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Analysis of User Requirements for an Educational Laboratory Material Inventory System Using the Quality Function Deployment (QFD)

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ABSTRACT
Inventory management in one of the educational laboratories in Karawang is still carried out manually, causing inconsistency in stock data with actual conditions, delays in updating information, and low efficiency in supporting practicum and research activities. This research aims to identify the needs of students and lecturers as the main users, then translate them into technical specifications for the development of laboratory inventory information systems. The method used is Quality Function Deployment (QFD) through House of Quality (Phase I) and Part Deployment (Phase II). Data was collected through observations, interviews, and questionnaires that have been tested for validity and reliability before being analyzed. The results of the study show four main needs of users, namely system access speed, data security, attractive interface, and ease of use. In QFD Phase I, these needs translate into priority technical characteristics in the form of servers and databases, menu structures, and interfaces and user experience. Furthermore, QFD Phase II produces eight priority component characteristics, including multi-device support, rapid system response, API integration with College Information Systems, responsive design, database management, simple navigation, data encryption, and high-availability servers. This research contributes through the application of QFD up to Phase II as a systematic approach in designing a laboratory inventory information system that is oriented to user needs so as to improve service quality, ease of use, and operational efficiency.

INTRODUCTION

Education Laboratories have an important role in supporting the quality of learning, especially through practicum and research activities of students and lecturers. Equipment borrowing activities and requests for practicum and research materials are routine activities carried out in the laboratory [1] The availability of adequate practicum tools and materials is an important factor so that all laboratory activities can run effectively [2]

Inventory is a stock of goods that is stored in a warehouse to meet future needs [3] According to [4] well-managed inventory is able to increase operational efficiency and optimize resource utilization. Good inventory management according to [5]. includes monitoring and controlling stock, so that raw materials are always available when needed, and avoid waste. However, if inventory is poorly managed, such as

inaccurate inventory data according to [6] can lead to shortages or overstocks. In addition, according to [3] it can lead to waste and financial losses.

At the Education Laboratory of Universitas Buana Perjuangan Karawang, the process of requesting materials, borrowing tools, purchasing, and stock taking is still carried out manually using a logbook. According to [3], [6] paper-based recording has disadvantages in the form of a high risk of recording errors, delays in data updates, and mismatches in inventory information. Based on the results of observation, it was found that 368 items of materials were purchased, there were 34 items that were not recorded in the material inventory data and 25 items that were not recorded in the usage data. In addition, there was a level of mismatch between purchase, usage, and actual stock data. According to [7], [8] manual system used can increase the risk of unused materials passing the expiration period, thus having an impact on the smooth running of laboratory activities. Even according to [9] the computer-based inventory system with Microsoft Excel alone still has shortcomings in terms of speed of information provision, recording time and monitoring of problems such as damaged goods, warehouse errors and inventory differences, which can affect services and finances.

The development of research on inventory information systems shows a shift from just building web-based systems to designing systems that are increasingly oriented to user needs. Most studies have developed inventory information systems using the Software Development Life Cycle (SDLC) approach, particularly the waterfall model, which has been proven to improve the accuracy of data management, speed up the recording process, support stock monitoring, and produce more integrated information [10] [11] [12], [13] [14], [15] [16] . Along with these developments, the Quality Function Deployment (QFD) approach began to be applied in the development of information systems to translate user needs into technical characteristics, such as in the development of an Integrated Academic Information System [17] as well as the design of an Integrated Fleet Weapon System (SSAT) that integrates QFD with SDLC [18]. However, these studies generally still focus on translating user needs into technical characteristics, while the systematic linkage between customer requirements, technical requirements, and part characteristics as the basis for the preparation of system specifications has not been widely discussed, especially in laboratory inventory information systems.

