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Exploring Augmented Reality Design for Robot Maintenance Training through the Kano Model

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ABSTRACT

Augmented Reality (AR) is a technology that allows users to access the real world while embedding it with a layer of virtual objects designed to coexist seamlessly in real time. Recently, researchers and developers have found a growing number of AR uses. The effectiveness of staff and student training has improved due to the improvement of AR technologies. However, since the field of AR is still in its early stages, there needs to be more literature on AR user requirements. As a result, implementing customer insights is critical. This research aims to identify consumer requirements for designing AR-based robot maintenance training. The Kano model determines consumer requirements and classifies the factors influencing customer intentions to use AR-based robot maintenance training. The framework and results from this study can be used to prioritize and comprehend customer needs for designing AR-based robot maintenance training according to the user requirements.

Keywords: Augmented Reality (AR); Customer requirements; Kano model; Robot maintenance

1. Introduction

Augmented Reality (AR) is a cutting-edge technology that allows users to view the real world while embedding it with a layer of virtual objects developed to collaborate in real-time [1]. The advancement of communication and information-gathering technologies can also be an enabler in using intelligent devices and holographic applications. Several studies discuss the benefits of AR, such as how AR can help users access more knowledge and information [2] and communicate with others in real-time at long distances [3].

Recently, researchers and developers have discovered increasingly more applications for AR, such as tourism [4], medicine [5], E-commerce [6], and training [7]. While AR applications exist in other

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domains, industrial augmented reality (IAR) refers to using AR technology to enhance industrial processes, including product creation and manufacturing [8]. With these technologies, consumers may become involved in the process and provide manufacturers with helpful information about potential future market demands.

Over the past few decades, significant advancements have been made in AR technologies, leading to their widespread adoption in educational and training settings. These technologies have played a pivotal role in enhancing the efficiency of education and training for students and staff. Nevertheless, numerous issues regarding its usage in education and training still need to be addressed, including the cost-effectiveness and efficiency of AR teaching systems compared to traditional approaches [8]. Because the field of AR is still developing, there needs to be more literature on AR user requirements. As a result, it is essential to incorporate customer insights.

The integration of AR holds paramount importance for robots within manufacturing systems, as evidenced by its ability to significantly enhance human performance in technical maintenance tasks, streamline maintenance operations, and facilitate managerial decision-making [9]. Given that maintenance constitutes a substantial portion (60 to 70%) of total costs in manufacturing [1], optimizing its efficiency is imperative. AR-based robot maintenance training emerges as a solution to this challenge, offering improved training efficacy and performance. In modern manufacturing systems characterized by robust machinery with extended lifespans yet susceptible to various performance-degrading factors, AR technology is pivotal in mitigating quality deterioration by providing real-time assistance and guidance during maintenance procedures.

In this study, we adopt the Kano model to determine consumer requirements of AR for robot maintenance training. The Kano model helps prioritize and understand customer expectations and needs [10-11]. This study is structured as follows: Section 1 presents the introduction, Section 2 provides a detailed description of the methods utilized in this research, and Section 3 demonstrates the results obtained from the analysis. Section 4 presents the discussion drawn from the study. Section 5 provides limitations and future research, and finally, conclusions are presented in Section 6.

2. Method

2.1 Kano model

Kano developed a method for categorizing product or service attributes based on how effectively they satisfy customer needs [12, 13]. The Kano model analyzes customer requirements or needs for specific features or services included in new products or services. This tool is critical in determining a product's success and serves as a practical guide for determining the priorities of the target market. As a result, the Kano model has gained widespread acceptance in product and service development. The Kano combines QFD tools to understand better customer perception of autonomous electric vehicles [11]. The Kano model is applied to gain an understanding and prioritization of students' requirements and expectations of the school [14]. The factors affecting the acceptance of autonomous driving technology could be categorized using the Kano model [15]. The function-combining design method was proposed to capture user requirements and design a stroller using a streamlined design process incorporating the KJ, Kano, and FAST methods [16].

