Information Resources Management Journal
Volume 37 • Issue 1

Improving Supply Chain Human-Machine Systems by the Analysis of Departmental-Level User Characteristics

Kun Yang, Henan Institute of Economics and Trade, China*

ABSTRACT

In this study, the authors aimed to enhance supply chain efficiency at Company A, a key player in China's manufacturing sector, by focusing on user-centric system design. The approach involved analyzing departmental-level user characteristics to inform the development of an optimized human-machine interface. To achieve this, they conducted focus groups and card sorting exercises, identifying specific user needs across departments like planning, purchasing, receiving, warehousing, production, and quality control. The application of these insights into system design led to significant operational improvements. Notably, time savings were observed in departments such as receiving (74.44%) and quality control (41.86%). This tailored approach underscored the importance of understanding and integrating user characteristics in supply chain systems, leading to enhanced productivity and a competitive edge. The study demonstrates the impact of user-focused system design in improving both efficiency and user satisfaction in supply chain management.

KEYWORDS

Human-Machine Interface, Supply Chain System, User Characteristics, User Needs

INTRODUCTION

Accompanied by the development of information technology, the supply chain system is gradually becoming the most important tool for enterprise operation and revenue (Nuamah & Seong, 2017). The supply chain system integrates the information of every link in the enterprise supply chain, realizes the rational allocation of resources, strengthens the synergy between various departments, and continuously improves the productivity and international competitiveness of enterprises. As an operational supply chain system, user experience (UX) sensing is the primary problem to solve, and the satisfaction of system users directly affects the enterprise's behavior and decision-making (Cao et al., 2021). The main means to improve UX sensing is to help enterprises grasp the actual needs

DOI: 10.4018/IRMJ.337387 *Corresponding Author

of users by analyzing the user characteristics of supply chain systems as well as designing friendly human-machine interfaces to help users use the system more conveniently to achieve the purpose of optimizing product design, improving product quality, enhancing UX, and improving the market competitiveness of enterprises (Kumar & Lee, 2022). Therefore, research on user characterization and human-machine interface design of supply chain systems has become a hot topic.

This paper takes the supply chain system of Company A, a key player in China's manufacturing sector, as the research object by investigating the actual business needs and supply chain characteristics of Company A (according to the company's supply chain process), developing the company's supply chain system by using focus groups and the card method, comparing the differences in the user characteristics of the supply chain's various departments and designing them into the system, realizing the system's human-computer interface function, and analyzing (using the UX questionnaire [UEQ]) the efficiency of each link of the optimized system and customer satisfaction to improve the company's supply chain efficiency and to provide theoretical data support for the user characteristic analysis and human-machine interface design of the supply chain system. There is a formal relationship between the company's use cases and the UX model for the UEQ analysis, which together constitute a complete UX that is essential for the development and growth of the company. At the same time, UX modeling is also closely related to efficiency, and good UX modeling can improve efficiency and promote the development and growth of the company. Therefore, companies should pay attention to UX and continuously optimize their products and services to increase user satisfaction and loyalty, thus improving their efficiency and competitiveness.

The innovation of this study is that it adopts a system design that gives user characteristics to achieve user-centered system optimization; it proposes an effective task management strategy by analyzing the correlation between task completion time and satisfaction to provide system efficiency and user satisfaction; and it analyzes in depth the role of the human-computer interface function, demonstrating its significant impact on improving processing efficiency and reducing resource consumption. It provides theoretical and practical references for the optimization and enhancement of enterprise supply chain management systems.

LITERATURE REVIEW

Research on user characterization and human-machine interface design of supply chain systems has achieved certain research results. Some research scholars have studied the modular system establishment of the supply chain, taking the actual business needs of users as the goal, using micro-servicing technology to transform the traditional procurement system, splitting each module of the procurement system, realizing the independence of each module, and not affecting the operation of the main business when the system carries out horizontal business expansion. Through micro-servicing technology, it realizes the business peak of the procurement system and maximizes resource savings by expanding the business modules horizontally to solve the problem of poor stability and low performance of the traditional procurement system. Through micro-servicing technology, it is realized that when the procurement system is in peak business, the business modules involved can be expanded horizontally to maximize resource savings and solve the poor stability and low performance of the traditional procurement system (Whicker et al., 2009). Some research scholars proposed an enterprise supply chain system based on microservice architecture and designed the microservice architecture enterprise supply chain system by analyzing the user requirements. Finally, the system formed the key business function modules (demand, project, contract management, commodities, and order center) and innovative function modules (blockchain access certificate, risk prevention and control, supplier information, and customer service center) (Zarei et al., 2023). Some researchers and scholars have studied the personalized interface design of supply chain systems, analyzed the individual needs and use of each user through on-site investigation and research, and concluded that the user groups of supply chain systems have diversified needs and the demand for the system varies from the management personnel, purchasing personnel, supervisors, warehouse workers, and other employees at each level, making it necessary to design personalized human-computer interfaces for different user groups.

