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Fuzzy Logic-Based Quantification of Usability Expectation for M-Commerce Mobile Application by Using GQM and ISO 9241-11

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Abstract: Fuzzy logic-based quantification of usability expectation for an m-commerce mobile application is a process of measuring the usability of a mobile application by using fuzzy logic principles. The usability of any mobile application is used to find out the user experience of the mobile application by analyzing the user's expectations and preferences. Fuzzy logic always be the optimal choice for quantification. Fuzzy logic-based quantification of usability expectation assesses the user experience of an m-commerce mobile application by taking into account the user's needs, preferences, and expectations. Usability expectation also takes into account the ability of the user to understand and interact with the application, the degree to which the application meets the user's expectations, and the overall satisfaction with the application. This process helps to identify areas of improvement, enabling the developers to make necessary changes for a better user experience. This study presents to design of a usability metric framework and then quantifies the overall usability quality of an m-commerce mobile application with the help of fuzzy logic. The proposed usability metric framework is based on the Goal-Question-Metric (GQM) approach and is intended to provide a comprehensive and systematic approach to design metrics to assess the qualitative aspect of mobile phone applications. The framework has been developed and tested in an m-commerce context and provides a set of measurable criteria to quantify m-commerce mobile applications as per standard. The results of the evaluation can then be used to improve m-commerce mobile applications and to ensure that the user experience is optimized.

Keywords: Usability, M-Commerce, GQM Approach, ISO 9241-11

Introduction

Usability for m-commerce is the degree to which users can easily, quickly and conveniently interact with an e-commerce website or mobile application. This includes factors such as navigation, layout and user interface design. Usability also includes the ability to make purchases, provide feedback, and access help quickly and easily. The goal of usability in m-commerce is to maximize user satisfaction and convenience, while also optimizing conversions. By making sure that users can quickly and easily access the information and products they need, m-commerce businesses can improve both their user experience and their bottom line.

The development of mobile and digital technologies has enabled Mobile Commerce (M-Commerce) to become an increasingly important part of the retail landscape. However, the usability of m-commerce applications remains an area of concern for industry stakeholders, particularly given the wide range of mobile devices and platforms available. As a result, there is a need for an effective usability metric framework for m-commerce applications that can be used to assess the usability of these applications across platforms. This study presents a usability metric framework for m-commerce applications using ISO 9241-11 standard. The proposed framework is designed to facilitate the assessment of m-commerce applications in terms of usability, user experience and user satisfaction. The framework is based on the ISO 9241-11 standard, which defines a set of usability metrics that can be used to evaluate the user-friendliness and

effectiveness of m-commerce applications, then the proposed framework implemented as a case study of an m-commerce mobile application to illustrate the practical application of the framework. The results of the case study demonstrate the overall quantification of usability expectations of the proposed framework and provide an effective way to assess the usability of m-commerce mobile applications.

Literature Survey

Software development is always evolving. We must recognize that software development is a part of our lives and will continue to evolve. As software engineers, we must strive for excellence and build tools and ways to achieve our goals. Collaboration may enhance the future of software development. According to Basili (1989), software development activity should be considered as experimental rather than theoretical, and he presents a new project-specific model that can be better understood with the aid of knowledge, process, and product. This model is intended primarily for educational and research purposes. Excellence in software development may be accomplished by quantification based on the perspectives of many stakeholders. The establishment of a quantitative assessment approach for software engineering methods is critical for determining their efficacy. According to Basili (1985), an assessment process should contain metrics that quantify the quality of the engineering process. Thus, the goal of quantification is to improve the entire quality of software as a product. Many variables influence the overall quality of software programs. According to McCall (1977) official technical report, building high-quality software that is stable and error-free is dependent on the development of suitable metrics. These measurable indicators increase the overall quality of the Air Force system while also improving the experience of its command-and-control software. The environment in which software is produced, maintained, and utilized has an impact on its quality. As a result, it is critical to examine all of these elements while designing, maintaining, and utilizing software to ensure that it achieves the highest quality standards available. The next critical issue is if we can construct metrics in a systematic manner using an appropriate model. Yes, GQM is the correct answer. Basili (1992) GQM paradigm is a strong tool for software modeling and measurement. It offers a thorough framework for defining and assessing software objectives, questions, and measurements. This paradigm enables systematic analysis and improvement of software processes, products, and services. It may be utilized to give software stakeholders with a shared knowledge of software systems as well as an efficient platform for communication and agreement. Software engineers may use the GQM paradigm to minimize the complexity of software development while increasing the efficacy of their software models and metrics.

