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Applying TRIZ to Enhance Service Quality in Computer Maintenance Workshops: A Mixed-Methods Case Study

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ABSTRACT
This paper examines the impact of applying the TRIZ (Theory of Inventive Problem Solving) methodology on service quality and operational performance in a computer maintenance workshop. The study addresses persistent challenges such as long repair cycles, inconsistent diagnostic accuracy, and high variability in service quality. A mixed-methods design was adopted, integrating quantitative measures based on the SERVQUAL model with qualitative interviews and workflow observations. Data were collected before and after TRIZ implementation to evaluate changes in service quality dimensions (Tangibles, Reliability, Responsiveness, Assurance, and Empathy), maintenance time, and repeat-failure rates.
Results indicate substantial improvements across all SERVQUAL dimensions, with mean scores increasing notably in Tangibles, Responsiveness, Assurance, and Empathy. Average maintenance time decreased from 120 to 75 minutes, representing a 37.5% reduction, while repeat-failure rates dropped from 20% to 10%, indicating a 50% improvement in reliability. The findings suggest that TRIZ is an effective framework for resolving operational contradictions, standardizing diagnostic procedures, and enhancing both perceived service quality and technical performance. The study proposes a TRIZ–SERVQUAL-based improvement model and highlights implications for ICT maintenance management and future research.
Keywords: *TRIZ, service quality, SERVQUAL, computer maintenance workshop, mixed methods, maintenance time, repeat failures.*

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I INTRODUCTION

The reliability of computer systems has become a critical enabler of organizational performance, especially in environments that rely heavily on information and communication technologies (ICT) for daily operations. In such contexts, computer maintenance workshops play a key role in ensuring service continuity, minimizing downtime, and supporting user productivity. However, many workshops face recurring problems, including long repair cycles, inconsistent diagnostic accuracy, shortages of skilled technicians, and high variability in service quality.

Traditional improvement methods in maintenance often focus on incremental adjustments or corrective actions, addressing symptoms rather than underlying structural contradictions. In contrast, the TRIZ (Theory of Inventive Problem Solving) methodology offers a systematic, innovation-oriented approach based on the analysis of patterns of inventive solutions across thousands of patents.[1] TRIZ is designed to identify and resolve contradictions—situations in which improving one performance parameter leads to the deterioration of another.

This paper reports on a case study that applies TRIZ to enhance the quality of service in a computer maintenance workshop. Specifically, the study investigates how TRIZ principles can be integrated with the SERVQUAL model to diagnose service gaps, redesign maintenance workflows, and evaluate the impact of changes on both service quality and operational performance.

II LITERATURE REVIEW

2.1 TRIZ: Theory of Inventive Problem Solving

TRIZ was developed by GenrichAltshuller after a large-scale analysis of patent databases to identify recurring patterns of inventive solutions. [1] The central premise of TRIZ is that innovative solutions are not random but follow identifiable principles and trends. TRIZ provides a set of tools, including:

- **Technical and physical contradictions** (e.g., "increase speed without reducing accuracy"),
- The **contradiction matrix**,
- The **40 inventive principles**, such as segmentation, inversion, prior action, and dynamization, [1,3,4]
- **Patterns of system evolution** and ideality trends. [3]

These tools have been widely used in engineering design and process improvement to systematically remove contradictions and generate high-level solutions. [2–4]
Although originally developed for technical systems, TRIZ has been extended to service and management contexts. Studies report successful TRIZ applications in healthcare, banking, logistics, and service process innovation, where it has been used to simplify workflows, reduce delays, and enhance customer experience. [5]

2.2 Service Quality and the SERVQUAL Model
Service quality is commonly defined as the degree to which a service meets or exceeds customer expectations. [6] The SERVQUAL model conceptualizes service quality across five dimensions: Tangibles, Reliability, Responsiveness, Assurance, and Empathy. [6,7] It measures the gap between customer expectations and perceptions, typically using a Likert-scale questionnaire.
SERVQUAL has been applied extensively in technical and engineering services, showing that improvements in responsiveness and reliability are particularly important for customer satisfaction and retention. [9,10] In ICT maintenance environments, service quality encompasses accurate diagnosis, timely repair, professional communication, and well-organized technical facilities.

2.3 TRIZ in Maintenance and ICT Contexts
Empirical studies have demonstrated the effectiveness of TRIZ in maintenance and operations. Hsiao and Chiu (2014) reported that TRIZ-based interventions in maintenance processes led to a 30% reduction in equipment downtime by clarifying diagnostic procedures and addressing root causes rather than symptoms. [8] Other work has shown that structured analysis and innovative problem-solving tools can reduce maintenance cycle time and repeated failures in IT workshops.[11–13]
Despite these contributions, the integration of TRIZ with service quality frameworks such as SERVQUAL remains limited, especially in computer maintenance settings. Most existing studies focus on technical performance indicators (e.g., downtime, throughput) rather than user-centered quality dimensions. This study addresses this gap by combining TRIZ and SERVQUAL in a single improvement framework applied to a computer maintenance workshop.

III METHODOLOGY

3.1 Research Design
A mixed-methods case study design was employed to capture both quantitative and qualitative aspects of the maintenance workshop's performance before and after TRIZ implementation. [14,15] Quantitative data were collected through a SERVQUAL-based questionnaire and operational performance metrics (maintenance time and repeat-failure rates). Qualitative data were gathered via semi-structured interviews and direct observations of maintenance workflows.