Based on previous research studies, the Quality Function Deployment (QFD) or House of Quality (HoQ) approach has been widely used to translate the voice of customer into technical characteristics as the basis for product development, service quality improvement, and system design. In the context of information systems, QFD has been used to analyze user needs in the decision support system for the promotion of lecturers [19], evaluate the service quality of customer marketing information systems [20], design ERP-based monitoring tools on SAP systems [21] develop smart aquaculture systems based on the Internet of Things (IoT) [22], as well as improving the quality of educational services through the integration of Servqual and QFD methods [23]. In addition, QFD is also applied to product development, such as the identification of technical characteristics and critical components in the design of plastic shredding machines through the integration of QFD and Design for Manufacturing and Assembly (DFMA) [24]. Other research shows that QFD is effectively used to improve the quality of academic information system services [17] and support system design through integration with the Software Development Life Cycle (SDLC) [18] However, these studies generally use QFD to identify user needs and determine the priority of technical characteristics, while the application of QFD as an approach that integrates customer

requirements, technical requirements, and part characteristics in the design of laboratory inventory information systems is still not widely reported. As a result, the relationship between user needs, technical specifications, and component characteristics as the basis for system implementation has not been systematically depicted. This gap is the basis for this research to apply QFD to Phase II (Part Deployment) in producing laboratory inventory information system specifications that are more oriented to user needs.

The importance of developing a laboratory inventory information system that is not only able to manage stock data digitally, but also truly represents the needs of users in supporting practicum and research activities. Information systems that are designed without systematically considering the needs of users have the potential to produce features that are not in line with laboratory business processes, reduce ease of use, and reduce the effectiveness of system utilization. Therefore, a design approach is needed that is able to translate the needs of students and lecturers into technical specifications and component characteristics as the basis for system development. This approach is expected to produce an inventory information system that is more user-oriented, has better functional quality, and supports more effective, efficient, and sustainable management of laboratory inventories.

Based on the problems, research gaps, and urgency that have been described, this study aims to analyze the needs of students, and lecturers as the main users of the laboratory inventory information system, then translate these needs into technical characteristics and component characteristics using the Quality Function Deployment (QFD) approach through the House of Quality (QFD Phase I) and Part Deployment (QFD Phase II) stages. The results of the research are expected to produce specifications for inventory information systems that are oriented to user needs as a basis for the development of a more effective, efficient, and easy-to-use educational laboratory inventory information system.

This research makes a contribution both theoretically and practically. Theoretically, this study expands the application of Quality Function Deployment (QFD) in the field of information system design by integrating House of Quality (QFD Phase I) and Part Deployment (QFD Phase II) to build a systematic relationship between user requirements (customer requirements), technical requirements, and component characteristics (part characteristics). This approach enriches the study of the application of QFD, which has been more widely used in product development and service quality improvement. Practically, this research produces a framework for designing laboratory inventory information systems that can be used as a reference by system developers and laboratory managers in designing information systems that are more user-oriented, so as to be able to improve service quality, ease of use, inventory management effectiveness, and operational efficiency of educational laboratories.

MATERIALS AND METHODS

This study uses a descriptive quantitative approach with the Quality Function Deployment (QFD) method to analyze user needs as the basis for designing a laboratory material inventory information system [25] The QFD method was chosen because it is able to translate the Voice of Customer (VoC) into technical characteristics that are a reference in system development. The research is limited to QFD Phase II (Part Deployment), resulting in priority user needs, technical characteristics, and recommendations for information system components.

The research subjects consisted of lecturers and students using the Laboratory of Buana Perjuangan University Karawang. A total of 234 respondents were selected using the purposive sampling technique, namely users who have used laboratory facilities and understand the process of requesting and using practicum materials. In addition, the determination of Technical Requirements is carried out through interviews with several web-based information system development experts who have experience in laboratory system development.

The research used two main variables, namely Customer Requirement (CR) and Technical Requirement (TR). The CR variable represents the needs and expectations of the user for the information system, while the TR is a technical characteristic designed to meet these needs. In QFD Phase II, each Technical Requirement is developed into a Part Characteristic (PC) as a recommendation for system components to be implemented. The operational definition of each variable along with the indicators and codes used in the preparation of the research instrument is presented in Table 1. The presentation of these indicators aims to explain aspects of user needs that are measured through questionnaires and become the basis for the preparation of the QFD matrix.

Table 1. Operational Research Variables and Questionnaire Indicators

Variabel	Indicator	Code
Customer Requirement	Laboratory Materials Service	QDM1
	System Menu	QDM2
	Real-time Information	QDM3
	Access Speed	QDM4
	Audit of Data Change	QDM5
	Data Security	QDM6
	Attractive Interface	QDM7
	Ease of Use	QDM8
	System Connection	QDM9
	Internet support	QDM10

The overall stages of the research are shown in Figure 1. Data collection was carried out through observation of the business process of laboratory material inventory, the distribution of questionnaires to obtain Voice of Customer (VoC), interviews with experts to formulate the technical characteristics of the system, and literature studies as the conceptual basis for the research. The research instrument was tested using SPSS software through a validity test using the Pearson Product Moment method and a reliability test using Cronbach's Alpha [12].