The role of quality can be divided into six categories using a classification form derived from the two dimensions of the Kano model, each representing a different level of user acceptance and satisfaction. This method thoroughly explains how users perceive various features

or attributes regarding their impact on overall product quality [17].

Must have (M): The primary criterion for any product is its essential quality because it is of the utmost significance. Customers can accomplish their goals and feel comfortable when this criterion is satisfied. On the other hand, customers will be happier if the essential quality is met. It is important to remember that there is a point at which more than simply maintaining the fundamental quality may be required to satisfy the customer completely.

Attractive (A): A sufficiently conditional quality characteristic that makes it more satisfying when fully realized. But when only partially perceived, it will not cause dissatisfaction

One-dimensional (O): A necessary conditional quality attribute that, when fulfilled, causes satisfaction and, when unsatisfied unfulfilled, causes dissatisfaction.

Indifferent (I): The customers' responses remain standard. They are not happy and not depressed. Regarding their properties, they do not show any emotion.

Reverse (R): These characteristics appear when too many features are available. The consumer does not like the product as a result.

Questionable (Q): In some instances, customers may mistakenly submit responses that simultaneously generate conflicting feelings of liking and disliking. This situation arises when the respondent's feedback or perception contradicts itself, leading to mixed or ambiguous emotions regarding the product or service.

Customer satisfaction is distributed into six categories, as shown in Fig. 1.

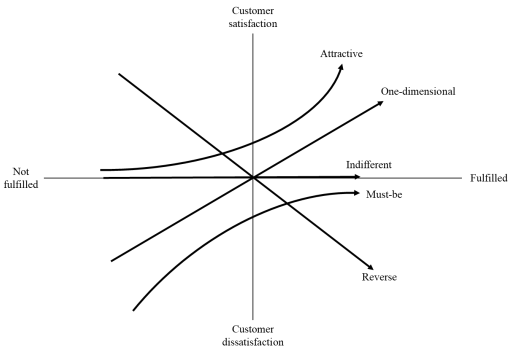

Fig. 1. Kano model diagram.

A customer survey to gather feedback is used to determine the satisfaction level. After the responses are collected, discussions and assessments are conducted to classify each answer into the following types.

2.2 Gathered user requirements

The requirements of AR in the robot maintenance context were gathered through user interviews. The interviewees included maintenance engineers and robot maintenance instructors.

The initial inquiry examines the customer's response to a specific feature within the product (termed the functional form of the question). At the same time, the subsequent query focuses on their reaction to the absence of said feature (referred to as the dysfunctional form of the question) [18]. The Kano questionnaire, a structured assessment tool, solicits feedback on customer requirements and product importance. Positive and negative questions have been formulated for each quality attribute under investigation.

The interviewee is given five options to choose from for each question: 1) Satisfying, 2) Should be so, 3) Does not matter, 4) Tolerable, and 5) Disagree. The data was gathered from a survey conducted using an online Google form shown in Fig. 2.

User guide

A user manual intended to assist users in using a particular AR Robot maintenance application

	Satisfying	Should be so	Does not matter	Tolerable	Disagree
Provide	☐	☐	☐	☐	☐
Not Provide	☐	☐	☐	☐	☐

Fig. 2. Sample question for the survey.

The model can evaluate the relationship between user requirements and product functions by assessing how each condition improves customer satisfaction. This analysis aids in understanding which specific product functions directly impact customer satisfaction and how meeting these requirements can result in higher customer satisfaction [16].

In the Kano model, there are five categories for requirement elements: must-be (*M*), attractive (*A*), one-dimensional (*O*), indifferent (*I*), reverse (*R*), and questionable (*Q*), as shown in Table 1.

Table 1. Customer requirements assessment using the Kano model.

