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Neutrosophic Likert Scale to Assess the User Satisfaction with Retail Software Developed by Software Engineering Students

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Abstract: This study aimed to evaluate user satisfaction with retail software developed by Software Engineering students using a Neutrosophic Likert Scale, which captures agreement, indeterminacy, and disagreement dimensions to better reflect real-world user perceptions. The results demonstrated high agreement scores (mean ~0.75) across key characteristics such as ease of use, speed, and response quality, indicating strong user satisfaction, while moderate indeterminacy scores (mean ~0.25–0.75) highlighted areas for minor improvements. The study's key contributions include the application of neutrosophic logic to assess software usability, validation of the student's technical and managerial competencies, and actionable insights for enhancing system performance and user experience.

Keywords: Neutrosophic logic, Likert scale, user satisfaction, retail software, software engineering education

1. Introduction

The Software Engineering program at the University of Guayaquil ensures that its students not only the technical side of software development but also the management side of a software project [1, 2]. One of the most relevant aspects of this management is knowing how to develop a system that meets user satisfaction because it directly influences adoption, engagement, and long-term success [3, 4]. Developing a retail system as a software engineering project provides students with hands-on experience in designing, building, and deploying a real-world application that mimics modern retail operations. This type of system typically includes features such as inventory management, sales processing, customer relationship management (CRM), and reporting tools, allowing students to practice key software engineering concepts such as database design, user interface (UI) development, API integration, and security best practices. By working in a retail system, students gain exposure to business logic, transaction handling, and data analytics, preparing them for industry challenges while fostering teamwork, problem-solving, and project management skills.

In addition, a retail system project helps students understand the importance of user-centric design and system scalability. Since retail applications must cater to both employees (cashiers and managers) and customers (online shoppers), students learn to balance functionality, usability, and performance. They also explore emerging technologies such as mobile payments, cloud storage, and AI-driven recommendations, making the project relevant to modern retail trends. Completing such a project not only strengthens

technical expertise, but also demonstrates practical experience to potential employers, showcasing their ability to develop functional, efficient, and user-friendly software solutions.

When users find a system intuitive, efficient, and aligned with their needs, they are more likely to use it consistently, recommend it to others, and remain loyal [5, 6]. A well-designed system reduces frustration, minimizes errors, and enhances productivity, leading to higher retention rates and lower support costs [7]. Additionally, satisfied users provide valuable feedback, enabling continuous improvement and innovation [8,9]. Ignoring user satisfaction, on the other hand, can result in poor adoption, negative reviews, and wasted resources, ultimately undermining the purpose of the system [10].

The Neutrosophic Likert Scale improves decision-making in fuzzy or uncertain environments, such as user satisfaction surveys [11]. It acknowledges that real-world opinions often exist in a spectrum rather than in fixed categories, reducing bias from forced choices [12]. For example, in the use of retail software, where user satisfaction can be influenced by multiple conflicting factors, this scale helps identify subtle trends and areas that need improvement.

In this paper, we address the user evaluation of a retail system developed by Software Engineering students at the University of Guayaquil. This system is available in [13] and we describe its components. To evaluate user satisfaction, we will consider a neutrosophic Likert scale since it can measure truth, falsity, and indeterminacy, reflecting real-world user ambiguity better than traditional scales.

2. Materials and Methods

2.1 System Description

This section provides an overview of the structure and design of the system developed by software engineering students that is freely available in [13]. This section also includes a description of each of its components and the technologies selected for its implementation.

Figure 1. presents the components of the developed system.

