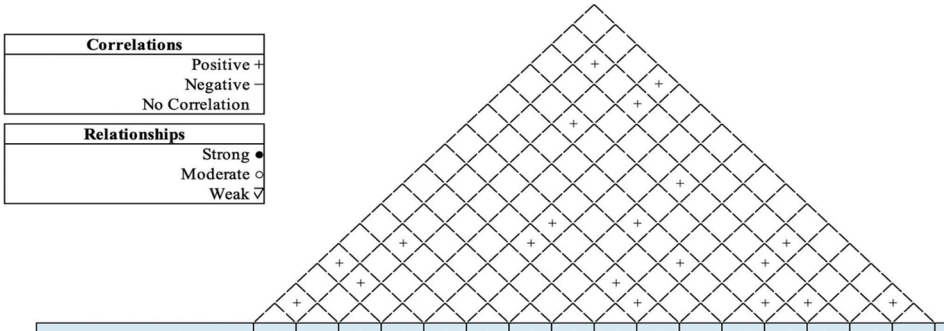
4.3.1. Customer-based results

In the HoQ results, IR and CR show customers' explicit perceptions toward SST. In particular, IR reflects customers' desired expectation whilst CR shows their actual experience of the given service based on each SST attribute. According to the IR, customers consider *Convenience* (IR = 4.00) as the most important SST attribute and *Design* (IR = 3.96) as the second most important SST attribute in the restaurant setting. Nevertheless, *Customization* (IR = 3.68) was viewed as the least important SST attribute. How did consumers evaluate their restaurant SST experiences? Similar to IR, *Convenience* (CR = 3.90) was given the highest CR, followed by *Functionality* (CR = 3.83). Overall design (CR = 3.25) was given the lowest CR by customers. It suggests that customers regard overall design of SST in restaurants as the least satisfactory. This is especially true considering that the negative disconfirmation between Design's IR (3.96) and CR (3.25). Similarly, *Enjoyment* (CR = 3.41) received the second lowest. However, as per the IR, customers are expecting enjoyable SST service (IR = 3.81) – This suggests another negative disconfirmation between customers' expectation and actual experience.

4.3.2. Service provider-based results

PG and PF measure service providers' (e.g., managers) opinion regarding restaurant SST. Specifically, PG measures service providers' perceived importance of each SST attribute while their PF reflects the expected capability of an attribute to bring financial profits to restaurants. PG shows that restaurant managers claimed *Assurance* (PG = 4.30) as the most important SST attribute in restaurants. In the similar vein, *Security* (PG = 4.22) was considered as the second most important attribute among the seven SST attributes. In other words, service providers value assurance and security of SST the most. Despite being rated the highest in terms of PG, the *Security* attribute was given the lowest PF (1.0). This suggests that security related features are seen by service providers as less likely to produce financial profits compared to other SST attributes. Similar to security, *Assurance* (PF = 1.2) attribute of SST is not expected to be a profit generating factor. On the other hand, the *Convenience* (PF = 1.5) attribute is seen as the most profit generating attribute by the managers.

In comparison with customers-based results, *Convenience* was consistently regarded as one of the crucial SST attributes for both restaurant customers and managers as per the IR and PG respectively. The inconsistency between customers and managers was the *Design* attribute. Customers rated overall *Design* (IR = 3.96) as the second most important service attribute when they utilize SST. However, restaurant