Software metrics are a very important tool for any firm. According to Grady and Caswell (1987), the enhancement of software development process in terms of quality, cost, and time necessitates the first steps of issue diagnosis, establishment of performance objectives, and evaluation of software project efficacy. Organizations may enhance their level of success by dedicating resources towards the establishment and execution of a comprehensive software metrics program, which enables them to get a deeper comprehension of their software development procedures.

From the perspective of each individual user, usability emerges as a vital feature. Usability refers to the evaluation of a system's effectiveness in terms of a user's ability to access, comprehend, and engage with it. According to Bevan (1995), it is essential to prioritize the consideration of quality of use as a primary design aim while developing interactive software products. This research further posits that the success of businesses is contingent upon usability, hence necessitating the establishment of usability as a primary objective in the design process. The consideration of usability is crucial in ensuring that users are able to successfully and efficiently use a system with little cognitive and physical exertion.

M-commerce, or mobile commerce, involves purchasing and selling products and services on smart phones and tablets. Today, users may use their mobile devices to make online purchases, pay bills, and manage their accounts. Mobile commerce is complicated and depends on several factors, according to Feng *et al*. (2006). Firms must understand customer needs, do thorough market research, and stay current on technology to succeed in this field. Businesses must invest in research and development, customer service, and marketing to succeed in mobile commerce.

This research introduces a novel methodology for assessing the overall quality of m-commerce apps using the GQM paradigm and ISO 9241-11 (2018) standard, using fuzzy logic as a tool.

GQM Paradigm and ISO 9241-11

The GQM paradigm has a hierarchical structure and utilizes a top-down approach. It begins by establishing goals, followed by the formulation and collection of questions, and concludes by linking metrics to each question. The process known as goal-question-metric is used to assess the effectiveness of projects and programs. This strategy facilitates the organization and analysis of information, providing guidance for decision-making and subsequent actions. The proposed approach encompasses the first step of determining a specific objective or target for a certain project or program,

followed by the formulation of inquiries pertaining to the means by which it might be achieved, and then devising quantifiable measures to monitor and evaluate the advancement towards said objective.

The use of the goal-question-metric method proves to be very advantageous in scenarios when a project or program involves several stakeholders. This approach facilitates effective communication and enables the measurement of success via a shared language and framework. Additionally, this approach promotes the engagement of all relevant parties in evaluating the consequences of their choices and behaviors in relation to the overarching objective. The use of the goal-question-metric strategy enables firms to effectively identify areas for development and concentrate their endeavors on achieving the intended result.

In general, the goal-question-metric method is seen as a valuable instrument for assessing the effectiveness of a project or program. The framework offers a systematic approach for assessing results and promotes stakeholder awareness of the consequences of their choices and actions in relation to the overarching objective.

The ISO 9241-11 standard is well recognized as a benchmark for evaluating usability. This resource offers valuable insights on the use of efficient measuring techniques to enhance the usability of software products. Usability is defined as the degree to which a product may be used by designated users to successfully accomplish predetermined objectives with effectiveness, efficiency, and satisfaction within a certain context of utilization [9].

Fuzzy Logic

Fuzzy logic employs the principles of fuzzy set theory to accurately capture and articulate the intrinsic imprecision and vagueness that characterizes human cognitive processes and thinking. The fundamental idea of this notion is that problems might have several viable solutions, which requires the use of a "fuzzy" problem-solving technique to facilitate decision-making. Fuzzy logic has practical use in several domains such as image processing, robotics, and natural language processing. This particular method seems to be particularly advantageous in scenarios when conventional decision-making processes would exhibit an excessive level of rigidity or inflexibility.