Available /Unavailable		Negative				
		Satisfying	Should be so	Does not matter	Tolerable	Disagree
Positive	Satisfying	*Q*	*A*	*A*	*A*	*O*
	Should be so	*R*	*I*	*I*	*I*	*M*
	Does not matter	*R*	*I*	*I*	*I*	*M*
	Tolerable	*R*	*I*	*I*	*I*	*M*
	Disagree	*R*	*R*	*R*	*R*	*Q*

However, because the Kano model considers the quality attribute classification the most frequent quality attribute, relatively weaker quality attributes are dismissed. The customer satisfaction coefficient was used to calculate the impact of customer satisfaction and dissatisfaction to address these issues. The following is the formula for these coefficients:

Satisfaction Coefficient (SC):

$$SC = \frac{(A+O)}{(A+O+M+I)}, \qquad (2.1)$$

Dissatisfaction Coefficient (DC):

$$DC = \frac{(O+M)}{(A+O+M+I)}. \qquad (2.2)$$

3. Result and discussion

3.1 The Kano model result

The AR-based robot maintenance training application and customer requirements were gathered through user interviews and the literature survey. The 15 interviewees included eight maintenance engineers and seven robot maintenance instructors. The interview results are shown in Table 2. For the interviewee selection process, maintenance engineers and instructors have extensive experience in robot maintenance, totaling more than five years. This criterion ensured that our interviewees deeply understood the intricacies and challenges associated with robot maintenance, enriching the insights gathered during the interviews.

This study utilizes saturation sampling to determine the sample size for interviewees, encompassing maintenance engineers and robot maintenance instructors. Saturation sampling [19], a widely employed technique in qualitative research, establishes the sample size based on reaching data saturation. Data saturation occurs when further data collection fails to yield novel insights or themes. To implement this approach, interviews are conducted with participants from the three specified groups until data saturation is achieved. At this point, no additional information or themes emerge, indicating that data collection is comprehensive, and further interviews are deemed unnecessary.

The Kano questionnaire is structured to determine the product's importance to users. The online survey was distributed to 105 students from the faculty of engineering.

Table 2. Customer requirements for using AR in robot maintenance training.

Item	Customer Requirement (CR)	Description
CR1	User guide	AR has instructions on how to use it.
CR2	Verification system	AR has a user verification system.
CR3	Learning record	AR has a learning record.
CR4	Part name	AR shows the part names of each part.
CR5	Part location	AR shows the location of each part on the robotic arm.
CR6	Assembly and disassembly procedure	AR shows the assembly and disassembly procedure.
CR7	Maintenance procedure	AR shows robot maintenance procedures in all parts.
CR8	Tools guide	AR shows the tools needed for each maintenance stage.
CR9	Operation check	AR gives feedback and shows whether the operation was right or wrong.
CR10	Operation notified	AR must be notified immediately of a wrong operation.
CR11	Accurate and reliable	The information is accurate and reliable.
CR12	Animations	The animations are realistic.
CR13	Lightweight device	The AR device is lightweight
CR14	Durable device	The AR device is durable
CR15	Continuity	It can be used continuously throughout the training period
CR16	Ease of use	The AR device does not cause any barriers while working.
CR17	Motion sickness	Using the AR device does not cause motion sickness
CR18	Self-usage	I can operate with the AR without the help of a trainer.
CR19	Interface	Friendly and efficient user interface
CR20	Availability	AR is always available as training support.

After removing the samples with incomplete information, 102 samples were kept for analysis.

The reliability of the instrument's twenty quality dimensions for the SC/DC scales was assessed using Cronbach's Alpha, with a minimum threshold set at 0.70 for individual dimensions [20]. The overall Cronbach's Alpha coefficient for the SC/DC scale was 0.83, indicating high internal consistency and reliability across all measured dimensions.

Table 3 illustrates the customer requirement assessment and represents the requirements elements according to the highest number of 'A,' 'O', 'I,' 'M,' 'R,' and 'Q.' The results of the satisfaction and dissatisfaction coefficient for 20 customer requirements are also shown in Table 3.

3.2 Must-Be

Must-Be (*M*) characteristics are the most essential factors for any product. If this requirement is met, the customer will be unbiased. If not, this reflects a negative image of the consumers, including CR10, CR13, CR19, and CR20.

CR10: Operation notification is considered a Must-Be feature in the Kano model for AR-based Robot Maintenance Training because it addresses critical safety aspects, error prevention, compliance, real-time feedback, and user training. Failing to provide this feature falls short of user expectations and poses risks regarding safety, regulatory compliance, and overall system effectiveness.