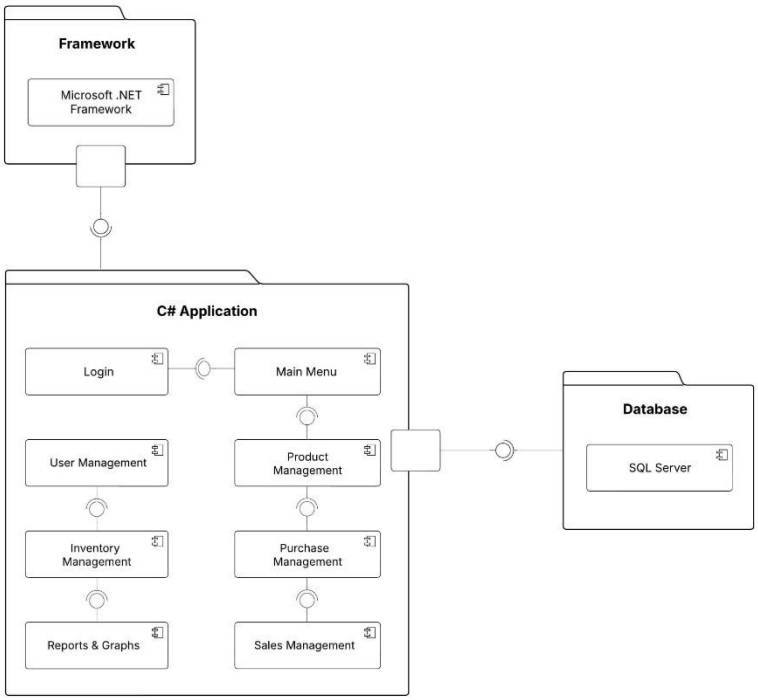

Figure 1. System component diagram.

Each component is described in the following lines, grouping it by packages:

(1) Framework:

- Microsoft .NET Framework: This component represents the underlying infrastructure used by the C# application. It provides a runtime environment for the development and execution of applications.

(2) C# Application:

- Login: This component handles user authentication, ensuring that only authorized users can access the application.
- Main Menu: This component serves as the central navigation point of the application, allowing users to access various functions and modules.
- User Management: This component manages user information and permissions, including creating, modifying, and deleting user accounts.
- Product Management: This component is responsible for managing product information, including adding, modifying, and deleting products
- Inventory Management: This component handles inventory data, including tracking stock levels and updating inventory counts.
- Purchase Management: This component manages activities related to purchases, including creating and tracking purchase orders.
- Sales Management: This component manages sales data and processes, including creating and tracking sales orders.
- Reports & Graphs: This component generates reports and visual data representations, providing users with important information for decision-making.

(3) Database:

- SQL Server: This is the database server used to store and manage the application's data.

An example of the system interface can be seen in Figure 2. For more details on how to use the system, you can consult the user manual found in its GitHub repository [13]. In addition, a video demonstration of the use of the system is available at [14].

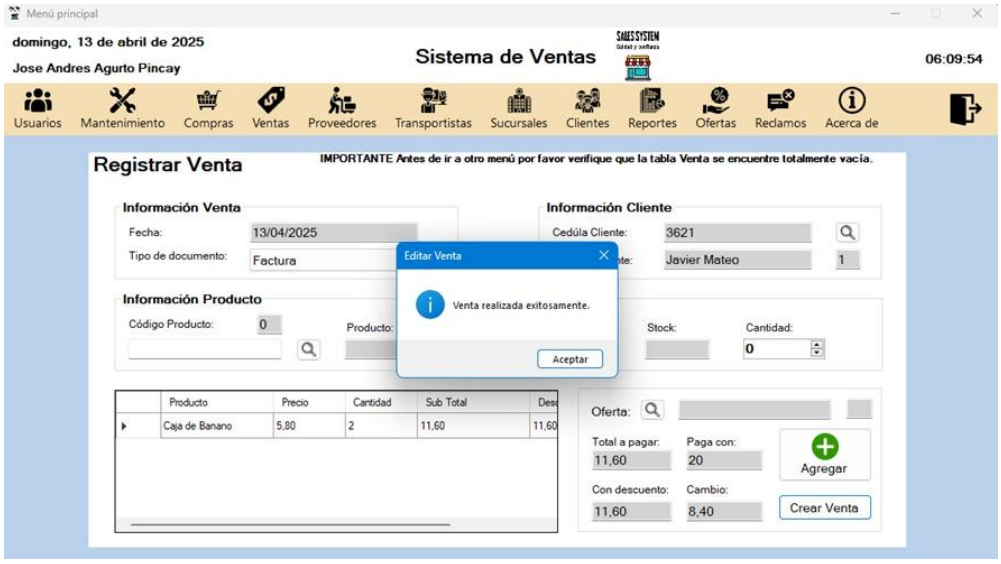

Figure 2. Interface to register a purchase.

2.2. Neutrosophic Likert Scale Questions

To obtain information on user satisfaction with the proposed chatbot, 150 users were selected to participate in application tests. The selected sample corresponds to people who have a high degree of knowledge of the use of technologies such as cell phones, tablets, and laptops. Their ages are between 18 and 55 years. Five characteristics were considered in the survey. Those were: The ease of use (A), speed (B), correct behavior (C), confidence to use it again (D), and the quality of response provided (E).