Fuzzy logic is grounded on the concept of partial truth, whereby statements possess varying degrees of validity or applicability, as opposed to adhering strictly to a binary framework of absolute truth or falsehood. This approach facilitates a more intuitive decision-making process by enabling judgments to be formulated based on the available evidence, rather than only depending on a binary outcome of either a definitive positive or negative response. Fuzzy logic facilitates a heightened level of adaptability in problem-solving approaches, as it allows the system to acquire knowledge from errors and then modify its decision-making mechanism.

Table 1: Fuzzy weight and fuzzy rate

Criteria	Fuzzy weights	Fuzzy ratings
Very Low (VL)	(0.0, 0.0, 0.25)	(0.0, 0.1, 0.3)
Low (L)	(0.0, 0.25, 0.50)	(0.1, 0.3, 0.5)
Medium (M)	(0.25,0.50, 0.75)	(0.3, 0.5, 0.7)
High (H)	(0.50, 0.75, 1.0)	(0.5, 0.7, 0.9)
Very High (VH)	(0.75, 1.0, 1.0)	(0.7, 0.9, 1.0)

The use of the triangular fuzzy function methodology has been employed in the present investigation. The Triangular Fuzzy Function is a specific form of mathematical function that is often used in fuzzy logic systems for the purpose of assigning a membership value to an input value. The graph in question is a triangle form that represents the mapping of an input value to a corresponding value ranging from 0-1. In this context, 0 represents the lowest value while 1 represents the highest value. The parameters used in this investigation are derived from a publication recommended by Singh and Vidyarthi (2008), as seen in Table 1.

Fuzzy Operations

This study adopts two basic fuzzy operations explained by Ross (2004):

(a) Fuzzy multiplication
(b) Fuzzy addition

(a) Fuzzy multiplication it is defined as the pairwise product of two triangular fuzzy sets.
For example, suppose there are two triangular fuzzy sets (d, e, f) and (g, h, i) then the fuzzy multiplication is defined as:
$(d, e, f) \times (g, h, i) = (d \times g, e \times h, f \times i)$

(b) Fuzzy addition it is defined as the pairwise maximum of two triangular fuzzy sets.
For example, suppose there are two triangular fuzzy sets (d, e, f) and (g, h, i) then the fuzzy addition is defined as:
$(d, e, f) + (g, h, i) = [\max(d, g), \max(e, h), \max(f, i)]$

Fuzzification and Defuzzification

Fuzzification is defined as the process of converting a numerical input into a fuzzy set. It involves mapping a crisp input value to a fuzzy value, allowing the input to take on any value between the two. The purpose of fuzzification is to provide a more accurate representation of data by allowing greater flexibility in how inputs are interpreted.

Fuzzification is the process that converts matrices of sub-characteristics of usability into fuzzy values. Let us define the criteria by taking an example, considering the matric of error and recovery as illustrated in Table 2.

Table 2: Example of fuzzification

Matric	Description	Probability	Criteria	Fuzzy rating
Probability (P) to recover from error for each task	$P = \frac{recoverable\ errors}{total\ number\ of\ errors}$	0<p<0.2	VL	(0.0, 0.1, 0.3)
		0.2<p<0.4	L	(0.1, 0.3, 0.5)
		0.4<p<0.6	M	(0.3, 0.5, 0.7)
		0.6<p<0.8	H	(0.5, 0.7, 0.9)
		0.8<p<1	VH	(0.7, 0.9, 1.0)

Defuzzification is defined as the process of converting a fuzzy set of values into a single crisp value. It is the reverse of the process of fuzzification, which is the process of taking a crisp value and transforming it into a fuzzy set. This study adopts the centroid method to defuzzifuy a triangular fuzzy set:

$$\text{Centroid formula } z^* = \frac{\int \mu(z).z\ dz}{\int \mu(z)\ dz}$$

Here, z^* is the defuzzified crisp value, z is the value on the x-axis, and $\mu(z)$ is the membership function.

Research Approach

The Goal Question Metric (GQM) technique may help evaluate mobile phone applications. This method simplifies setting quantifiable application goals and objectives and linking them to particular metrics. Goal-oriented assessment, which sets clear, quantifiable application goals and ensures they are measured, underpins the GQM technique. GQM makes it easy to identify usability issues and provide precise usability measurements to assess their impact. The strategy requires setting user-centered and task-focused objectives. It is also crucial to choose the correct measures to assess goal achievement. The GQM approach helps quantify mobile app usefulness. Write out the application's objectives initially. After goal and target setting, the GQM approach may be utilized to analyze use precisely. Use the GQM approach to identify usability issues and create metrics to assess their effects. Compare changes over time and watch how the software evolves using GQM.

