

Human-centered design approach for enhancing supply chain management systems in SMEs: insights from Malaysia

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ABSTRACT

A reliable supply chain management (SCM) system is crucial to small and medium enterprises (SMEs) to meet the increasing demands of supply chain operations. However, the misalignment between the functional SCM system and the complex, dynamic, and diverse needs of the supply chain stakeholders is paramount. This paper presents an effort to adopt human-centered design (HCD) in the process of identifying requirements for a SCM system, aimed at providing valuable support to SMEs. The HCD places a strong emphasis on shaping design choices in alignment with users' tasks, needs, and preferences, instead of requiring users to adapt their behaviors to fit the system. The survey method is employed to get the SMEs' perspectives on the potential benefits of incorporating HCD into the requirements of the SCM system. The findings showed that a minimum of 80% of the respondents agreed that HCD brings numerous benefits to the development of SCM systems for SMEs in Malaysia.

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1. INTRODUCTION

Having the right requirements is indeed important to produce a meaningful system that meets the stakeholders' needs. This is crucial for the small and medium enterprises (SMEs) that rely so much on the supply chain management (SCM) system to sustain their business and stay relevant, especially during the pandemic. However, the focus on the technical side of building a software system is most common, and many projects fail to address critical human aspects during the development phases [1]. This can result in technically sound products that fail to relate to users or adequately address their requirements [2]. Additionally, the issues with usability and user experience may only be identified late in the development cycle, leading to costly redesigns or user dissatisfaction post-launch [3]. Furthermore, the exclusion of diverse perspectives and stakeholders can result in products that do not cater to the needs of all user groups or fail to consider important contextual factors [4]. While some RE literature acknowledges the importance of considering diverse perspectives [5], traditional RE processes often lack systematic methods for incorporating these perspectives into the design process. Research in inclusive design and user-centered methodologies like human-centered design (HCD) emphasizes the need for actively involving diverse stakeholders throughout the design process to ensure that products meet the needs of all user groups. However, in many cases, traditional RE practices may not sufficiently address the specific concerns and

requirements of diverse user populations, leading to products that are less inclusive or fail to adequately consider important contextual factors. Therefore, there is a growing recognition of the need to integrate diverse perspectives more effectively into RE processes to enhance the inclusivity and relevance of the final product [6]. Overall, these deficiencies in the current requirements engineering process highlight the need for a more human-centered approach while eliciting requirements. Following the rationale, human-centered requirements engineering (HCRE) is eventually being introduced [1], [7] to adequately address the needs, preferences, and behaviors of end users. By integrating HCD principles into the requirements engineering process, HCRE aims to ensure that user needs are considered from the beginning of a project.

Many research efforts collectively contribute to advancing the field of HCRE by providing methods [7], [8], techniques [1], [9], validation studies, and best practices for integrating HCD principles into the requirements engineering process [10]. However, the implementation and applicability of the HCRE to obtain a good list of software requirements are limited. Recent effort [1] presents the gaps in requirements practices when engineering human-centered AI systems. The effort is more into finding problems and what is lacking to be improved in the future. Thus far, to the best of our knowledge, there are no published papers presenting the implementation of HCRE to elicit requirements for software systems to be developed.

This paper presents an effort to apply HCRE to elicit the high-level requirements for the SCM system to assist and benefit the SMEs. The research explores the HCD factors through literature and conducts interviews with SME owners to design potential requirements for the SCM system. The list of potential requirements was then validated through a survey with 30 respondents among the SME owners.

Following the introduction, section 2 describes the research method and section 3 elaborates on the applicability of HCD for the SCM system. This is then followed by section 4 which discusses the results obtained from the survey conducted. Finally, section 5 concludes the paper.