CR13: Lightweight device - A lightweight device is a Must-Be characteristic important for customer satisfaction. AR-based robot training often involves wearing or handling devices for extended periods. If the device is heavy, it can cause discomfort and hinder the overall training experience. Meeting this requirement is essential to ensure user convenience and minimize physical strain.

CR19: Interface - The interface is vital to user experience and satisfaction. The Must-Be characteristic related to the interface underscores the importance of having an intuitive and user-friendly design. If the interface is complicated or unintuitive, users may struggle to navigate the training program, leading to frustration and dissatisfaction.

CR20: Availability - The Must-Be characteristic of availability addresses the importance of ensuring the availability of the AR-based robot maintenance training

program. If the program is not accessible or frequently experiences downtime, it can reflect poorly on the overall product and create negative perceptions among customers.

Must-Be (*M*) characteristics, including the maintenance procedure, lightweight device, motion sickness mitigation, interface design, and availability, are crucial for a positive customer experience in AR-based robot maintenance training. Failing to meet these requirements can result in customer dissatisfaction, negative perceptions, and an overall poor product image, potentially impacting customers.

Table 3. The customer requirement assessment.

Item	CR	*A*	*O*	*I*	*M*	*R*	*Q*	Category	SC	DC
CR1	User guide	25	6	42	29	0	0	*I*	0.30	-0.34
CR2	Verification system	7	0	70	0	25	0	*I*	0.09	0.00
CR3	Learning record	26	12	54	10	0	0	*I*	0.37	-0.22
CR4	Part name	25	12	36	29	0	0	*I*	0.36	-0.40
CR5	Part location	24	39	12	27	0	0	*O*	0.62	-0.65
CR6	Assembly and disassembly procedure	41	16	29	16	0	0	*A*	0.56	-0.31
CR7	Maintenance procedure	32	28	21	21	0	0	*A*	0.59	-0.48
CR8	Tools guide	18	6	55	22	0	1	*I*	0.24	-0.28
CR9	Operation check	8	54	16	24	0	0	*O*	0.61	-0.76
CR10	Operation notified	28	2	34	38	0	0	*M*	0.29	-0.39
CR11	Accurate and reliable	0	84	0	18	0	0	*O*	0.82	-1.00
CR12	Animations	32	1	60	6	1	2	*I*	0.33	-0.07
CR13	Lightweight device	14	20	28	40	0	0	*M*	0.33	-0.59
CR14	Durable device	32	12	37	21	0	0	*I*	0.43	-0.32
CR15	Continuity	20	12	53	16	0	1	*I*	0.32	-0.28
CR16	Ease of use	34	49	8	11	0	0	*O*	0.81	-0.59
CR17	Motion sickness	8	40	23	31	0	0	*O*	0.47	-0.70
CR18	Self-usage	23	8	53	5	13	0	*I*	0.35	-0.15
CR19	Interface	20	19	27	36	0	0	*M*	0.38	-0.54
CR20	Availability	17	26	21	38	0	0	*M*	0.42	-0.63

3.3 Attractive

Attractive (*A*): Customers do not request features. However, they are overjoyed to discover the service provided in the product. Customers are not dissatisfied with the lack of the original: the results are CR6 and CR7.

The Assembly and disassembly procedure (C6) in the context of robot maintenance training is a value-added feature. It provides customers the additional benefit of learning and understanding how the robot is put together and taken apart, which can enhance their overall understanding of its functionality and maintenance requirements.

CR7: Maintenance procedure holds an "Attractive" status within the Kano model for AR-based Robot Maintenance Training for several compelling reasons. It significantly enhances the overall user experience by providing comprehensive maintenance procedures for all robot parts, surpassing basic expectations. This feature not only adds substantial value to the training system but also improves learning efficiency, allowing users to master

intricate maintenance tasks with ease. In doing so, it instills a sense of confidence and competence in users as they gain proficiency in maintaining the entire robot, which is an attractive attribute for those seeking advanced training opportunities.