The first approach has dominated human-machine systems research for several decades and has led to orthodoxy in modeling, in which certain structural characteristics are accepted without question. Hollnagel (2002) describes a type of functional model called a contextual control model, which shows how it is possible to account for both different control modes and how performance is affected by time(Hollnagel, 2002). Lin et al. (2004) study controller design and reduction of bullwhip for a model supply chain system using z-transform analysis. A discrete time series model of a supply chain system is derived using material balances and information flow. The bullwhip effect, i.e., magnification of amplitudes of demand perturbations from the tail to upstream levels of the supply chain, is a very important phenomenon for supply chain systems (Lin et al., 2004). Whicker et al. (2009) investigate, through the use of an industrial case study, how analysis of both time and cost can be combined to provide a more accurate view of supply chain performance, which can lead to better-informed decision-making. The subsequent analysis provides insight into the relationship between time and cost in supply chain processes and demonstrates how product costs accumulate in the supply chain (Whicker et al., 2009). The intersection of supply chain management and sustainability is still a rather young research field, emerging as a growing topic only recently. Gold et al. (2010) outline the findings of a content analysis systematically assessing all case studies in the field of sustainable supply chain management, published from 1994 to 2007 in English-speaking peer-reviewed journals, and thus mapping and evaluating the scope of current SCM topics reflected in these case papers. The analysis confirms previous research that highlights pressures from governments, customers, and stakeholders as triggers of sustainable supply chain management and the neglect of the social dimension of sustainability within supply chain management (Gold et al., 2010). Supply chain product visibility may be defined as the capacity of the supply chain to have a view of a product's lifecycle, from its conception, manufacturing, and distribution, to its delivery to the end customer, the customer's experience of the product, and the product's end-of-life activities and processes. Based on an extensive content analysis of academic and trade literature, including websites and documents of vendors and users of the technologies, Musa et al. (2014) capture, analyze, compare, and contrast the design choices, essence, results, and current and potential future impacts of some recent developments. The contribution of Madenas et al. (2016) is to demonstrate a system architecture for integrating product lifecycle management (PLM) systems with cross-supply chain maintenance information to support root cause analysis. By integrating product data from PLM systems with warranty claims, vehicle diagnostics, and technical publications, engineers were able to improve the root cause analysis and close the information gaps (Madenas et al., 2016). The contribution of Behnake and Janssen (2020) is to identify boundary conditions for sharing assurance information to improve traceability. Four cases in the food supply chain have been investigated using a template analysis of 16 interviews (Behnke & Janssen, 2020). The pharmaceutical supply chain involves some level of commingling of a collection of stakeholders, such as distributors, manufacturers, wholesalers, and customers. If exposed beyond the temperature range, the medicine no longer works as intended. An internet of things sensor-based blockchain framework is proposed that tracks and traces drugs as they pass slowly through the entire supply chain (Singh et al., 2020).

RESEARCH OBJECTS AND METHODS

Research Object

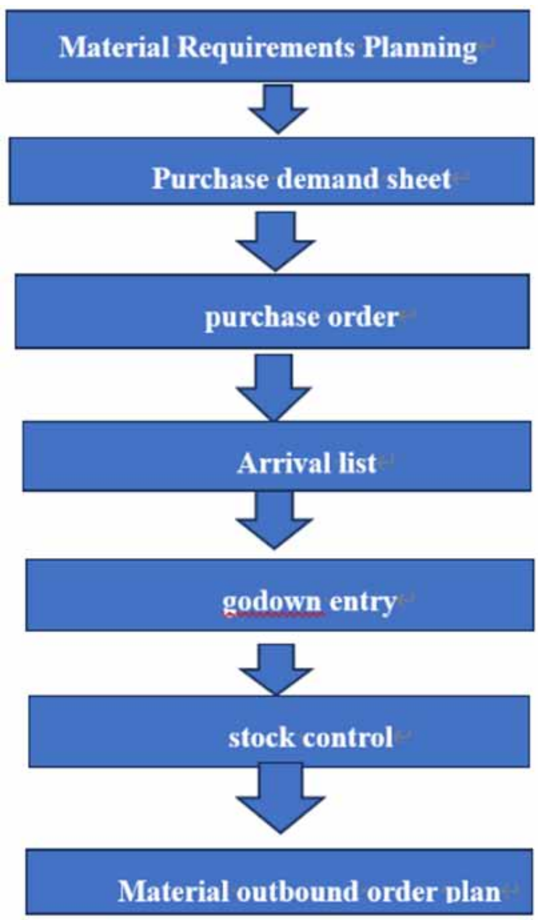
This paper takes the supply chain of enterprise resource management at Company A as the research object. Company A is in a leading position in the manufacturing industry, and its main competitors are all from abroad. These competitors all have advanced enterprise resource management systems. Company A has a complete industrial chain and produces many kinds of products. With the change in market demand for various products, its production mode is also adjusted, which brings certain challenges to company management (Borkar et al., 2021). As a manufacturing company, Company A has a great demand for employees. At present, it has more than 20,000 employees, most of whom are front-line employees with low education levels. However, the production of products requires high precision and quality, relatively little manual labor, and the human resource structure is quite complicated (Zhang et al., 2021).

The company has been distributed in three prefecture-level cities in four plants. Each plant is responsible for different businesses. There is a need for coordination and unity in the enterprise management system of each plant. The internal management system needs to be sound and inter-plant production should be coordinated. Logistics and production management put forward higher requirements.