The Goal Question Metric (GQM) technique may be used to create usefulness requirements for mobile applications. The Goal-Question-Metric (GQM) technique helps create a framework with distinct objectives and questions. This framework can assess and grade mobile phone app usefulness.

To test mobile phone app usefulness using the Goal-Question-Measure (GQM) methodology, complete these steps:

1. Set a goal for the mobile app: The first step is to describe and create a goal for a mobile app for a certain area based on the requirements and standards. The goal should be clear and concise about what you want to happen when you use the app
2. Figure out the questions: The questions should be carefully thought out based on the goal of the mobile app in a certain area
3. Establish the metric: The metric should be made so that it measures how well the mobile app works with the goals and questions that have been set

Following the GQM method can help businesses create a complete framework for measuring and evaluating the usefulness of mobile phone apps. This framework will ensure a constant and dependable way to measure and evaluate the usability of mobile phone apps.

Procedure

This study proposed the following procedure to quantify the overall usability quality of m-commerce mobile applications:

Step 1: Design a Usability Metric framework that depends upon goals and questions for m-commerce mobile application

Step 2: Fuzzy weight as per developers and tester's view and fuzzy rates as per end- user's view

Step 3: Calculate of overall rating for 6 goals features, time taken, learn-ability, accuracy, security, and user's feedback by taking the user's response. Fuzzy rating of goal features, usability factor, and overall rating for usability of m-commerce mobile application calculated by the following formula:

$$\textit{Fuzzy rating} = r_1 \times w_1 + r_2 \times w_2 + \ldots\ldots\ldots\ldots + r_n \times w_n = \sum r_i \times w_i$$

Step 4: Calculation of overall fuzzy rating for 3 usability factors efficiency, effectiveness, and satisfaction

Step 5: Calculation of overall fuzzy rating for usability of m-commerce mobile application

Step 6: Calculation of crisp value of usability of the m-commerce mobile application by using the centroid method

Case Study

Suppose we are going to quantify the 'ABC' m-commerce mobile application.

Step 1: Design a usability metric framework that depends upon the goal and questions for 'ABC' m-commerce mobile application

Usability factor	Goal	Question	Metric
Efficiency	Features	What about display and navigation	Consistency in text, font, and colors
			Easy to navigate in mobile app
			Support night vision
		What about search pattern (text pattern and speech pattern)	Finding information about the product is easier
			Speech to text converted accurately
		What about product description	Description of each product is accurate
			Product photograph displayed adequately
			Prices of products are adequately shown
			Status (available, out of stock) of each product is adequately shown
		What about the purchase process	Easy to register
			Easy to change customer information
			Easy-to-order product
			The shopping cart's information is accurate
			Adequate information about how to order
			Adequate information about payment options
			Adequate information about how to cancel the product
			Adequate information about returns and refund policy
			Adequate information about order detail
			Adequate information about delivery time
			Adequate information about delivery cost
			Adequate information about the delivery area
			Delivery to other address
			Online order tracking is available
	Time is taken	What about time to search a sub-task	Search particular product
		What about time to complete a whole task	Time to complete task
Effectiveness	Learn-ability	What about intuitive learning about mobile app	Easy to learn interface
			Adequate content management
		What about help or customer service?	Adequate help (demo version)
			Adequate help (text version)
	Accuracy	What about mobile app response as per action	Mobile app responds properly as per action
			Every component of the interface respond accurately
			Probability of search successfully task completion in 1st attempt
		What about the chance for successful completion of task or sub-task	Probability to completion of task within given time
Satisfaction	Security	What about the security of personnel data and financial data	Adequate information about the privacy policy
			Secure socket layer used by mobile app
			Well-recognized secure payment methods
			Different modes for verification such as OTP based
	Feedback	What about the feedback process	Overall features
			Overall learning process
			Overall accuracy
			Overall security
			Overall experience using this mobile app