Row #	Customer Requirements (WHATs) \ Technical Requirements (HOWs)	1 Eye-catching kiosk body	2 Eye-catching screen display	3 Screen protector	4 All-empompassing touch screen	5 Multi-language support	6 Showing product images	7 Showing product prices	8 Search engine function	9 Customizable function	10 Additoanl communication support	11 Confirmation before transaction	12 Variety of payment methods	13 Secure credit card transactions	14 Print receipt option	15 Easy to go back, continue, quit	16 Sensitive screen response	Importance rates (IR)	Customer rates (CR)	Performance goal scores (PG)	Rate of level up scores (RL)	Priority factor scores (PF)	Absolute weights (AW)	Relative weights (RW in %)
1	Functionality	▽	○	○	○	●	●	●	●	●	●	●	●	●	●	●	○	3.86	3.83	4.18	1.09	1.20	**5.06**	**13.8%**
2	Enjoyment	●	●	▽	○	●	●	▽	○	●	○	▽	▽	▽	▽	●	○	3.81	3.41	3.55	1.04	1.20	**4.76**	**13.0%**
3	Security	▽	▽	●	▽	▽	○	●	▽	▽	●	●	○	●	●	▽	▽	3.76	3.79	4.22	1.11	1.00	**4.19**	**11.4%**
4	Assurance	▽	○	▽	▽	●	●	●	●	○	●	●	○	○	●	●	○	3.86	3.54	4.30	1.21	1.20	**5.63**	**15.3%**
5	Design	●	●	○	●	○	○	○	○	●	○	▽	●	▽	○	●	●	3.96	3.25	3.88	1.19	1.20	**5.67**	**15.5%**
6	Convenience	▽	○	▽	●	●	●	●	●	○	●	○	●	▽	●	●	●	4.00	3.90	4.18	1.07	1.50	**6.43**	**17.5%**
7	Customization	▽	▽	▽	▽	●	○	○	●	●	●	▽	●	▽	○	○	▽	3.68	3.46	3.95	1.14	1.20	**5.04**	**13.7%**
	Absolute weights (AW)	**120**	**150**	**91.8**	**153**	**263**	**242**	**229**	**235**	**225**	**268**	**169**	**234**	**122**	**229**	**267**	**164**							
	Relative weights (RW in %)	**3.8%**	**4.8%**	**2.9%**	**4.8%**	**8.3%**	**7.6%**	**7.2%**	**7.4%**	**7.1%**	**8.5%**	**5.3%**	**7.4%**	**3.9%**	**7.2%**	**8.5%**	**5.2%**							

Fig. 3. HoQ Results.

managers assigned the second lowest PG to *Design* (PG = 3.88) out of the seven attributes. Additionally, it was noted that there is a notable gap between the *Enjoyment* attribute's IR (3.81) by customers and PG (3.55) by managers.

The level-up ratings reveal the combined customer-service provider perspectives since it considers the difference between CR and PG. These level-up values pinpoint the potential improvement pertaining to each SST attribute. *Assurance* (RL = 1.21) has the biggest potential for improvement in the future and followed by the *Design* (RL = 1.19) attribute. Taking into consideration of the overall planning matrix, *Convenience* (AW = 6.43, RW = 17.5 %) is identified as the most important SST attribute. Meanwhile, *Security* was the lowest ratings in the overall planning matrix (AW = 4.19, RW = 11.4 %), when both the various inputs by both consumers and managers are factored in.

4.3.3. Technical specificity-based results

The overall relationship matrix shows the strength of relationships (i.e., strong, moderate, and weak) between each SST attribute and the SST technical specificities. According to the matrix, among the 16 suggested technical specificities of SST, *Additional communication support* (AW = 268, RW = 8.5 %) had the most enhancing effect on restaurant SST services. For example, if SST has an additional communication support element, *functionality*, *security*, *assurance*, *convenience*, and *customization* attributes of SST are more likely to be enhanced due to the strong relationship between *additional communication support* and these five attributes. Such a specificity is also expected to support the *enjoyment* and *overall design* attributes, considering its moderate relationship with these two attributes.

Furthermore, *Easy to go back, continue, and quit* (AW = 267, RW = 8.5 %) was the second most essential technical specificity of SST as it shows strong relationships with *functionality*, *enjoyment*, *assurance*, *design*, and *convenience* attributes. This technical specificity appears to have a weak relationship with the *security* attribute. *Multi-language support* (AW = 263, RW = 8.3 %) was seen to enhance *functionality, enjoyment, assurance, convenience, and customization* attributes. It is also shown to have a moderate relationship with the *overall design* attribute and a weak relationship with the *security* attribute. *Screen protector from other people* (AW = 91.8, RW = 2.9 %) was the least important technical specificity with a robust relationship with the *Security* attribute only. It has a weak relationship with the rest six SST attributes.

Finally, the technical correlation matrix showcases the interrelationship of each pair of the 16 technical specificities. Based on this correlation matrix, *easy to go back, continue, and quit* functions has the strongest correlation with other technical specificities; such a technical specificity tends to improve *eye catching screen display*, *all-encompassing touch screen*, *confirmation before transaction*, and *sensitive screen response* characteristics. For instance, if SST is designed to allow restaurant users to easily to go back, continue, and quit, customers should able to find such a function on the SST screen easily, which in return will improve the general screen display characteristics of SST, and vice versa. On the other hand, several technical specificities, including *screen protector, multi-language support, showing product prices, search engine function,* and *confirmation before transactions* are noted have low a correlation with other specificities. In other words, these specificities are not dependent on other SST technical specificities.