By including this feature in the training program, customers may find exploring the robot's inner workings enjoyable, gaining insights into its structure, components, and the interplay between them. Assembly and disassembly procedures contribute to a more comprehensive understanding of the maintenance process and potentially increase customer engagement and satisfaction. Moreover, the Assembly and disassembly procedure is an Attractive (A) characteristic that can differentiate the training program from others in the market. It adds an element of novelty and surprise, creating a positive impression and enhancing the overall customer experience.

3.4 One-Dimensional

One-Dimensional (*O*) characteristics are attributes that directly impact customer satisfaction. These characteristics are often explicitly requested by customers, and their presence or absence can significantly affect their satisfaction levels. The one-dimensional characteristics of designing an AR-based Robot Maintenance Training are CR5, CR9, CR11, CR16, and CR17.

CR5: Part location - The One-Dimensional characteristic related to part location addresses the importance of providing clear and accurate information regarding the location of various parts in the robot. Customers expect the training program to guide them effectively in identifying and locating different components during maintenance. Failing to provide this information can lead to frustration and decreased satisfaction while meeting this requirement can contribute to a smooth and efficient maintenance process.

CR9: Operation check - The Operation check characteristic refers to the ability to verify the proper functioning of the robot after maintenance or repairs. Customers expect the training program to include thorough instructions and procedures for conducting comprehensive operation checks to ensure the robot works accurately. Meeting this requirement instills confidence in customers that the maintenance process has been effective, enhancing their satisfaction.

CR11: Accuracy and reliability - Accuracy and reliability are crucial one-dimensional characteristics in any training program. Customers require AR-based robot maintenance training to provide accurate information, instructions, and procedures. The program's lack of accuracy or reliability can lead to errors, ineffective maintenance, and customer dissatisfaction. Ensuring the accuracy and reliability of the training program is vital for meeting customer expectations.

CR16: Ease of use - Ease of use is a One-Dimensional essential characteristic in training programs. Customers expect the AR-based robot maintenance training to be user-friendly, intuitive, and easy to navigate. Customers may face usability issues and become dissatisfied if the program is complex, difficult to understand, or requires extensive training. Designing the program focusing on ease of use contributes to a positive user experience and increased customer satisfaction.

CR17: Motion sickness is classified as One-Dimensional in the Kano model for AR-based Robot Maintenance Training due to its straightforward relationship with user satisfaction. Preventing motion sickness is a fundamental expectation when using AR technology; users anticipate a comfortable and nausea-free experience. In this context, not causing

motion sickness is a baseline requirement that aligns with user expectations, but it does not go above and beyond to enhance user satisfaction significantly. It operates within a linear framework where meeting the essential requirement suffices without adding substantial delight to the user experience.

The One-Dimensional (O) characteristics, including part location, operation check, accuracy and reliability, and ease of use, play significant roles in customer satisfaction when designing an AR-based robot maintenance training. Meeting customer expectations regarding these characteristics contributes to a positive training experience, while failing to do so can result in dissatisfaction. The training program can be tailored to meet customer needs and enhance satisfaction by focusing on these attributes.

3.5 Indifferent

The remaining items are Indifferent (I), and customers' feelings are consistent. When it comes to their properties, they are emotionless. The result is CR1, CR2, CR3, CR4, CR8, CR12, CR14, CR15, and CR18.

CR1: User guide - The user guide is an Indifferent (I) characteristic, meaning that customers' feelings and satisfaction levels are consistent and not significantly impacted by the presence or absence of a user guide. While a well-designed and comprehensive user guide can be helpful for users, its absence may not cause significant dissatisfaction if the training program is intuitive and provides sufficient instructions.

CR2: Verification system - Customers' satisfaction is consistent, and the presence or absence of a verification system in the training program does not significantly influence their feelings. While a verification system can provide additional confidence in the maintenance procedures, its absence would not necessarily lead to dissatisfaction if the training program ensured accuracy and reliability through other means.