2. METHOD

This research is divided into three main phases as illustrated in Figure 1. Phase 1 is initial and has two main activities which are a literature survey and preliminary study. The purpose of this phase is to grasp the state-of-the-art of HCD and the essence of the SCM system in Malaysia. Literature review provides insight into current research efforts on HCD and how it benefits the software system, especially the SCM system. The literature outcome is then validated through the interviews with the SCM stakeholders and at the same time the interviews provide information on the users' needs, desires, and behaviors as the inputs for SCM system requirements. Then, phase 2 utilizes the inputs from the initial stage to design the high-level requirements and subsequently implement the survey for data collection. The high-level requirements statement for the SCM system is designed based on the inputs gathered from phase 1. The potential SCM system users among SMEs were then asked to look into the high-level requirements statements and provide their perception of how the high-level requirements designed based on HCD could benefit the SMEs through the SCM system. Following the investigation phase, phase 3 proceeds with data analysis and reporting. Based on the high-level requirements that adopt a HCD for the SCM system, the SMEs' perceptions of potential benefits were evaluated by using a 5 5-point Likert scale.

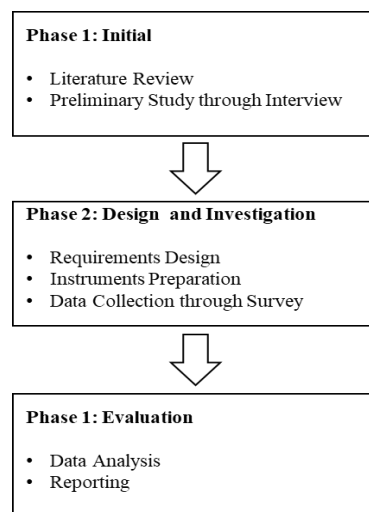


Figure 1. The research phases

2.1. Literature review

A literature review was conducted during the initial phase of this research based on the keywords search to the most common and influential databases which are IEEE Explore, Science Direct, Springer, Semantic Scholar, and Google Scholar. Several keywords were used to find relevant literature in the area which are HCD, human-centric design, HCRE, and SCM system. The literatures attained are then filtered to include only proceedings and journal papers, written in English and related to software system development. Finally, the list of literature is filtered for quality. Only literature on HCD for software development providing information on problems, features, factors, and current research progress like framework, method, and implementation are referred to. The literatures provide comprehension of HCD definitions, concepts, factors, and contributions in the research thus far. The literature also helps to understand the SCM system required by SME businesses.

2.2. Interview

Interviews with the SME owners are conducted to elicit the potential requirements for the SCM system. The information gathered during the interview helps to complete and support the information obtained through the literature on SCM systems for SMEs.

2.2.1. Population and subject

The population is among the owners of small craft businesses in the historical city of Melaka, Malaysia. They are doing small businesses and are directly involved in the entire supply chain process. Since the size of their businesses is small, most of the processes are handled manually. However, due to the pandemic outbreak several years ago, small business owners are adopting the SCM system to assist them to sustain in their business. Five owners volunteered as the subjects for the interview to share their needs, preferences, and expectations from a good SCM system.

2.2.2. Instruments

The instrument is a set of open-ended questions to capture the small business owners' needs, preferences, and expectations from a SCM system. Follow-up questions are also applied to let them elaborate on the potential requirements stated. Several close-ended questions are given to confirm if the SCM features captured through literature are also within their preferences.

2.2.3. Method

Before conducting the interview, an arrangement was made to interview the subjects separately at their business location. The time and approximate interview duration of 30 minutes to an hour was agreed upon by the subjects. The researcher met the subjects with a list of potential questions to elicit the high-level requirements for the SCM system that represent the SME owners' needs, preferences, and expectations. The interview starts with the opening where the purpose, time frame, and key objectives are explained. Then the transition to the core of the interview took place by leading into the first question. The interviews were recorded while the main points were noted by the researcher.

2.3. Survey

The survey is conducted to get feedback from the SME owners regarding the potential benefits they could obtain through the SCM system if the system is developed based on the requirements that incorporate human-centered elements and at the same time represents the SME's interest. The procedures are generally referred to in a quantitative survey research book [11].

2.3.1. Population and subject

The population is among the owners of small craft businesses in the historical city of Melaka, Malaysia. Other than the five subjects volunteered for the interview, 30 subjects were identified to participate in the survey.