Research Methods

The healthy and orderly development of enterprises cannot be separated from a reliable and advanced supply chain management system (Herbert et al., 2018). This paper analyzes the logic of supply chain operations for enterprises and establishes the user group of the system software according to the type of business carried out by the supply chain system. Figure 1 gives the main process of the supply chain of Company A. Company A's supply chain system starts with material demand application.

Figure 1. The main process of supply chain of Company A



After formulating purchasing demand, issuing a purchase order, and purchasing material arrives, the receiving department formulates an arrival list, and distributes it to each warehouse according to the material type. The warehouse completes the designated purchasing warehousing order and puts the material on the shelves in the warehouse. The material then enters the inventory management of Company A.When the production line uses the materials, it will put forward the application form for material release, and the warehouse will send it to the production line according to the application form for material release to meet the demand of the production department. The company's entire supply chain system involves more departments and business diversification. Supply chain departments also need to carry out quality inspections of materials, outsourcing operations, production line returns, procurement returns, and inventory of a series of operations.

According to the supply chain process, the company is divided into six departments: planning, purchasing, receiving, warehouse, production line, and quality control. The planning department is mainly responsible for the formulation of material requirements and purchase orders, paying attention to the company's annual and monthly plans, making inventory statistics, and grasping the production capacity of the production line (Hancock & Chignell, 1987). The purchasing department makes purchase orders and purchases materials, focusing on the receiving capacity and inventory of the receiving department. The receiving department formulates the arrival document and is responsible for distributing the materials to various warehouses. It is necessary to determine the arrival time and quantity of the materials and the quantity sent to each warehouse (Zarei et al., 2023). The warehouse is mainly responsible for a series of operations, such as purchase receipt, inventory management, material delivery, transferring in and out, good inventory, and material loading and unloading. Some people in the production line make a material delivery application form and record the production and material inventory of the production line in detail (Trotta et al., 2021). Quality control is mainly responsible for the inventory, allocation, and arrival inspection of materials, as well as understanding the warehouse inventory and production line requirements.

Based on arranging the responsibilities of each department of a company's supply chain, the characteristic information of system users in each department is obtained to develop the supply chain system (Rojas et al., 2018). Through the focus group, the staff of all departments were investigated before the system design, the staff of departments involved in the supply chain were called to collect requirements (see Table 1), and group discussions were held on product functions, workflow, user requirements, design of user interface structure, user model, etc. Using the card method, many functions of system products are written on cards (Arnold, 2018). Designers and users classify these cards according to business logic, work content, and other factors and arrange them according to the importance of users' requirements for these functions, to obtain the degree of users' requirements for each functional module of the product and carry out function development and human-machine interface design (Akundi et al., 2022).

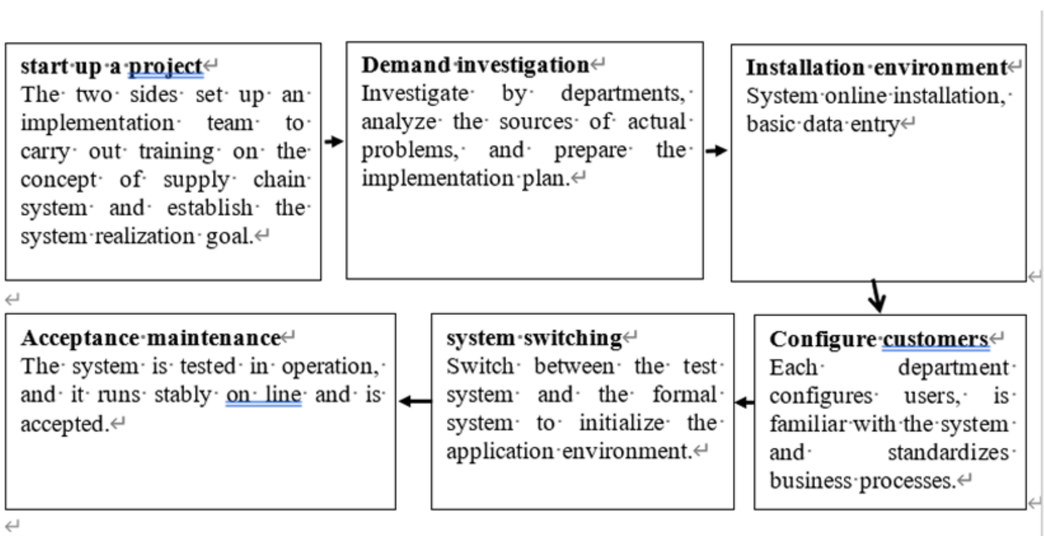
Supply chain system development is divided into starting the project, demand research, selecting the installation environment, configuring the customer, online operation, system training, acceptance, and operation. Before the start of the project, Company A makes system development plans and sets up a special research and development team and the IT department assigns special people to cooperate and mobilize employees to help them better understand the advantages of the supply chain system. In the supply chain system step-by-step development, first, the supply chain departments must carry out demand research to understand the system concerns of each department and become familiar with the internal management model of each department (Petzoldt et al., 2020). To configure the supply chain system installation environment, this paper adopts the Python programming language, chooses a Java environment, and upgrades the browser to ensure the normal use of the supply chain system through the operation of the system by the various departments of staff training so that they are skilled in the system operation with the enterprise's existing data into the test system, the parallel test system, and the real system to compare the effect of operation (Zhang et al., 2022). There are differences in the responsibilities of the supply chain departments and the need to configure the