Step 2: Assign Fuzzy weight as per the developers and tester's view and fuzzy rates as per end- user's view

Usability factor	Goal	Metric	Average fuzzy weight	Average fuzzy rate
Efficiency	Features	Consistency in text, font, and colors	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)
		Easy to navigate in mobile app		(0.7, 0.9, 1.0)
		Support night vision		(0.5, 0.7, 0.9)
		Finding information about the product are easier		(0.7, 0.9, 1.0)
		Speech to text converted accurately		(0.5, 0.7, 0.9)
		The description of each product is accurate		(0.5, 0.7, 0.9)
		Product photograph displayed adequately		(0.7, 0.9, 1.0)
		Prices of products are adequately shown		(0.7, 0.9, 1.0)

Step 2: Continue

		Status (available, out of stock) of each product is adequately shown		(0.7, 0.9, 1.0)
		Easy to register		(0.5, 0.7, 0.9)
		Easy to change customer information		(0.5, 0.7, 0.9)
		Easy to order product		(0.7, 0.9, 1.0)
		The shopping cart's information is accurate		(0.7, 0.9, 1.0)
		Adequate information about how to order		(0.5, 0.7, 0.9)
		Adequate information about payment options		(0.7, 0.9, 1.0)
		Adequate information about how to cancel the product		(0.7, 0.9, 1.0)
		Adequate information about return and refund policy		(0.7, 0.9, 1.0)
		Adequate information about order detail		(0.7, 0.9, 1.0)
		Adequate information about delivery time		(0.5, 0.7, 0.9)
		Adequate information about delivery cost		(0.7, 0.9, 1.0)
		Adequate information about the delivery area		(0.7, 0.9, 1.0)
		Delivery to other addresses		(0.7, 0.9, 1.0)
		Online order tracking available		(0.7, 0.9, 1.0)
	Time taken	Search particular product	(0.75, 1.0, 1.0)	(0.7, 0.9, 1.0)
		Time to complete a task		(0.5, 0.7, 0.9)
Effectiveness	Learn-ability	Easy to learn interface	(0.75, 1.0, 1.0)	(0.5, 0.7, 0.9)
		Adequate content management		(0.5, 0.7, 0.9)
		Adequate help (demo version)		(0.5, 0.7, 0.9)
		Adequate help (text version)		(0.7, 0.9, 1.0)
	Accuracy	Mobile app responds properly as per action	(0.75, 1.0, 1.0)	(0.7, 0.9, 1.0)
		Every component of interface responds accurately		(0.7, 0.9, 1.0)
		Probability to search successfully task completion in 1st attempt		(0.7, 0.9, 1.0)
		Probability to completion of task within given time		(0.5, 0.7, 0.9)
Satisfaction	Security	Adequate information about privacy policy	(0.75, 1.0, 1.0)	(0.7, 0.9, 1.0)
		Secure socket layer used by mobile app		(0.7, 0.9, 1.0)
		Well-recognized secure payment methods		(0.7, 0.9, 1.0)
		Different modes for verification such as OTP based		(0.7, 0.9, 1.0)
	Feedback	Overall features	(0.75, 1.0, 1.0)	(0.7, 0.9, 1.0)
		Overall learning process		(0.5, 0.7, 0.9)
		Overall accuracy		(0.5, 0.7, 0.9)
		Overall security		(0.7, 0.9, 1.0)
		Overall experience to use this mobile app		(0.5, 0.7, 0.9)

Step 3: Calculation of overall rating for 6 goals features, time taken, learn-ability, accuracy, security, and user's feedback by taking the user's response

Usability factor	Goal	Fuzzy wt	Overall fuzzy rate
Efficiency	Features	(0.75, 1.0, 1.0)	(0.35, 0.675, 1.0)
	Time taken	(0.75, 1.0, 1.0)	(0.525, 0.9, 1.0)
Effectiveness	Learn-ability	(0.75, 1.0, 1.0)	(0.35, 0.675, 1.0)
	Accuracy	(0.75, 1.0, 1.0)	(0.525, 0.9, 1.0)
Satisfaction	Security	(0.75, 1.0, 1.0)	(0.525, 0.9, 1.0)
	User's feedback	(0.75, 1.0, 1.0)	(0.525, 0.9, 1.0)