The Neutrosophic Likert scale[15,16] used in this study can be mathematically defined as follows:

For each evaluated characteristic (A, B, C, D, E), a neutrosophic three-dimensional assessment is employed, which can be represented as a set of ordered triplets:

$L_N s = (T_i, I_i, F_i) | i \in 1,2,3,4,5$ (1)

Where:

T_i represents the degree of agreement (truth)

I_i represents the degree of indeterminacy (uncertainty)

F_i represents the degree of disagreement (falseness)

Each dimension (T, I, F) can take discrete values in the set {1, 2, 3, 4, 5}, where:

1 represents the minimum value of the dimension

5 represents the maximum value of the dimension

Normalization to [0,1] Scale

To convert values from the original {1,2,3,4,5} scale to a normalized scale in the interval [0,1], the following transformation is applied:

$T_{normalized} = \frac{T-1}{4}$ (2)

$I_{normalized} = \frac{I-1}{4}$ (3)

$F_{normalized} = \frac{F-1}{4}$ (4)

Where:

$T, I, F \in \{1,2,3,4,5\}$ are the original values

$T_{normalized}, I_{normalized}, F_{normalized} \in [0,1]$ are the normalized values

This normalization maps the original values as follows:

$1 \rightarrow 0$

$2 \rightarrow 0.25$

$3 \rightarrow 0.5$

$4 \rightarrow 0.75$

$5 \rightarrow 1$

For a participant j evaluating a characteristic k, their normalized assessment is expressed as:

$E_j, k^{norm} = \left(\frac{T_j,k-1}{4}, \frac{I_j,k-1}{4}, \frac{F_j,k-1}{4}\right)$ (5)

The overall normalized assessment for a characteristic k considering all n participants can be calculated as:

$E_k^{norm} = \left(\frac{1}{n}\right)\sum_{j=1}^{n} E_j, k^{norm} = \left(\left(\frac{1}{n}\right)\sum_{j=1}^{n}\frac{T_j,k-1}{4}, \left(\frac{1}{n}\right)\sum_{j=1}^{n}\frac{I_j,k-1}{4}, \left(\frac{1}{n}\right)\sum_{j=1}^{n}\frac{F_j,k-1}{4}\right)$ (6)

This transformation allows the expression of the assessments in the standard neutrosophic framework with values in the unit interval [0,1], facilitating their interpretation and comparison with other neutrosophic studies [17, 18, 19].

Below are the questions designed to measure the five characteristics (A-E) on a Neutrosophic Likert scale. The scale includes three dimensions: Agreement (T), Indeterminacy (I), and Disagreement (F), each rated from 1 to 5 (where 1 = lowest, 5 = highest).

Table 1. Neutrosophic Likert Scale Questions

Characteristic	Question	Dimension
A: Ease of Use	The software is intuitive and easy to navigate.	T: Agreement
	I am unsure about some features of the software.	I: Indeterminacy
	The software is complicated to use.	F: Disagreement
B: Speed	The software responds quickly to user inputs.	T: Agreement
	Sometimes, the software's speed is inconsistent.	I: Indeterminacy
	The software is slow and delays my work.	F: Disagreement
C: Correct Behavior	The software performs all functions correctly without errors.	T: Agreement
	I occasionally encounter unexpected behavior in the software.	I: Indeterminacy
	The software frequently malfunctions or crashes.	F: Disagreement
D: Confidence	I would confidently use this software again in the future.	T: Agreement
	I am hesitant about using this software again.	I: Indeterminacy
	I would avoid using this software again.	F: Disagreement
E: Quality of Responses	The software provides accurate and helpful responses.	T: Agreement
	Some responses from the software are unclear or irrelevant.	I: Indeterminacy
	The software's responses are often incorrect or unhelpful.	F: Disagreement

Regarding the dimensions, in the following lines we describe the interpretation given to each of them.

Agreement (T):

- High scores (e.g., 4-5) indicate strong user satisfaction with the software's ease of use, speed, correctness, confidence, and response quality.
- Low scores (e.g., 1-2) suggest dissatisfaction or significant issues.

Indeterminacy (I):

- High scores reflect uncertainty or inconsistency in user experiences (e.g., occasional delays or unclear responses).
- Low scores indicate that users are confident and rarely encounter ambiguities.

Disagreement (F):

- High scores highlight significant problems (e.g., software is slow, malfunctions, or provides poor responses).
- Low scores suggest minimal disagreement or negative experiences.

3. Results

This section presents the results obtained from the user satisfaction survey conducted using the Neutrosophic Likert Scale. The section includes visual and statistical analyses of the survey data, focusing on three dimensions: Agreement (T), Indeterminacy (I), and Disagreement (F). For this purpose, we consider a bar graph with the mean scores for each dimension across the evaluated characteristics (ease of use, speed, correct behavior, confidence, and quality of responses). Moreover, we consider the distribution of scores through boxplots.