Table 1. Company A supply chain system specific demand development form

Function Needs	Priority	Functional Description
Supplier qualification certificate	B	Certificate expired and cannot be purchased
Stage price maintenance	B	Material stage price maintenance
Import material demand requisition	B	Import purchase requisitions in different formats
Order card control	A	Qualified stage, stage price, and frozen purchase
Storage card control	A	Shelf life, GP validity period
In-warehouse inspection	B	Check the consumption, freezing, and thawing of materials
Transfer receipt document	B	Transfer receipt material quantity
Zero inventory requisition purchase order	B	Generate arrival documents and material requisition documents
Zero inventory material arrival document	B	Human-machine interface completes material warehousing, inspection, and delivery
Transfer outbound order	B	Consolidated print of outbound order
Incomplete billing materials	A	return

supply chain system customers according to the departmental business processes in the system to standardize (Nguyen et al., 2022). The system formally began to run online, and the company used the problems encountered in the first round of feedback to the developers and questions and answers. The system has been in operation for one month and is stable; each department's staff have been able to operate it proficiently. (see Figure 2). In this paper, the supply chain system adopts the B/S (Browser/Server) structure system, which enters the supply chain system by inputting and logging in the browser, transmits and operates the data through the hypertext mode, and at the same time,

Figure 2. Company A supply chain system implementation process



issues commands by using the processing system, feeds back the results of the command's execution to the client's browser, and analyzes the data.

RESEARCH RESULTS

User Characteristic Analysis

Company A's supply chain system is divided into six segments according to corporate departments, and each supply chain segment has different roles. This paper compares the differences between the user characteristics of each sector of the supply chain in terms of the user's education, the number of people using the system in each sector, the scope of responsibilities of the sector, and the documents that need to be operated. By incorporating user characteristics into the system, it truly realizes user-centered design, enhances the efficiency of supply chain system usage, and improves the competitiveness of enterprises.

The planning department staff are more educated than the staff in other departments, and they are more receptive to the new system. At the same time, they have higher requirements for the system's human-machine interface, data accuracy, and real-time requirements. The planning department staff mainly study the quarterly and annual production planning of the enterprise, accurately grasp the production efficiency of the production department and the situation of the warehouse materials, and make the material demand list and purchase request list so the system can clearly show that the data is the key concern of the planning department.

The purchasing department mainly completes the purchase according to the material requirements of the planning department. Users in the purchasing department require the system to clearly show the material requirements of the planning department, and purchase orders can be formed through as few operations as possible. When the system is designed, the material demand requisition can be automatically generated into a purchase order, and the main material information (such as code, model, supplier, and quantity) of the demand requisition can be automatically matched with the purchase order. Only by providing the printing function can the purchasing department print the document and complete the purchase project.

The receiving department is mainly responsible for the handling of goods and filling in arrival documents, with a relatively heavy workload. The arrival documents are automatically generated through the system and the receiving department only needs to check the data of the arrival documents and distribute them directly to each warehouse. The efficiency of the receiving department can be greatly improved through the system.

Warehouse operation is the link with the largest number of users in the supply chain system and the types and quantities of documents are also the largest. According to different businesses, warehouses can be divided into material warehouses, parts warehouses, municipal warehouses, and other modules. There are more than 1,500 warehousing orders and more than 1,000 outbound orders in the warehouse every day. There are also transfers between materials in various factories. Therefore, the warehouse is the core user of the supply chain system, and the demand is diversified. It is necessary to ensure that the check between the inventory and the purchase warehousing is convenient, intuitive, and accurate.

The production line mainly plays the role of data checking and interception to ensure data accuracy. As the core software of enterprise management, the accuracy of data is particularly critical, and the comfort of use should also be ensured. Therefore, the accuracy of the data should be ensured in the system development process.

The quality control link is mainly about the inspection of materials, and various quality inspections are carried out on materials, mainly based on input data and a few operating systems. Pay attention to the convenience of the system when designing the quality control module. The import and export operation of the inspection sheet is simple, and the experimental information and material consumption quantity are filled in.

By further refining the requirements of the participating departments of the supply chain system and further optimizing and perfecting the system functions, the time taken by users to complete tasks before and after the system optimization is compared (see Figure 3).