Data analysis was carried out using the QFD method which consists of two phases. In QFD Phase I (House of Quality), identification of user needs (Customer Requirements), determination of technical characteristics (Technical Requirement), preparation of relationship matrix between CR and TR, analysis of correlations between technical characteristics, and calculation of priority of technical characteristics as the basis for determining system development targets. Furthermore, QFD Phase II (Part Deployment) uses the priority Technical Requirement from Phase I as input to determine Part Characteristics, analyze the relationship between TR and PC, and calculate the priority of each component so that recommendations for system components that are the focus of the development of laboratory material inventory information systems are obtained.

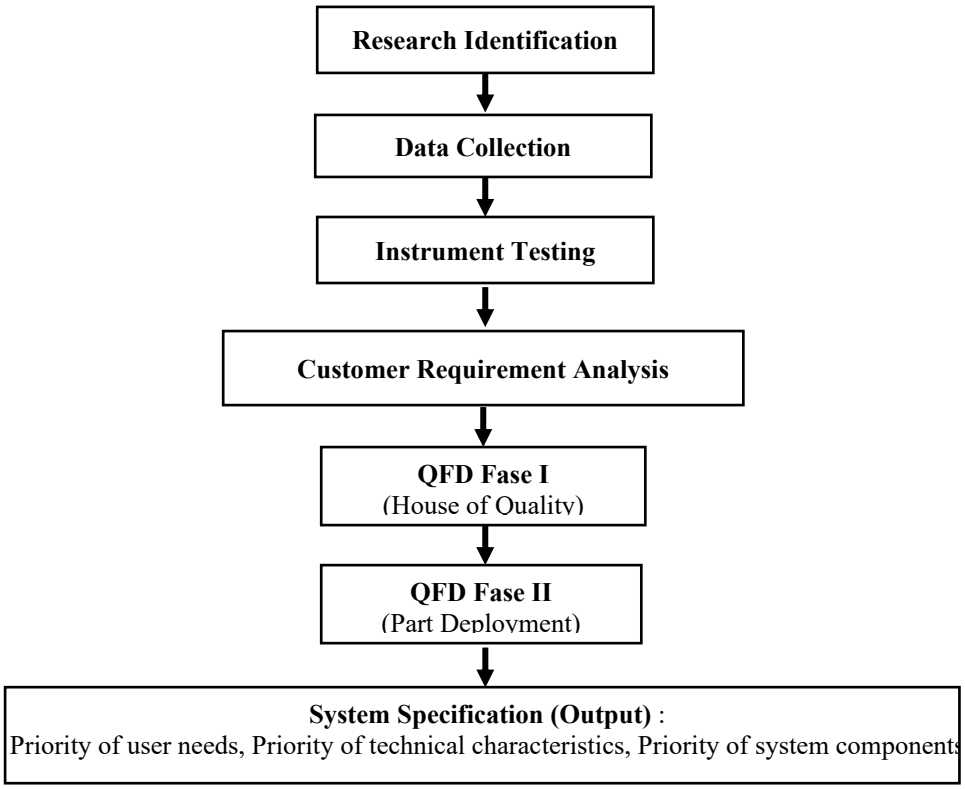


Figure 1. Research stages using the QFD approach.

RESULTS AND DISCUSSIONS

Before the needs analysis is carried out using Quality Function Deployment (QFD), the research instrument is first tested for validity and reliability to ensure that the data obtained is suitable for use as a basis for analysis. The results of the validity test can be seen in table 2. indicates that the whole question item has a Pearson Correlation value greater than the r-table value (0.532) at a significance level of 5%. In addition, all items have a significance value of less than 0.05 so that all statements are declared valid and able to represent the user's needs for the inventory information system. Furthermore, the results of the reliability test can be seen in table 3. shows Cronbach's Alpha value of 0.943, higher than the minimum limit of 0.60. These values show that the research instrument has an excellent level of internal consistency so that it is suitable for use in the analysis of user needs.