3.1. Bar plot with means.

Figure 3 presents the bar graphs for each dimension of the Neutrosophic Likert Scale survey, which includes Agreement (T), Indeterminacy (I), and Disagreement (F).

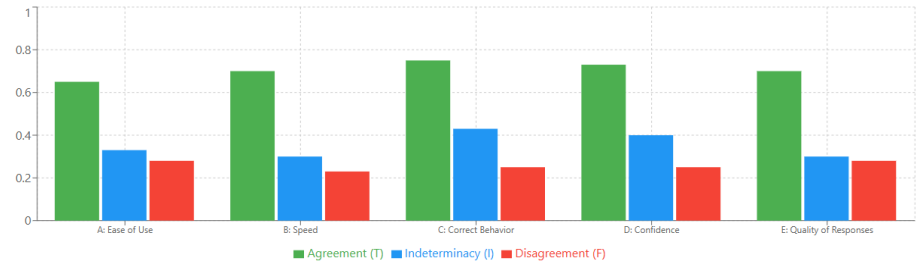

Figure 3. Plot bar graphs for each dimension (Agreement, Indeterminacy, Disagreement).

Figure 3 indicates that the Agreement (T) scores are consistently high, with a mean of approximately 0.75, reflecting strong user satisfaction in all the characteristics evaluated, such as ease of use, speed, correct behavior, confidence, and quality of responses.

In addition, Indeterminacy (I) scores are moderate, with a mean of approximately 0.375, suggesting that some users experienced occasional uncertainties or inconsistencies, such as delays or unclear responses. In contrast, the Disagreement (F) scores are very low, with a mean of around 0.125, indicating minimal significant issues or negative experiences. Overall, these results demonstrate that the retail software developed by the students was well received, with high satisfaction levels and only minor areas that needed improvement.

3.2 Boxplots of distribution of Neutrosophic Likert Scores

Figure 4 displays the boxplots of the distribution of Neutrosophic Likert Scores from the survey, illustrating the variability and central tendencies of the Agreement (T), Indeterminacy (I), and Disagreement (F) dimensions across the evaluated characteristics (A-E).

The boxplots of Figure 4 reveal that Agreement (T) scores are consistently high, with medians close to 0.75 and a narrow interquartile range, indicating strong consensus among users regarding the software's ease of use, speed, correct behavior, confidence, and response quality. In contrast, Indeterminacy (I) scores show moderate variability, with medians ranging between 0.25 and 0.5, reflecting occasional uncertainties or inconsistencies in user experiences, such as delays or unclear responses. Disagreement (F) scores are clustered at the lower end of the scale, with medians around 0 to 0.25 and minimal spread, suggesting that significant issues or negative experiences were rare. Overall, the boxplots confirm the robustness of the software's performance, with high user satisfaction and only minor areas requiring improvement, as evidenced by the low levels of disagreement and moderate indeterminacy.

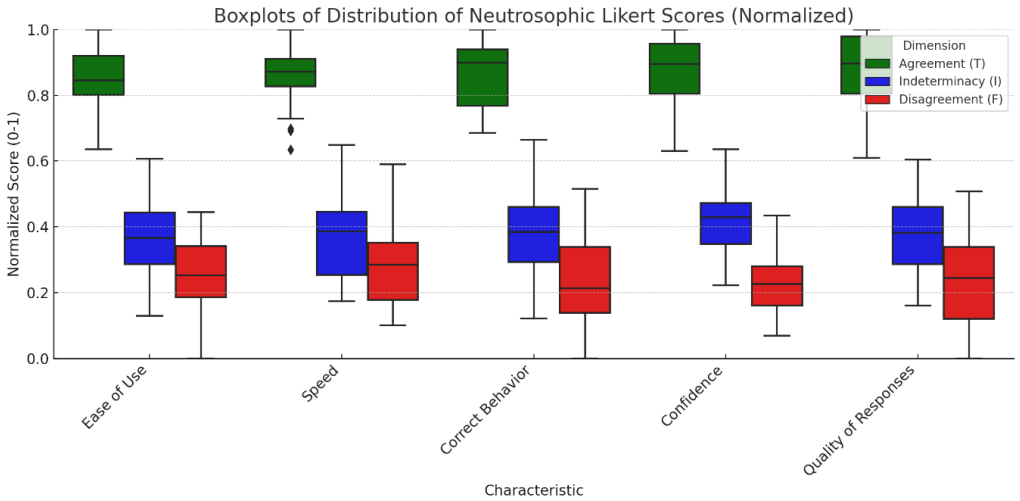

Figure 4. Distribution of Neutrosophic Likert Scores.