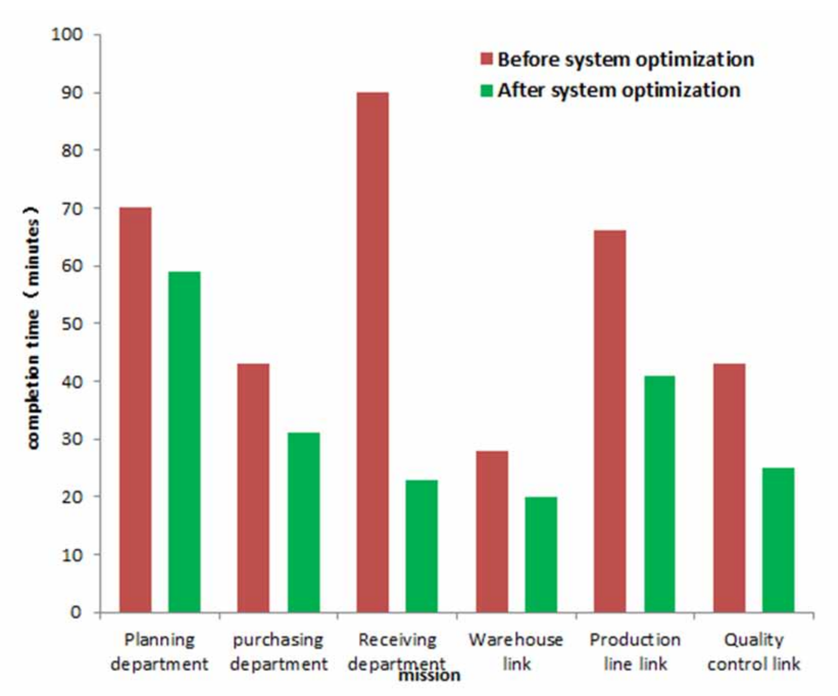
The operation time of the planning department is saved by 15.71%. By adding the inventory display function, users can know the inventory situation of materials in the purchase order interface without going to the scene to inquire about the inventory, which simplifies the operation steps and saves the page conversion time and the system query response time. When the planning department prepares the purchase order, the system can visually observe the safety stock of the material, the consumption quantity of the previous month, and the information of the next order that has not arrived, so that the purchase will not be duplicated, resulting in waste.

The operation time of the purchasing department is saved by 27.91%, and the improved system adds the function node of supplier certificate maintenance, which can facilitate the purchasing department to maintain supplier certificates, intuitively display the relevant information of each supplier certificate to the purchasing personnel, and facilitate the buyers to carry out purchasing business.

The receiving department had an operation time savings of 74.44%. The original supply chain system needs to receive materials in the receiving order link, and then check the materials in and out of the warehouse. It required opening the system's three nodes. After the optimization of the system, only the arrival order node needs to be opened, and the user can directly carry out the operation of the warehouse and out of the warehouse, thus saving system operation time and reducing the user's workload.

The storage link saves about 28.57% of operation time. After the improvement, the system adds material warehousing interception. When users operate purchasing warehousing, there is a lot of data and it is very easy to forget the purchasing warehousing type, which leads to an error in the material warehousing type, which will affect the return of materials and lead to unnecessary disputes with suppliers. At present, the system has ensured the accuracy of information, saved inspection time, and made the supply chain process more accurate.

Figure 3. User task completion time



The production line saves about 37.88% of operation time. After the improvement, users of the system can directly transfer the materials to the warehouse without customizing the inspection documents and delivery documents and they can click the button of inspection to send the materials for inspection. After the system signs, it automatically completes the operation of inspection and consumption delivery and generates the material delivery documents.

The quality control link saves about 41.86% of operation time. After the improvement, the system will directly send the materials that need to be sent for inspection, freeze the materials when they are sent for inspection, unfreeze and deduct the inspection consumption after the inspection is completed, reduce the system operation time for quality control, improve work efficiency, and improve user satisfaction.

System satisfaction is mainly based on questionnaire surveys on the system interface, interaction mode, operation mode, and accuracy from the user's point of view. The theories of psychology and human-computer interaction are used to construct a model to verify the relationship between UX and efficiency. According to psychological research, UX is affected by several factors, such as cognition, emotion, and behavior, while efficiency is affected by factors such as task complexity, tool availability, and individual ability. By combining these factors, a comprehensive model can be built to validate the relationship between UX and efficiency. In this paper, we record the user's expression and speech when operating the system in the form of an interview to determine the user's satisfaction, and the satisfaction is fully categorized into five levels, as shown in Table 2.

Figure 4 shows the user's satisfaction. Although the time saved in the warehouse link is only 28.57%, the satisfaction increased a lot, mainly due to the obvious improvement in the accuracy of data such as material warehousing and warehousing when users use the supply chain management system. The accuracy of data has been enhanced by intercepting the warehousing and warehousing types, so the satisfaction of users has improved.

The overall optimized system of supply chain management is more standardized, and the operational efficiency is significantly improved. Through the optimization of business operations, it makes personnel more comfortable and convenient. By modifying and improving some functions of the system business process, the business process is optimized, and the multi-step process is simplified to a button operation, saving the operation time. The process is also simplified to effectively reduce the probability of error by the staff and to ensure more accurate and reasonable distribution and processing of materials. Supply chain systems set up several systems for card control and effective control of human errors in operation. With the progress of science and technology, the level of enterprise information management is constantly strengthened to help enterprises in the development of good results. Therefore, UX and efficiency are two indispensable aspects in the design and development of supply chain management systems. Only by considering UX and efficiency can the product stand out in the market and gain the recognition and love of the users, and through continuous optimization of the product, it can provide a better UX and higher efficiency.