Table 2. Validity Test Results

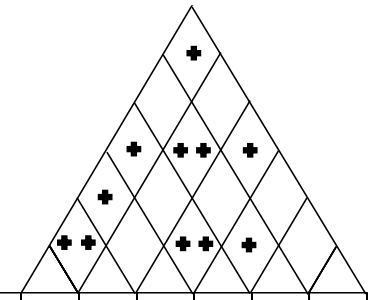
Item	Pearson Correlation	Significant	Status
QDM1	0,792	0,000	Valid
QDM2	0,798	0,000	Valid
QDM3	0,826	0,000	Valid
QDM4	0,827	0,000	Valid
QDM5	0,826	0,000	Valid
QDM6	0,832	0,000	Valid
QDM7	0,851	0,000	Valid
QDM8	0,806	0,000	Valid

QDM9	0,781	0,000	Valid
QDM10	0,798	0,000	Valid

Table 3. Reliability Test Results

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0,943	0,943	10

The results of the Quality Function Deployment (QFD) Phase I analysis can be seen in figure 2. It shows that there are four customer requirements with the highest level of importance, namely system access speed, data security, attractive interface appearance, and ease of use of features. These four needs reflect the main expectations of students and lecturers as users of the laboratory inventory information system so that they become the basis for determining the technical characteristics of the system.



Engineering Requirements / *Customer Requirements*		*Customer Importance*	*Menu Structure*	*Server & Database*	*User Interface (UI) & Experience (UX)*	*Information Architecture*	*System Security*	*Internet Technology*
Functionality	The proposed information system supports laboratory material management and service processes.	0,84	9	3		1	1	1
	The available menus support material requests, receipt, returns, stock monitoring, and usage history tracking.	0,84	9	9	3	3		
	The information system displays all data in real time.	0,85		3	3	1		3
Usability	The information system provides fast access and response during operation.	0,86		3	3			3
Data Security	All data modifications are recorded in a structured manner.	0,85	3		1	3	1	
	Data stored in the information system are protected against various security threats.	0,86		3			9	
User Interface	The information system has an attractive user interface.	0,86	3	3	9	3		
	The system features are easy to understand and use.	0,86	3		3	9		
Connectivity	The information system is integrated with other relevant units according to the operational workflow.	0,85	1	3		1		
	Access to the information system is supported by a reliable internet connection.	0,85		1			1	9
	Absolute Importance		23,745	23,808	18,818	17,94	10,273	13,655
	Relative Importance		22%	22%	17%	17%	9%	13%
	Rank		2	1	3	4	6	5
	Target Value		3 Menu	< 2 Second	Score > 70	2-3 level per clink	Hashing Techinical	> 10 Millisecond

Figure 2. House Of Quality (QFD Fase I)

Based on the values of absolute importance and relative importance, the three technical requirements that have the highest priority are server and database, menu structure, and user interface and user experience. The correlation analysis between technical characteristics shows a positive relationship, with a strong relationship between server and database and menu structure, while the relationship between menu structure and user interface and user experience is included in the medium category. These results show that improving server performance will have an impact on ease of navigation, while improving menu structure will support improved user experience.

Based on these priorities, the system's technical target is set in the form of a server response time of less than 2 seconds, a navigation structure consisting of three main menus, namely the dashboard, material request, and request status, and the target value of the System Usability Scale (SUS) $\geq$ 70 as an indicator of the system usability level.

Furthermore, QFD Phase II (Part Deployment) is used to translate technical characteristics into system component characteristics see figure 3. The results of the analysis showed that the components with the highest priority were multi-device support, system loading speed, and Application Programming Interface (API) integration with the Higher Education Information System (SIPT). In addition, other components that are priorities include Bootstrap-based responsive design, database management using MySQL, a maximum of three levels of navigation structure, data security using Secure Sockets Layer (SSL), and server uptime $\geq$ 99%. The priority of these components is a reference in the preparation of specifications for the laboratory material inventory information system