5. Conclusion and discussions

Utilizing the QFD method, this research established a HoQ structure for restaurant SST. This HoQ was built based on the inputs from not only consumers but also restaurant managers along two dimensions of measures: SST attributes and SST technical specificities. This HoQ presents a relationship matrix that allows restaurants to assess SST attributes in relation to SST technical design specificities in a measurable way. Such a relationship matrix takes in multiple perspectives and considerations in designing restaurant SST services. This research thus provides an

illustration of how the QFD method can be a useful tool in SST service design in restaurants.

SST attributes for restaurants include *Functionality, Enjoyment, Security, Assurance, Design, Convenience, and Customization.* These seven attributes are viewed somewhat different by restaurant customers and restaurant managers, highlighting gaps that restaurants may need to consider reconcile. The 16 self-service design considerations are *eye-catching kiosk body, eye-catching screen display, screen protector, all-encompassing touch screen, multi-language support, showing product images, showing product prices, search engine, customizable function, additional communication support, confirmation before transactions, variety of payment options, secure credit card transactions, print receipt option, easy to go back, continue, and quit the process, and sensitive screen response.* These various technical aspects are found to be contributing to the various SST attribute performances and business goal fulfilment in a varying fashion.

These two sets of measures (i.e., SST attributes and technical specificities) in the HoQ function together to allow comparing and contrasting consumer input with restaurant managers' input. These measures also help to understand how restaurants' SST performance goals and design considerations align or misalign with restaurant customers' preferences and experiences. This can help restaurants to locate gaps and set priorities; The simultaneous data inputs allow businesses to establish linkages between consumer preferences, technical design aspects, and restaurant business goals.

5.1. Theoretical implications

Much research is needed in understanding how the SST interfaces with consumers experiences organizations service design goals. These topics can provide much needed knowledge as to how technology-enabled services such as SST transforms service models and consumer satisfaction. It is in this context, this study contributes to the literature of hospitality services. This research filled a much needed void the the restaurant management literature: It demonstrated the applicability of the QFD method in SST design in the restaurant setting. The HoQ matrix developed can provide a structured guideline for redesigning and developing SST design in the restaurants through discovering the relationship of its service attributes and engineering factors.

As has been noted, service migration from the traditional human service model to SST has been a visible trend in the hospitality industry. This research can be timely in encouraging appropriate qualtiy deployment in self-service hospitality design via the QFD method. SST is transforming how hospitality service is being delivered and received. To ensure quality of services not being compromised, SST design and interface with consumers are critical. Retaurant SST design needs to incorporate multiple perspectives and goals, not simply operational efficiency. Consumers' voice in particular need to be heard. In addition, despite the reputation of QFD as a customer-focused approach, it also takes into account the organizational manner as it values a service provider's opinion in determining several different QFD processes. QFD is an ideal methodology in addressing how to utilize SST in the hospitality industry in an optimal fashion that translate the voice of the customer of restaurant SST services into engineering and design characteristics. It allows the inclusion of both customer and service provider perspectives and organizes them it into an intuitive matrix form that makes it easy to visualize how particular design elements contribute to service quality. QFD has a great potential for delivering better SST quality as well as customer experience that ultimately affects customer retention and market share.

The identified gaps provide insights in the triangulation between customer preferences, service provider's perceptions of SST, and its engineering factors in restaurant practices currently. The outcomes of this research are expected to lend insights to hospitality scholars whether and how SST should be adopted in hospitality service. As an important finding from this study, both customers and service providers perceived *Convenience* as the most critical SST attribute. This finding is similar to King (2019) which suggests that SST offer a plan to make any service more accessible. King (2019) particularly highlighted that the overall SST process should be entirely convenient and hassle-free and offer empowerment to consumers. Another interesting discovery is that the *Security* attribute was perceived relatively less important by customers. This seems to counterintuitive at a first glance. However, this lesser importance perception should not be understood as the security feature is not relevant in SST design considerations. But rather, perhaps at this stage of online transaction operations, consumers and managers alike seem security as a given- a baseline hygiene factor, the absence of it can be upsetting to the consumers. (Lin and Chang, 2011).