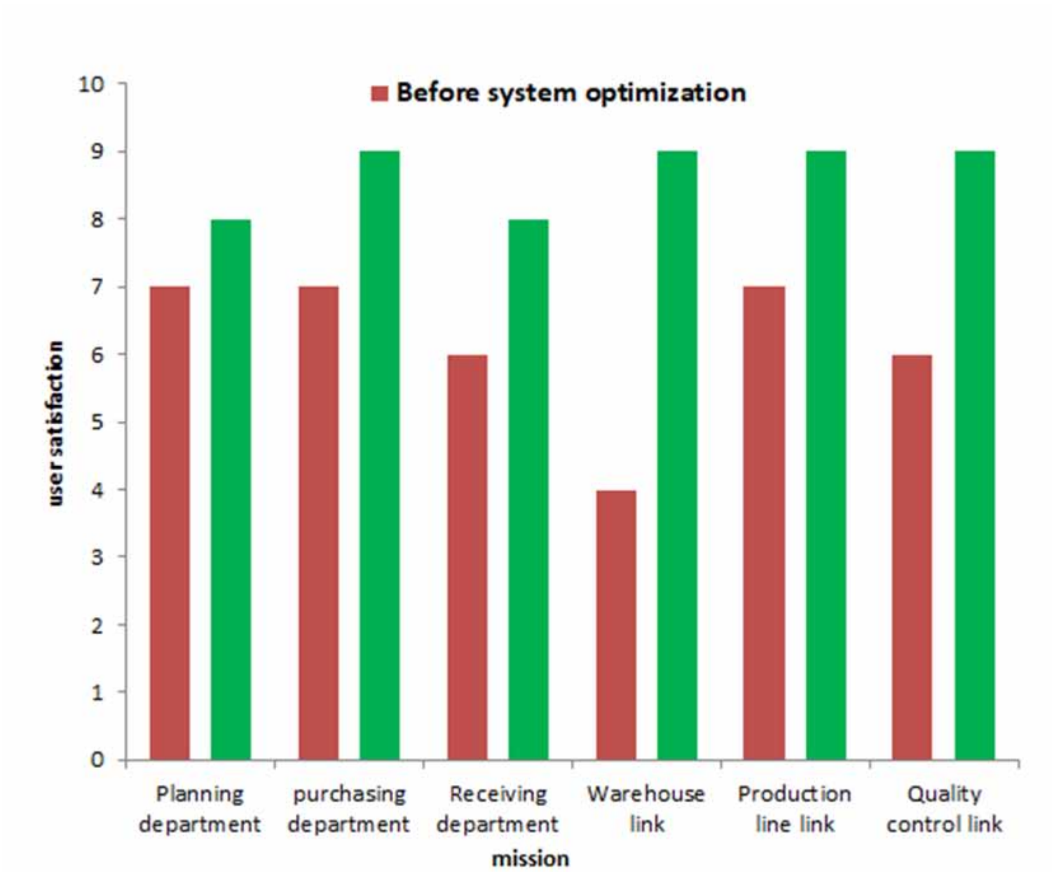
HUMAN-MACHINE INTERFACE DESIGN EFFECT ANALYSIS

In the design of the human-machine interface, the system realizes a table of material information, which can be directly checked, and it is not easy to cause inconsistency between the actual situation and the system data. When the system has a human-machine interface function, each

Table 2. User satisfaction level

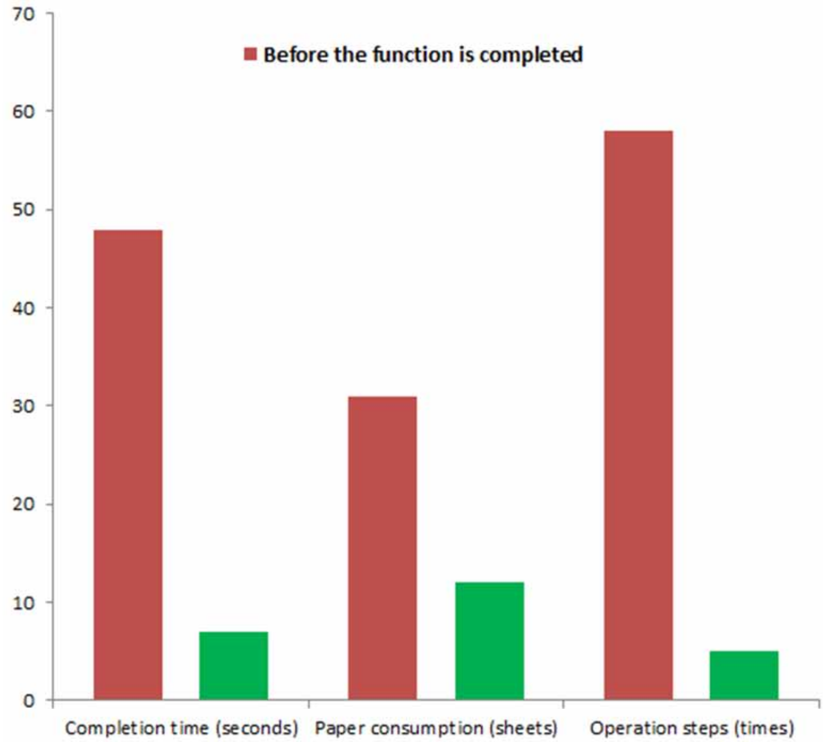
Satisfaction Score	9~10	7~8	5~6	3~4	1~2
Satisfaction evaluation	Very satisfied	Satisfied	Common	Dissatisfied	Very dissatisfied