2.3.2. Instrument

The first instrument for the survey is the list of high-level requirements for the SCM system which were carefully designed based on the inputs obtained through literature and interview in phase 1. The second instrument was a list of potential benefits that the SME owners could benefit from having the SCM system developed based on the designed high-level requirements.

2.3.3. Method

Initially, after the subjects were identified, they were approached and a brief explanation was given to prepare the subjects as the survey participants. The purpose, the objective, and the content of the survey

are explained to ensure reliable responses will be given. Following the briefing, the survey sheet was given to the individual participants. After given about 30 minutes, the survey sheets were collected. Since there is a centralized location that places many small craft businesses in Melaka city, the researcher has no problem personally approaching the participants individually without having the participants leave their businesses.

3. THE HUMAN-CENTERED FACTORS FOR SUPPLY CHAIN MANAGEMENT SYSTEM

According to Noueihed and Hamzeh [12], the need for a HCD is important to humans, and this should have predictability and control of the physical output of any technology. Thus, humanity is an internal factor that is required for humans to flourish and succeed, and technology exists only to support it. As it evolves from the domain of human-computer interaction technology, HCD is an approach that focuses on the user, their needs, and requirements to ensure that the developed system is usable and useful for the users.

In encouraging HCD, the focus lies on addressing stakeholders' needs through the thoughtful integration of technology to enhance human activities [13]. Referring to the rigorous literature review, the HCD is developed based on factors that are also influenced by the nature of the system to be developed. Generally, it could be concluded that there are six significant factors which are; i) emotion/feeling, ii) cognitive, iii) behavior, iv) needs and requirements, v) usability, and vi) trust. The operational definition of HCD factors is shown in Table 1.

Table 1. HCD factors

Factors	Operational definition	References
Emotional/feeling	Coordinated a set of behavioral, experiential, and physiological response tendencies.	[14], [15]
Cognitive	How users typically react when facing complex situations.	[15], [16]
Behavior	Incorporate an understanding of human behavior into some process that can lead to more effective technology.	[17]-[19]
Needs and requirements	Understanding of people and their needs, perhaps how they behave or are influenced by the environment.	[20]-[22]
Usability	It is the components to be considered how well the system or management can be used by the actual user.	[18], [23], [24]
Trust	A specific trust between the human and the system to ensure the correct balance.	[25], [26]

Additionally, through the interview with the SME owners, it is found that all of the HCD factors stated in Table 1 are relevant to the SME owner's expectations towards digital SCM. The information on the SCM processes and digitalization expectations gathered through the interviews were refined and mapped with the human-centered factors to verify the high-level requirements for the SCM system. Referring to the literature and the information collected during the interview, high-level requirements statements were designed for the SCM system. The high-level requirements for the SCM system and the mapping with the HCD factors are as stated in Table 2 (in Appendix).

4. RESULTS AND DISCUSSION

This section discusses the results of the survey.

4.1. Demographic analysis

The data for this research was gathered from a sample of 30 respondents who own small craft businesses in Melaka, Malaysia. The demographic analysis is presented in Table 3, which illustrates the profile of the respondents based on gender, age, nature of business, number of employees, and the company's ownership structure. In this study, the sample consisted of an equal distribution of genders, with 50% male and 50% female respondents, respectively. Furthermore, the age groups contributing to this study were as follows: 40% of respondents were between 25 and 30 years old, 20% fell into the 41-45 age group, 16% were 46 years and older, 13% were aged 36-40, and the smallest group, comprising only 10%, fell in the 31-35 age category.

Moreover, 46.7% of the respondents were associated with the wholesale and retail sector, while 36.7% were engaged in business and personal services. Only 16.7% of the respondents were involved in manufacturing and production. When it comes to the number of employees, 60% of respondents reported having 1-5 employees, and 20% mentioned having no employees, indicating their ability to independently manage their businesses. Additionally, 13.3% of respondents had 6-10 employees, and the smallest group, at

6.7%, included those with more than 10 employees. Regarding the company's ownership structure, the majority (80%) operated as standalone businesses, with 13.3% structured as partnerships, and only 6.7% recorded as subsidiary businesses.