		Importance Rating	Component Characteristics												
			Navigation Structure	Framework Frontend	Database Management	Backup & Recovery	User Activity Log	Role-Based Access Control (RBAC)	Data Encryption	Responsive Design	Server Uptime	Multi-device	Loading Time < 2 Seconds	Modular Architecture	API Integration
Technical Characteristics	Menu Structure	23,75	9	3				3		9		9	3	3	
	Server & Database	23,81			9	9	3	3	9		9		3	3	9
	UI & UX	18,82	3	9						9		9	9		3
	Information Architecture	17,94	9	3	9	3	3	3	3	3	3	3	3	9	9
	System Security	10,27			9	9	9	9	3		3			3	3
	Internet Technology	13,65		3	3	3		3	9	3	9	9	9	3	3
Priority Score			431,62	335,38	509,16	401,52	217,71	329,91	421,81	477,85	421,81	559,78	488,73	375,91	503,97
Priority Percentage			8%	6%	9%	7%	4%	6%	8%	9%	8%	10%	9%	7%	9%
Rank			3	5	2	4	6	5	3	2	3	1	2	4	2
Target			Three-Level Menu Structure	Laravel Blade	My SQL	Daily backup with a Recovery Time Objective (RTO) of ≤ 4 hours.	Login, Logout, Add/Edit/Delete Data, Export Data, and User Access Rights Management.	Lecturers, Students, Laboratory Technicians, and Head of Laboratory.	Secure Sockets Layer (SSL)	Bootstrap	≥99%	Desktop, Laptop, Tablet, and Smartphone.	Response time of < 2 seconds with a 5 Mbps internet	Dashboard, Material Request, and Request Status menus.	SIPT User Account Integration.

Figure 3. Part Deployment (QFD Fase II)

Discussions

The results show that the speed of system access, data security, ease of use, and interface display are the main needs of students and lecturers in the use of laboratory

inventory information systems. These findings show that users need not only a system that is able to accurately manage inventory data, but also a system that is high-performance, easy to use, and capable of presenting information quickly. This condition is in line with the development of digital transformation in the university environment, where the quality of information system services is greatly influenced by aspects of performance, security, and user experience.

The results of QFD Phase I show that server and database, menu structure, and user interface and user experience (UI/UX) are the technical characteristics with the highest priority. This shows that the quality of infrastructure and interface design are the main factors in meeting user needs, as they affect the speed of access, accuracy of information, ease of navigation, and user experience in managing laboratory inventory. These findings are in line with [26], [27] [28] which states that servers, databases, menu structures, and UI/UX are important components in the development of web-based information systems. In contrast to previous research that generally developed systems using SDLC by integrating inventory control methods such as EOQ, ROP, Safety Stock, or ABC, this study first translated the Voice of Customer into technical characteristics through QFD. This approach results in more targeted technical priorities so that the development of the system not only meets the functional aspects, but also aligns with the needs of laboratory users [29]

In QFD Phase II, technical characteristics are translated into characteristics of system components that can be implemented. The results show that multi-device support, system loading speed, and Application Programming Interface (API) integration are the components with the highest priority. These findings show that the flexibility of access, interoperability, and responsiveness of the system are key needs in supporting laboratory activities involving different types of devices and users. These results are in line with previous research that stated that web-based information systems need to support cross-device access, data integration, and rapid and efficient information delivery to improve service quality [30], [31] In addition, the use of Secure Sockets Layer (SSL), MySQL, Bootstrap-based responsive design, and server uptime targets of more than 99% indicate that security, reliability, and system availability are critical components in ensuring service continuity [32] Unlike previous research which generally only produced system designs, this study uses QFD Phase II to determine the priority of implementation components so as to produce a more targeted system specification that is in accordance with user needs.

As shown in Table 4, the results of this study have similarities with previous research in the use of the Quality Function Deployment (QFD) method as an approach to translate user needs into technical characteristics of the system [17], [18] [33] However, most of the previous research only stopped at the preparation of the House of Quality (QFD Phase I) so that the research output is still in the form of prioritizing user needs and technical characteristics. This research extends the analysis stage to QFD Phase II (Part Deployment) so that the technical characteristics that have been prioritized can be translated into more operational system components that are ready to be implemented.