Figure 4. User satisfaction



document must pull the progress bar to check hundreds of items of material information, which is very time-consuming and labor-intensive, and users need to check more than 1,500 items of data every day. Through the human-machine interface function, the checking time of each document is reduced by 10 seconds, and the total working time is greatly reduced. This paper compares 30 tests of data checking, combined printing, and operation steps. Figure 5 shows the comparison of data checking time, paper consumption, and operation steps before and after the use of the human-machine interface function. As can be seen from Figure 5, before and after the human-machine interface function is realized, the time for users to check 30 pieces of data is reduced by 85.42%, the paper consumption is reduced by 61.29%, and the operation steps are reduced by 91.38%. Therefore, through the human-machine interface function, the data processing time is faster. After adding the merge print button, document data can be printed all at once by selecting the data to be printed. This means that printing operation time has nothing to do with document data volume, which saves the workload. The traditional printing of material information one by one wastes paper, and the material information of each document on each paper is only two blue lines. After combined printing, the blank space on the paper can be filled, which can save about half of the paper and significantly reduce the printing cost.

Figure 5. Comparison of human-machine interface function before and after use



CONCLUSION

Enterprise supply chain systems directly affect the core competitiveness of the enterprise market, which is vital for the production capacity and profit of manufacturing enterprises. Taking Company A as an example, this paper analyzed its supply chain system and developed the company's supply chain system by using focus groups and card sorting according to the company's supply chain process after investigating its actual needs and supply chain characteristics. To contrast various supply chain departments, find the differences in user characteristics, design the differences into the system, realize the human-machine interface function, analyze the efficiency and customer satisfaction of each working procedure after system optimization, and improve the efficiency of the company's supply chain. The user characteristics analysis and human-machine interface design of the supply chain system provide theoretical data support. The main research results are as follows.

Company A, as a manufacturing enterprise, has a complete industrial chain, produces a wide range of products, has many employees, and has a presence in many regions. The whole supply chain system of Company A involves planning departments, purchasing departments, receiving departments, warehouses, production lines, quality control, and other departments. Before the development of the company's supply chain system, the requirements of the department personnel involved in the supply chain were collected, and the functions of the system were recorded using the card-by-card method. Designers and users were arranged according to the business process and work content of the supply chain, and the B/S (Browser/Server)structure system was adopted to complete the design of each functional module and human-machine interface of the supply chain system.

The user characteristics of various departments in the supply chain are quite different. By refining the requirements of the participating departments of the supply chain system and optimizing the functions of the supply chain system, the operation time of the planning department, the purchasing department, the receiving department, the warehouse, the production line, and the quality control department is reduced by 15.71%, 27.91%, 74.44%, 28.57%, 37.88%, and 41.86%, respectively. After the optimization, the supply chain management of the system is more standardized, the operation efficiency is improved, the personnel are more comfortable and find it more convenient to use, the step flow is simpler, and the accuracy is higher. With the realization of human-machine interface design, material data checking time, paper consumption, and operation steps are reduced, which greatly saves manpower and financial costs.

The user characteristics analysis of the supply chain system shows that it provides enterprises with more accurate market positioning and personalized services, while the novelty of the human-machine interface design is that it improves the UX, reduces the complexity of operation, and improves work efficiency.

AUTHOR NOTE

The authors of this publication declare there are no competing interests.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. Funding for this research was covered by the author of the article.

The author would like to show sincere thanks to those who have contributed to this research.

REFERENCES

Akundi, A., Euresti, D., Luna, S., Ankobiah, W., Lopes, A., & Edinbarough, I. (2022). State of Industry 5.0—Analysis and identification of current research trends. *Applied System Innovation*, *5*(1), 27. doi:10.3390/asi5010027

Arnold, M. G. (2018). Combining conscious and unconscious knowledge within human-machine-interfaces to foster sustainability with decision-making concerning production processes. *Journal of Cleaner Production*, *179*, 581–592. doi:10.1016/j.jclepro.2018.01.070

Behnke, K., & Janssen, M. F. W. H. A. (2020). Boundary conditions for traceability in food supply chains using blockchain technology. *International Journal of Information Management*, *52*, 101969. doi:10.1016/j.ijinfomgt.2019.05.025

Borkar, P. S., Chanana, P. U., Atwal, S. K., Londe, T. G., & Dalal, Y. D. (2021). The replacement of HMI (human-machine interface) in industry using single interface through IoT. In *Examining the impact of deep learning and IoT on multi-industry applications* (pp. 195–208). IGI Global., doi:10.4018/978-1-7998-7511-6.ch011

Cao, S., Powell, W., Foth, M., Natanelov, V., Miller, T., & Dulleck, U. (2021). Strengthening consumer trust in beef supply chain traceability with a blockchain-based human-machine reconcile mechanism. *Computers and Electronics in Agriculture*, *180*, 105886. doi:10.1016/j.compag.2020.105886

Gold, S., Seuring, S., & Beske, P. (2010). The constructs of sustainable supply chain management–a content analysis based on published case studies. *Progress in Industrial Ecology*. *International Journal (Toronto, Ont.)*, *7*(2), 114–137. doi:10.1504/PIE.2010.036045