Table 3. Demographic profile

Demographic	Classification	Frequency	Percentage (%)
Gender	Female	15	50.0
	Male	15	50.0
	25-30 years	12	40.0
	31-35 years	3	10.0
	36-40 years	4	13.3
	41-45 years	6	20.0
Nature of business	46 years and above	5	16.7
	Wholesale and retail	14	46.7
	Manufacturing and production	5	16.7
	Business and personal services	11	36.7
Number of employees	None	6	20.0
	1-5 people	18	60.0
	6-10 people	4	13.3
Company's ownership structure	More than 10 people	2	6.7
	Standalone	24	80.0
	Partnership	4	13.3
	Subsidiary	2	6.7

4.2. Survey analysis

In this study, the expected benefits obtained by the SMEs from the SCM system that incorporated HCD are explored through a survey with owners of small craft businesses in Melaka, a historical city in Malaysia. Table 4 lists down the ten major benefits that were given to the respondents to rate using 5-point Likert scale. Figure 2 and Table 5 presents the descriptive analysis obtained from the survey conducted. Referring to the figure, the majority of the feedback indicates positive responses as agree and strongly agree are dominant in all the ten benefits listed. Across the ten benefits, only one respondent disagrees (3.3%) with benefits 4, 8, and 9 which are 'Identifies the new areas for growth', 'Create a stronger bond and relationship with your workforce', and 'Reviewing customers' insights as an essential data to develop the business'. These probably relate to the inability to use the SCM system and the inability to envision the benefits based on the requirements statements alone.

Table 4. The 10 potential benefits obtained from SCM system with HCD

No	Benefit
Benefit 1	Assisting business owners in carrying out business activities
Benefit 2	Sales and profit margins will increase
Benefit 3	Boost customers' satisfaction
Benefit 4	Identifies the new areas for growth
Benefit 5	Sales and support representatives will be able to customize the solution
Benefit 6	Sales and support representatives will be more accessible to your customer
Benefit 7	Improving understanding of customers' needs
Benefit 8	Create a stronger bond and relationship with your workforce
Benefit 9	Reviewing customers' insights as an essential data to develop business
Benefit 10	Understand the customers' experience and relationship within e-commerce platforms or other digital footprints to help in business strategy

In terms of the percentage of agreed attainment, Table 5 summarizes both agree and strongly agree as agreeable to the benefits listed. The results showed that 'Boost customers' satisfaction' ranked first with 97% of respondents agreeing to it while 'Identifies the new areas for growth' and 'Create a stronger bond and relationship with your workforce' ranked last with only 80% of respondents agreeing to the benefits. Overall, at least 80% of respondents agreed with all the benefits listed and 6 out of 10 benefits scored 90% and above. The results indicate that the SME owners agreed that their business could benefit from SCM systems that incorporate HCD.