Step 4: Calculation of overall rating for 3 usability factors efficiency, effectiveness and satisfaction

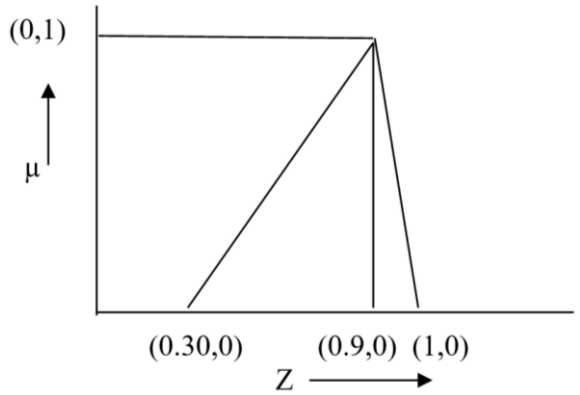
Usability factor	Fuzzy wt	Overall fuzzy rate
Efficiency	(0.75, 1.0, 1.0)	(0.394, 0.9, 1.0)
Effectiveness	(0.75, 1.0, 1.0)	(0.394, 0.9, 1.0)
Satisfaction	(0.75, 1.0, 1.0)	(0.394, 0.9, 1.0)

Step 5: Calculation of overall rating for usability of m-commerce mobile application

Overall fuzzy rating = (max (0.394×0.75, 0.394×0.75, 0.394×0.75), max (0.9×1.0, 0.9×1.0, 0.9×1.0), max (1.0×1.0, 1.0×1.0, 1.0×1.0))

= (0.296, 0.9, 1.0)

= (0.30, 0.9, 1.0)



Step 6: Calculation of crisp value of usability of the m-commerce mobile application by using the centroid method

Equation of line passing through (0.30, 0) and (0.9, 1):

$$\mu = 1.67\ z – 0.5$$

Equation of line passing through (1, 0) and (0.9, 1):

$$\mu = 10 – 10z$$

$$Z^* = \frac{\int_{0.3}^{0.9}(1.67\ z - 0.5)z\ dz + \int_{0.9}^{1}(10-10\ z)zdz}{\int_{0.3}^{0.9}(1.67\ z - 0.5)dz + \int_{0.9}^{1}(10-10\ z)dz}$$

On evaluating the above integral obtained value is 0.7422, thus the crisp value as per centroid method = 0.7422 or 74.22%. Thus, the overall quality of ABC m-commerce mobile application will be calculated as 74.22%.

Materials and Methods

This paper proposed a fuzzy based mathematical model which converts qualitative aspect of usability for m-commerce application in to quantitative aspect. Quantitative aspect always is a best way for any kind of analysis. This paper builds a structured framework for usability metrics based upon GQM and ISO-9241-11. Hence this framework accepts corresponding weight and rate for each matrices based on fuzzy parameter implemented by triangular fuzzy set. There are three usability factors efficiency, effectiveness and satisfaction, all these usability factors are computed with the help of fuzzy weight and fuzzy rate of matrices. The overall fuzzy rating for usability computed with the help of usability factors efficiency, effectiveness and satisfaction. The mathematical method involves as derivation of equation of two straight lines for resultant triangular fuzzy value as:

$\mu = 1.67\ z – 0.5$ (1)

$\mu = 10 – 10z$ (2)

The overall fuzzy value then converted in to corresponding crisp value with the help of centroid method for defuzzification as:

$$Z^* = \frac{\int_{0.3}^{0.9}(1.67\ z - 0.5)z\ dz + \int_{0.9}^{1}(10-10\ z)zdz}{\int_{0.3}^{0.9}(1.67\ z - 0.5)dz + \int_{0.9}^{1}(10-10\ z)dz}$$

Which evaluates overall crisp rating or overall quality equivalent to overall qualitative aspect.