Table 4. Comparison of Previous Studies and the Position of the Present Study

Research	Object	Approach	Main Findings	Difference from This Study
[19]	Decision Support System for Lecturer	Quality Function Deployment (QFD)	Identified and prioritized user requirements (*Voice of Customer*) to support	Did not continue the QFD results into Part Deployment (QFD Phase

	Academic Promotion		the design of a decision support system.	II) or derive system component specifications.
[20]	Customer Marketing Information System	Quality Function Deployment (QFD)	Measured information system service quality and proposed recommendations for service improvement.	Focused on evaluating service quality rather than developing implementation-oriented system specifications.
[21]	ERP-based Lubricant Monitoring Tool (SAP)	Quality Function Deployment (QFD)	Identified user requirements and developed an ERP-based monitoring tool.	QFD was used to determine application requirements, but did not derive system component characteristics through QFD Phase II.
[10]	Restaurant Inventory System	SDLC	Developed an inventory information system	Focused primarily on system implementation
[17]	Academic Information System	Quality Function Deployment (QFD)	Identified and prioritized technical requirements	Did not extend the analysis to Part Deployment (QFD Phase II)
[18]	Integrated Naval Weapon System (SSAT)	SDLC + QFD	Designed an information system based on user requirements	Did not derive system component characteristics
[15]	Inventory Information System	SDLC (Waterfall)	Developed a web-based inventory information system integrated with inventory management functions.	Focused on system implementation without systematically translating user requirements into technical specifications.
[11]	Inventory Accounting Information System	SDLC	Improved inventory recording accuracy and operational efficiency through a computerized inventory system.	Focused on system implementation without prioritizing user requirements in the design process.
[14]	Beauty Product Inventory Information System	SDLC (Waterfall)	Developed an inventory information system integrated with the Reorder Point (ROP) method.	Focused on inventory functionality without translating user requirements into technical and component specifications.
[12]	Sales and Inventory Information System	SDLC	Developed a web-based inventory information system integrated with the EOQ method.	Concentrated on software functionality rather than systematic user requirement deployment.
[13]	Spare Part Procurement Information System	SDLC	Developed a web-based procurement information system.	Did not employ a structured user-centered design approach.
[34]	Raw Material Inventory Information System	SDLC	Developed a web-based inventory application integrated with the Just-in-Time (JIT) method.	Focused on inventory optimization rather than systematic requirement translation.
[16]	Coffee Warehouse Inventory Information System	SDLC (Waterfall)	Developed a web-based inventory and warehouse management system with real-time inventory monitoring.	Focused on system development and inventory analysis without systematically linking user requirements to

				technical and component specifications.
This Study	Laboratory Inventory Information System	QFD Phase I (House of Quality) + Phase II (Part Deployment)	Customer Requirements → Technical Requirements → Part Characteristics	Produces implementation-oriented system specifications by systematically linking user requirements, technical requirements, and system component characteristics

The implementation of QFD up to Phase II provides added value compared to previous research because it is able to establish a clear relationship between Customer Requirement, Technical Requirement, and Part Characteristic. Thus, the information system design process is not only based on user needs, but also produces recommendations for system components that can be used as a reference in the software development process. This approach helps to reduce the gap between the results of the needs analysis and the implementation of the system so that the resulting specifications become more targeted and in accordance with the needs of laboratory users.

The main contribution of this research is to produce a framework for designing a laboratory inventory information system that integrates user needs, technical characteristics, and priority system components in one systematic analysis flow. This approach provides a more comprehensive guide for system developers and laboratory managers in determining the priorities for the development of information systems that not only meet the technical aspects, but also improve the quality of services for users.

CONCLUSION

This research successfully identified the needs of students and lecturers as the main users of the laboratory material inventory information system and translated it into technical specifications using the Quality Function Deployment (QFD) approach. The results of the analysis show that the most prioritized user needs include system access speed, data security, attractive interface appearance, and ease of use. These needs are then translated through QFD Phase I into priority technical characteristics, namely server and database, menu structure, and user interface and user experience. Furthermore, QFD Phase II results in priority component characteristics that form the basis of system design, including multi-device access support, system response time of less than two seconds, API integration with Higher Education Information Systems (SIPT), responsive design, database management, simple navigation structure, data encryption mechanism, and high server uptime.

The findings of the study show that the QFD approach is not only able to identify user needs, but also systematically translate them into technical characteristics and measurable component characteristics. In contrast to the needs analysis approach to information system development which generally results in a list of functional and non-functional needs, this approach provides a prioritization mechanism as well as a clear relationship between user needs, technical specifications, and system components. Thus, this research contributes to the development of Industrial Engineering science through the application of QFD to Phase II (Part Deployment) as a needs analysis framework in information system design, thereby producing system specifications that are more objective, measurable, and oriented to user needs.

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