5.2. Managerial implications

This study provides an assessment of the current state of SST applications in the restaurant industry. Therefore, SST engineers can refer to this study as baseline data in order to design self-service kiosks, and restaurant practitioners also can use the findings of this study to discover the common thread of customer satisfaction and how to increase business opportunities and production efficiency through SST. First, it proposes a call for SST providers to improve the *Design* aspects of their SST gadgets due to the biggest gap between IR and CR. Nevertheless, this study shows that restaurant managers do not believe design is an SST priority resulting in a large disparity between consumer preference and management priority in the design attribute of SST. Such a negative disconfirmation between expectations and actual service perceptions can cause harmful emotions such as customer dissatisfaction (Kim et al., 2019). Therefore, restaurants are encouraged to pay special attention to design features of SST in general.

This research also showcases that QFD can be an effective tool for designing and managing SST in the restaurant setting. One of the biggest benefits of QFD is being able to pinpoint the potential necessary improvements of certain product or service attributes through developing its engineering characteristics. In other words, this study allows practitioners to see not only the need for improving design aspects of SST but also how to improve it. Specifically, SST providers such as restaurant managers can refer to the result of the matrix and potentially improve the design aspect of SST by assuring *eye-catching kiosk body, eye-catching screen display, all-encompassing touch screen, customizable function, variety of payment method, easy to go back/continue/quit the process, and sensitive screen response*.

Furthermore, the results of this study show that *additional communication* support should be considered as a critical SST technical specificity as it is shown to have a significant impact on functionality, security, assurance, convenience, and customization attributes. This suggests that even if SST is a service provided by customers themselves, they desire to have an option to get help from employees if necessary (e.g., employee live chat). This is due to the inevitable occurrence of SST failure due to technology malfunction and SST users themselves (Shin and Perdue, 2019). As Williams and Savage (2019) advised, the hospitality industry needs to understand the balance between the value of technology to support the guest experience through empowerment and the value of human beings as they cannot completely replace human involvement. Specifically, service employees have the capability to understand the specific situation such as service failures and deliver assistance in the most seamless fashion. In this sense, this study also signals a fair warning to any service companies that provides SST exclusively.

5.3. Limitations and future studies

A few limitations need to be addressed in this study. A major limitation is inherently with the QFD approach itself. First, QFD heavily depends on both formal and informal data collected from customers and service providers. Therefore, inaccurate input data may cause bias which leads to unreliable guidelines for service management. Secondly,

compared to customer respondents, the sample size of manager respondents is relatively small. This study has a specific requirement for the manager sample as they had to currently working in an SST adopted restaurant. Despite this challenge, a small sample size may influence the reliability of results due to a higher variability. Even if this study collected more than the minimum sample size (i.e., 30) and there was no outstanding variation across the manager sample, future studies are highly encouraged to assemble more data to avoid potential issues. Similarly, there were three restaurant manager participants in in-depth interviews to determine the relationship matrix and technical correlation. As a suggestion for the future research, researchers can consider other alternative methods to collect the wider range of the data through the managerial cooperation.

The next limitation of this research is the lack of ability to collect data controlling restaurant types. SST is a particularly popular trend in fast-service restaurants compared to casual-service restaurants and fine-dining restaurants (Kim and Christodoulidou, 2013). The consumer respondents evaluated their SST experience and preferences based overwhelmingly fast food restaurants and fast casual dining restaurants. The results may not be generalizable to other settings such as fine dining. Wall and Berry (2007) mentioned that customers of quick-service restaurants tend to have a different service quality perception compared to other types of restaurants. Therefore, future research can be conducted in the same restaurant type or in one specific restaurant as a case study to avoid lurking effects while increasing data consistency. Lastly, the demographic profile of samples in this study is relatively not even. For example, there were remarkably more whites among customers as well as manager samples. This might be this study used Amazon MTurk to collect the data. As per Goodman et al. (2012), and Paloacci and Chandler (2014), MTurk workers belong to certain ethnic or race groups tend to be lower than the amount found in the general population. Considering this, future studies are encouraged to consider how to collect more representative data from different data collection tools.

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