Hancock, P. A., & Chignell, M. H. (1987). Adaptive control in human-machine systems. In P. A. Hancock (Ed.), Advances in psychology: Vol. 47. Human factors psychology (pp. 305–345). North-Holland. doi:10.1016/S0166-4115(08)62312-2

Herbert, R., Kim, J. H., Kim, Y. S., Lee, H. M., & Yeo, W. H. (2018). Soft material-enabled, flexible hybrid electronics for medicine, healthcare, and human-machine interfaces. *Materials (Basel)*, *11*(2), 187. doi:10.3390/ma11020187 PMID:29364861

Hollnagel, E. (2002). Time and time again. *Theoretical Issues in Ergonomics Science*, *3*(2), 143–158. doi:10.1080/14639220210124111

Kumar, N., & Lee, S. C. (2022). Human-machine interface in smart factory: A systematic literature review. *Technological Forecasting and Social Change*, *174*, 121284. doi:10.1016/j.techfore.2021.121284

Lin, P. H., Wong, D. S. H., Jang, S. S., Shieh, S. S., & Chu, J. Z. (2004). Controller design and reduction of bullwhip for a model supply chain system using z-transform analysis. *Journal of Process Control*, *14*(5), 487–499. doi:10.1016/j.jprocont.2003.09.005

Madenas, N., Tiwari, A., Turner, C. J., Peachey, S., & Broome, S. (2016). Improving root cause analysis through the integration of PLM systems with cross supply chain maintenance data. *International Journal of Advanced Manufacturing Technology*, *84*, 1679–1695. doi:10.1007/s00170-015-7747-1

Musa, A., Gunasekaran, A., & Yusuf, Y. (2014). Supply chain product visibility: Methods, systems and impacts. *Expert Systems with Applications*, *41*(1), 176–194. doi:10.1016/j.eswa.2013.07.020

Nguyen, T. P., Nguyen, H., & Thinh Ngo, H. Q. (2022). Planning the Emergency Collision Avoidance Strategy Based on Personal Zones for Safe Human-Machine Interaction in Smart Cyber-Physical System. *Complexity*, *2022*, 1–21. Advance online publication. doi:10.1155/2022/2992379

Nuamah, J., & Seong, Y. (2017). Human machine interface in the Internet of Things (IoT). In *2017 12th System of Systems Engineering Conference* (pp. 1–6). IEEE. doi:10.1109/SYSOSE.2017.7994979

Petzoldt, C., Wilhelm, J., Hoppe, N. H., Rolfs, L., Beinke, T., & Freitag, M. (2020). Control architecture for digital twin-based human-machine interaction in a novel container unloading system. *Procedia Manufacturing*, *52*, 215–220. doi:10.1016/j.promfg.2020.11.037

Rojas, R., Rauch, E., Dallasega, P., & Matt, D. (2018). Safe human-machine centered design of an assembly station in a learning factory environment. In *Proceedings of the International Conference on Industrial Engineering and Operations Management, Bandung, Indonesia, March 6–8, 2018* (pp. 403–411). IEOM. https://hdl.handle.net/10863/5588

Singh, R., Dwivedi, A. D., & Srivastava, G. (2020). Internet of things based blockchain for temperature monitoring and counterfeit pharmaceutical prevention. *Sensors (Basel)*, *20*(14), 3951. doi:10.3390/s20143951 PMID:32708588

Trotta, S., Weber, D., Jungmaier, R. W., Baheti, A., Lien, J., Noppeney, D., Tabesh, M., Rumpler, C., Aichner, M., Albel, S., Bal, J. S., & Poupyrev, I. (2021). 2.3 SOLI: A tiny device for a new human machine interface. In *2021 IEEE International Solid-State Circuits Conference* (pp. 42–44). IEEE. doi:10.1109/ISSCC42613.2021.9365835

Whicker, L., Bernon, M., Templar, S., & Mena, C. (2009). Understanding the relationships between time and cost to improve supply chain performance. *International Journal of Production Economics*, *121*(2), 641–650. doi:10.1016/j.ijpe.2006.06.022

Zarei, M., Lee, G., Lee, S. G., & Cho, K. (2023). Advances in biodegradable electronic skin: Material progress and recent applications in sensing, robotics, and human–machine interfaces. *Advanced Materials*, *35*(4), 2203193. doi:10.1002/adma.202203193 PMID:35737931

Zhang, X., Hui, L., Wei, L., Song, F., & Hu, F. (2021). A bibliometric analysis of human-machine interaction methodology for electric-powered wheelchairs driving from 1998 to 2020. *International Journal of Environmental Research and Public Health*, *18*(14), 7567. doi:10.3390/ijerph18147567 PMID:34300017

Zhang, X., Liao, X. P., & Tu, J. C. (2022). A study of bibliometric trends in automotive human–machine interfaces. *Sustainability (Basel)*, *14*(15), 9262. doi:10.3390/su14159262

Kun Yang was born in Henan, China, in 1989. From 2009 to 2013, he studied in Henan University of Technology and received his bachelor's degree in 2013. From 2013 to 2015, he studied in Shanghai Maritime University and received his Master's degree in 2015. Currently, he works in Henan Institute of Economics and Trade. He has published seven papers, one of which has been indexed by Core journal of Peking University. His research interests are included green Logistics and supply chain design and optimization.