CR3: Learning record - Customers' satisfaction is not significantly affected by the presence or absence of a learning record feature in the training program. While a learning record can help users track their progress and revisit previous training sessions, its absence would not cause substantial dissatisfaction if the training program were practical and informative.

CR4: Part name - Customers' satisfaction remains consistent regardless of whether the training program includes explicit part names. While providing part names can be helpful for users' understanding and communication, its absence would not typically lead to significant dissatisfaction if other means, such as visual representations, were used effectively.

CR8: Tools guide - Customers' satisfaction remains consistent and unaffected by the presence or absence of a specific tools guide in the training program. While a tools guide can provide additional guidance on the proper use of tools during maintenance, its absence would not necessarily lead to dissatisfaction if the training program adequately covered tool usage in other ways.

CR12: Animations are classified as Indifferent features in the Kano analysis. This suggests that customers may not have solid expectations or preferences for including animations in the training system. Although animations can enhance visual understanding and engagement during training, their absence may not significantly impact customer satisfaction.

CR14: Durable device; this implies that customers may not heavily prioritize the durability of the training system itself. While a durable device can enhance the overall longevity and reliability of the

system, its absence may not significantly affect customer satisfaction if the system functions as intended during the training process.

CR15: Continuity: Customers may not strongly associate the presence or absence of continuity features with their overall satisfaction. While continuity features, such as the ability to resume training sessions or save progress, can enhance user convenience, their absence may not be a significant concern for customers.

CR18: Self-usage: Customers may not emphasize the system's ability to be used independently without external assistance. While self-usage capabilities.

The Indifferent (I) characteristics have minimal impact on customer satisfaction when designing an AR-based Robot Maintenance Training. While these features can provide additional value and convenience to users, their absence would typically not cause significant dissatisfaction if the core training program fulfilled customers' needs effectively.

3.6 The ranges of satisfaction to dissatisfaction

The customer requirements in the form of an SC/DC plot are shown in Fig 4. The ranges of satisfaction to dissatisfaction for each CR are shown in Fig. 5. CR11 has the highest SC ($SC = 0.82$), and CR16 has a very high value ($SC = 0.81$). That means customers value the accuracy of the training content and ease of use as much as possible. Additionally, CR11 also has the highest DC ($DC = -1.00$); customers place the most significant value on the accuracy of training content and are incredibly dissatisfied if it needs to be more accurate. In addition, if the system does not have feedback and shows whether the operation was right or wrong (CR9, $DC = -0.76$), it will cause customer dissatisfaction. While the customer does not feel satisfied or dissatisfied with or without a verification system (CR2), the verification system does not affect customer satisfaction.

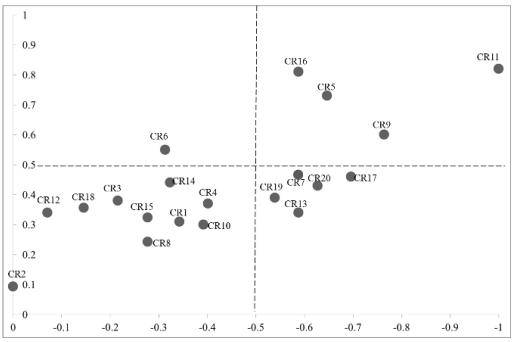

Fig. 4. SC/DC plot.

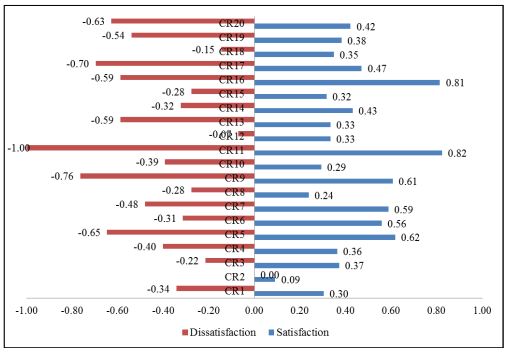

Fig. 5. Range of SC and DC.