Results

The usability framework evaluates overall fuzzy rating with the help of corresponding fuzzy weights and fuzzy rating as (0.30, 0.9, 1.0). This study proposes theoretical mathematical framework which derives two lines of equation one passing through (0.30, 0) and (0.9, 1) derived as:

$$\mu - 0 = \frac{(1.0-0)}{(0.9-0.3)}\ (z\text{-}0.30)$$

$$\mu = \frac{(1.0)}{(0.6)}\ (z\text{-}0.30)$$

$$\mu = \left(\frac{z}{0.6} - \frac{0.3}{0.6}\right)$$

$\mu = 1.67\ z – 0.5$ (1)

and other passing through (1, 0) and (0.9, 1) derived as:

$$\mu - 0 = \frac{(1.0-0)}{(0.9-1.0)}\ (z\text{-}1.0)$$

$$\mu = \frac{(1.0)}{(-0.1)}\ (z\text{-}1.0)$$

$$\mu = \left(\frac{z}{-0.1} + \frac{1.0}{0.1}\right)$$

$\mu = 10 – 10z$ (2)

Computation performed by defuzzification as:

$$Z^* = \frac{\int_{0.3}^{0.9}(1.67\ z - 0.5)z\ dz + \int_{0.9}^{1}(10-10\ z)zdz}{\int_{0.3}^{0.9}(1.67\ z - 0.5)dz + \int_{0.9}^{1}(10-10\ z)dz}$$

$$Z^* = \frac{0.211 + 0.05}{0.301 + 0.05}$$

$$Z^* = \frac{0.261}{0.351}$$

$Z^* = 0.7436$ or 74.36%

Thus the overall quality will be evaluated as 74.36%.

Discussion

The utilization of quantitative data guarantees the objectivity of decisions. It is useful for determining which areas require improvement, ranking the importance of additions or updates, and enhancing the development process's efficiency. With this, the software development company will be able to establish precise and quantifiable success metrics. This enables the establishment of measurable objectives and the tracking of progress over time. Quantitative data may also help allocate available resources more efficiently. If you measure the impact of the various additions or modifications you implement, you can focus your efforts on the areas that provide the highest return on investment. This strategy will provide a solid foundation for the successful conversion of qualitative aspects to quantitative evaluation. Therefore, it is recommended to all those enterprises, who produce mobile applications, that this framework approaches towards adequate computation. This will guarantee that app development organizations are able to give a comprehensive knowledge of their app's performance and user happiness via reliable quantitative data. As a result, it will be possible to enhance trust among investors and stakeholders.

This study presents a robust and innovative approach to assess the comprehensive quantitative software quality standards of M-commerce apps, focusing on the viewpoint of end users. This methodology supports stakeholders within mobile application enterprises in their pursuit of accurate computation for the analysis of overall quality throughout the development of mobile applications.

Conclusion

This research study has presented quantification of usability expectations for m-commerce mobile applications with the help of ISO 9241-11, the GQM approach, and fuzzy logic. It has demonstrated that fuzzy logic is a viable tool for quantifying usability expectations and providing an effective framework to explore the usability goals of a mobile application. The results obtained from the proposed approach are promising in terms of providing a comprehensive and accurate evaluation of the usability of m-commerce mobile applications. In terms of future scope of research, further studies could be conducted to evaluate the effectiveness of the proposed approach in different application domains. Furthermore, a comparative study could be conducted to explore the relative performance of fuzzy logic-based quantification of usability expectations for m-commerce mobile applications when compared to other approaches. Moreover, a study could be conducted to explore the potential of fuzzy logic-based quantification of usability expectations in the context of mobile application security. Overall, this research paper has provided a comprehensive framework for quantifying the usability expectation of m-commerce mobile applications with the help of fuzzy logic. The proposed approach shows potential for use in various application domains and offers a promising future for the development of mobile applications.

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Author's Contributions

Manish Mishra: Contributed to the conceptualization, formal analysis, methodology section, coding, validation, and original drafted written phases of the study.

Reena Dadhich: Contributed to the conceptualization, supervision, reviewed, edited and administration of the project.

Ethics

The work accurately and thoroughly represents the authors' research and analysis. The work acknowledges the valuable contributions of coauthors and co-researchers. The findings are properly put in research history. Text cites all references and related works.

Conflict of Interest

The authors hereby declare their complete independence from any organization or entity that may have a financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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