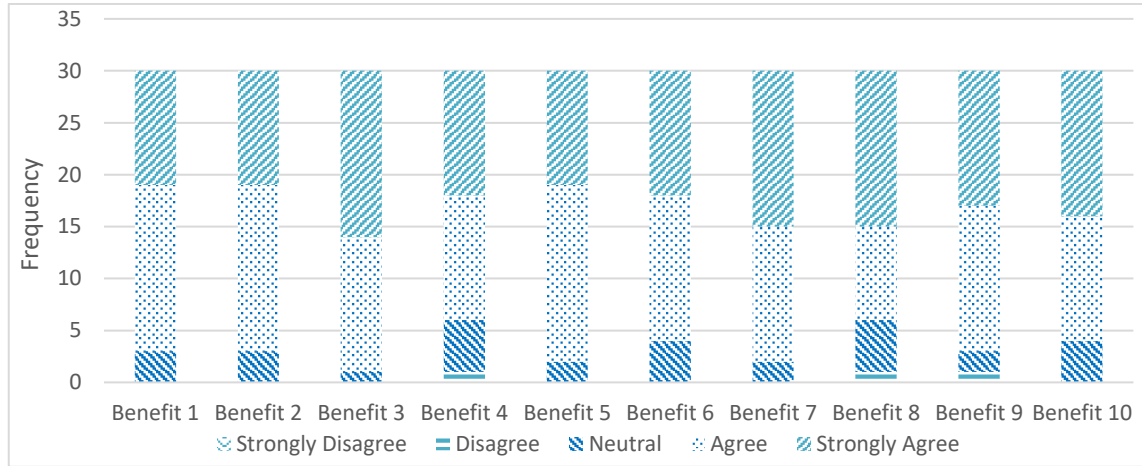


Figure 2. High-level requirements

Table 5. The survey results

Benefits	Frequency					Agree and strongly agree	Percent (%)
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
Benefit 1	0	0	3	16	11		90
Benefit 2	0	0	3	16	11		90
Benefit 3	0	0	1	13	16		97
Benefit 4	0	1	5	12	12		80
Benefit 5	0	0	2	17	11		93
Benefit 6	0	0	4	14	12		87
Benefit 7	0	0	2	13	15		93
Benefit 8	0	1	5	9	15		80
Benefit 9	0	1	2	14	13		90
Benefit 10	0	0	4	12	14		87

5. CONCLUSION

HCD brings numerous benefits to the development of SCM systems for SMEs in Malaysia. Through user research, usability focus, user involvement, localization, and iterative improvement, HCD ensures that the system is tailored to meet the specific needs and challenges faced by SMEs, leading to improved efficiency, effectiveness, and adoption among SME users. For practicality to benefit the community, the identified high-level requirements could be refined to provide requirements specifications for the SCM system development.

Among various research efforts on HCD, the focus is primarily on introducing new ways or enhancing current research efforts. The implementation of the HCD as part of the software development practice is rarely published. While this paper presents the practice of how software development could incorporate HCD factors into the list of software requirements for SCM systems during the requirements elicitation process, further research could be done to measure the impact of the HCD on the developed and deployed SCM system.

APPENDIX

Table 2. High-level requirements for SCM system with the human-centred factors

No	High-level requirements	Emotional/feeling	Cognitive	Behavior	Needs and requirements	Usability	Trust
1	The SCM system must efficiently process customer orders, ensuring accurate order entry, real-time order tracking, and timely order fulfillment.	x			x	x	x
2	The SCM system should facilitate effective supplier relationship management, including supplier selection, negotiation support, performance evaluation, and collaboration tools.	x		x	x	x	x

Table 2. High-level requirements for SCM system with the human-centred factors (*continued*)

No	High-level requirements	Emotional/ feeling	Cognitive	Behavior	Needs and requirements	Usability	Trust
3	The SCM system must optimize logistics and transportation processes, including route planning, shipment scheduling, and cost management for the efficient movement of goods.	x		x	x	x	x
4	The SCM system should provide robust inventory management capabilities, allowing for real-time tracking and control of inventory levels to meet demand while minimizing holding costs.	x	x	x	x	x	x
5	The SCM system must support demand planning and forecasting by analyzing historical data, market trends, and other factors to accurately predict future demand and align production and inventory accordingly.	x			x	x	x
6	The SCM system should offer comprehensive performance analytics and reporting capabilities, providing insights into key performance indicators (KPIs) to support data-driven decision-making and continuous improvement		x	x	x		
7	The SCM system must enable effective collaboration and communication among supply chain partners, offering tools for seamless information exchange and coordination.	x			x	x	
8	The SCM system should include risk management features to identify, assess, and mitigate supply chain risks, with provisions for contingency planning and business continuity.		x	x	x		
9	The SCM system must ensure compliance with industry regulations, standards, and legal requirements by maintaining documentation, conducting audits, and managing compliance-related risks.	x			x		x
10	The SCM system should seamlessly integrate with other enterprise systems, such as ERP and CRM, to enable data sharing, process automation, and improved work efficiency across various departments and functions.		x	x	x		




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