All in all, in Figures 3 and 4 can be shown that the Agreement (T) scores are consistently high (mean ~ 0.75). Moreover, the Indeterminacy (I) shows as moderate (mean ~0.25-0.5). Finally, the Disagreement (F) keeps scores very low (mean ~0-0.5). All in all, the survey results reflect a well-received software system with strong user satisfaction.

4. Discussion

4.1. Positive Aspects of the Results

The survey results using the Neutrosophic Likert Scale demonstrated strong user satisfaction with the retail software developed by Software Engineering students. Key positive findings include:

- **High Agreement (T) Scores**: The mean scores for Agreement were consistently around 4 across all evaluated characteristics (ease of use, speed, correct behavior, confidence, and quality of responses). This indicates that users found the software intuitive, efficient, reliable, and trustworthy.
- **Low Disagreement (F) Scores**: The mean scores for Disagreement were very low (0–0.25), suggesting minimal significant issues such as malfunctions, delays, or poor responses. This reflects the software's robustness and alignment with user needs.
- **Moderate Indeterminacy (I) Scores**: While Indeterminacy scores were slightly higher (2–3), they primarily reflected occasional uncertainties or inconsistencies, such as sporadic delays or unclear responses. These scores highlight areas for improvement but do not overshadow the overall positive reception.

The results validate the effectiveness of the software's design and implementation, particularly its user-centric approach and the integration of key functionalities like inventory management, sales processing, and reporting tools. The high satisfaction levels also underscore the students' success in applying Software Engineering principles to a real-world project [19-22].

4.2. Future Development Considerations

To further enhance the system, the following aspects should be considered:

Addressing Indeterminacy:

- Performance Optimization: Investigate and resolve occasional speed inconsistencies to reduce user uncertainty (e.g., optimizing database queries or server response times).
- Clarity in Responses: Improve the software's feedback mechanisms to ensure all responses are clear and relevant, particularly in features like reporting and CRM.

Feature Expansion:

- AI-Driven Recommendations: Integrate machine learning to provide personalized product recommendations, aligning with modern retail trends.
- Mobile Compatibility: Develop a mobile version or app to cater to users who prefer on-the-go access, enhancing convenience and usability.

User Training and Documentation:

- Provide comprehensive tutorials or tooltips for features where users expressed hesitation (e.g., advanced reporting tools). This could reduce Indeterminacy scores by increasing user confidence.

Scalability and Security:

- Ensure the system can handle increased user loads and data volumes as it scales.
- Implement advanced security measures, such as multi-factor authentication, to bolster user trust, especially for sensitive operations like payment processing.

Continuous Feedback Mechanisms:

- Incorporate real-time feedback tools within the software to gather ongoing user input, enabling iterative improvements and keeping the system aligned with evolving user needs.

All in all, the Neutrosophic Likert Scale effectively captured nuanced user perceptions, revealing both the strengths of the retail software and areas for refinement. The high satisfaction levels are a testament to the student's technical and managerial competencies, while the identified indeterminacies provide a clear roadmap for future enhancements. By addressing these aspects, the system can evolve into an even more robust and user-friendly solution, further bridging the gap between academic projects and industry standards.

5. Conclusion

The study demonstrated the effectiveness of the Neutrosophic Likert Scale in evaluating user satisfaction with retail software developed by Software Engineering students. The results revealed consistently high Agreement (T) scores (mean ∼0.75) across all evaluated characteristics— ease of use, speed, correct behavior, confidence, and quality of responses—indicating strong user satisfaction. Moderate Indeterminacy (I) scores (mean ∼0.25–0.5) highlighted occasional uncertainties, such as inconsistent speed or unclear responses, while very low Disagreement (F) scores (mean ∼0–0.25) confirmed minimal significant issues. These findings underscore the software's robustness and alignment with user needs, validating the students' technical and managerial competencies in developing a real-world application.

Despite positive outcomes, the study has limitations, including a sample size of 150 users, which may not fully represent broader user demographics. Additionally, the focus on a specific retail software context limits generalizability to other domains. Future work should address identified indeterminacies by optimizing performance and improving response clarity. Expanding features, such as integrating AI-driven recommendations and mobile compatibility, could further enhance user satisfaction. Longitudinal studies and larger and more diverse samples would strengthen the findings, while continuous feedback mechanisms could support iterative improvements, bridging the gap between academic projects and industry standards.

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Conflicts of Interest: The authors declare no conflict of interest.

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