4. Discussion

The results of the Kano model analysis for designing an AR-based robot maintenance training can provide valuable insights into customer satisfaction and expectations. The Must-Be (*M*) characteristics, such as maintenance procedure, lightweight device, motion sickness mitigation, interface design, and availability, are crucial for a positive customer experience. This finding aligns with previous studies conducted by Werrlich et al. [21], which also emphasized the importance of these Must-Be features in AR design for training purposes and found that incorporating an assembly procedure display in the Head-Mounted Display (HMD) served as a training support and created a "training island" that was separate from the

production line. Failure to meet these Must-Be requirements can lead to customer dissatisfaction and project a negative perception of the product.

On the other hand, the Attractive (*A*) characteristic identified in the study, the Assembly and disassembly procedure (C6), can bring joy and satisfaction to customers. Although not explicitly requested, customers are delighted when they discover this value-added feature in the training program. It can improve their comprehension of the robot's functionality and upkeep needs, set the program apart from competitors, and enhance the customer experience. This result is consistent with previous studies by Lorenz et al. [22], emphasizing the importance of features in an AR maintenance worker support system. Their research found that incorporating comprehensive documentation, including manuals, videos, photos, and workflow guidance, is crucial for practical AR-based maintenance training; information accessibility is also essential for customers [2].

The One-Dimensional (*O*) characteristics, including part location, operation check, accuracy and reliability, and ease of use, are directly linked to customer satisfaction. Meeting these requirements is crucial for customer expectations and can contribute to a positive training experience.

Lastly, the Indifferent (I) characteristics, including the user guide, verification system, and learning record, align with Han [23], who concluded that sharing information through these features does not significantly impact customer satisfaction. Similarly, the part name, tools guide, animations, durable device, continuity, and self-usage also have minimal influence on customer satisfaction. Customers' feelings and expectations remain consistent, and the presence or absence of these features does not significantly affect their satisfaction levels.

The Kano model's customer-centric approach prioritizes understanding and categorizing customer requirements based on satisfaction and dissatisfaction. It is well-suited for research on identifying consumer preferences and feature prioritization in product design or service delivery. Its versatility enables researchers to encompass various customer needs, from basic functionality to emotional desires, ensuring a comprehensive understanding of preferences. Unlike other models, such as QFD and FAST, the Kano model offers direct insights into customer satisfaction and dissatisfaction, enhancing its practical application in consumer behavior research. Moreover, its structured framework facilitates prioritization and decision-making in product development, marketing strategies, and resource allocation, contributing to more informed business decisions.

5. Limitations and Future Research

The primary limitation of this study is the small sample size, consisting of only 15 interviewees. Among them were eight maintenance engineers and seven robot maintenance instructors. This limited sample size may affect the generalizability of the findings to a broader population. Therefore, to generalize the results from an education and training management viewpoint, conducting additional surveys involving a larger sample size of customers from diverse sectors is recommended. Furthermore, further research efforts should encompass developing and rigorously evaluating a robot-based training application utilizing AR technology, emphasizing the education and industry sectors. By incorporating AR into the training application, an enhanced and immersive learning experience can be provided to learners. This would allow for the seamless integration of virtual

elements and real-world environments, enabling trainees to interact with virtual objects and simulations more tangibly and practically. Furthermore, by exploring the effectiveness and feasibility of AR-based robot training, valuable insights can be obtained regarding its potential to revolutionize training practices in both educational and industrial contexts.

6. Conclusion

This study utilizes the Kano model to gain insights into customer requirements for AR-based robot maintenance training applications. A total of 20 customer requirements were derived from interviews with 15 participants, including 13 engineering students and 2 robot maintenance instructors. The Kano model helps establish the relationship between customer expectations and product functionalities by analyzing the requirements across four elements. To ensure generalizability from an education and training management perspective, conducting further surveys with a more extensive and diverse sample of customers across various sectors is recommended. The intention is to develop a robot-based training application and evaluate its effectiveness in educational and industrial settings. The results will help validate the findings and provide valuable insights for implementing AR-based robot maintenance training applications practically.

Due to the current functional design phase, this study did not conduct an economic analysis. Future research should investigate the economic viability of the solution after real-world implementation and provide corresponding conclusions.

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