3.2 Study Context and Sample
The case study was conducted in a computer maintenance workshop (Eltaganah Workshop) that provides repair and technical support services for computers and peripheral devices. The **population** included technicians, maintenance engineers, administrative staff, and employees submitting devices for repair.
A **purposive sampling** strategy was used to select participants directly involved in or affected by maintenance operations. [16] The final sample comprised:

- **15 technicians and workshop staff** (qualitative component), and
- **100 employees** who completed the SERVQUAL questionnaire *before* TRIZ implementation and **100 employees** who completed the same questionnaire *after* implementation (quantitative component).

3.3 Data Collection Instruments

1. **SERVQUAL Questionnaire**
   The questionnaire was based on the SERVQUAL model with two sections: expectations and perceptions.[6,7] Items were rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) and covered the five dimensions: Tangibles, Reliability, Responsiveness, Assurance, and Empathy. The instrument was administered before and after TRIZ implementation to detect changes in perceived service quality.
2. **Maintenance Time Measurement**
   Maintenance time was measured for each device across key process stages (reception, diagnosis, repair, testing, and delivery) in two phases: pre-TRIZ and post-TRIZ implementation. Average maintenance time (in minutes) was calculated for both phases.

3. **Repeat-Failure Rates**
   The percentage of devices that returned with the same fault within a defined period was recorded, providing an indicator of diagnostic and repair reliability.
4. **Semi-Structured Interviews**
   Interviews with technicians and supervisors explored diagnostic challenges, workflow bottlenecks, repeated faults, tool availability, and communication with users.[17,18] These data supported the identification of contradictions and the design of TRIZ-based solutions.
5. **TRIZ Analysis Tools**
   TRIZ tools—including the contradiction matrix, 40 inventive principles, and root cause analysis—were used to map identified contradictions to appropriate solution strategies and to develop improved workflow designs.[1–4]

3.4 Validity and Reliability

1. Content validity of the questionnaire and interview protocol was established through expert review. Construct validity was supported by the use of SERVQUAL, an internationally recognized instrument. [6,7] Internal validity was enhanced through data triangulation between questionnaires, interviews, and observations. [17,19]
2. Reliability of the questionnaire was tested using Cronbach's alpha, with $\alpha \geq 0.70$ considered acceptable for internal consistency. [21] A pilot test with 10 participants ensured clarity and stability of the items.

3.5 Data Analysis

Quantitative data were analyzed using descriptive statistics (means, standard deviations, frequencies) to compare pre- and post-TRIZ results for SERVQUAL dimensions and operational indicators. [20,22,23] Gap scores for SERVQUAL were computed as:

$$\text{Gap Score} = \text{Perception} - \text{Expectation}$$

Qualitative data from interviews were thematically coded into categories such as "bottlenecks," "contradictions," "technician challenges," and "improvement opportunities." [17]

IV Results

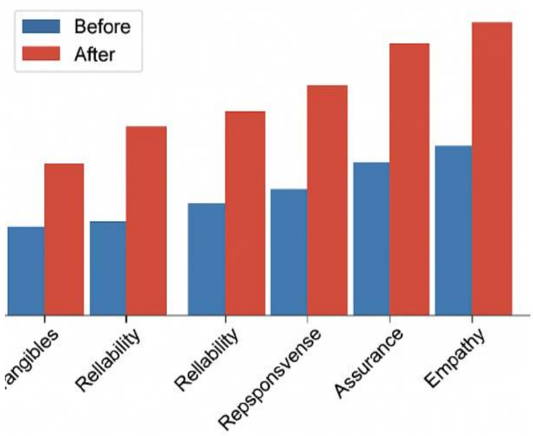
4.1 SERVQUAL Dimensions Before and After TRIZ

Table 1 presents the mean scores for the five SERVQUAL dimensions before and after TRIZ implementation.

Table 1. Mean SERVQUAL Scores Before and After TRIZ

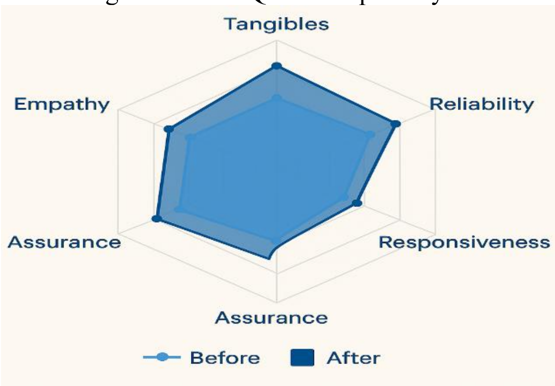
Dimension	Before TRIZ (Mean)	After TRIZ (Mean)	Improvement (Gap)
Tangibles	2.0	4.0	+2.0
Reliability	3.0	4.0	+1.0
Responsiveness	2.0	4.0	+2.0
Assurance	3.0	5.0	+2.0
Empathy	2.0	4.0	+2.0

Figure 1 Mean SERVQUAL Scores



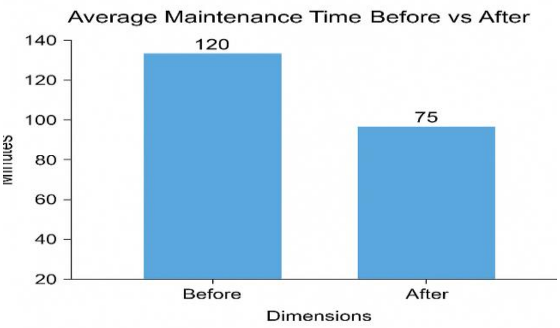
Substantial improvements were observed across all dimensions, with particularly large gains in Tangibles, Responsiveness, Assurance, and Empathy. These improvements indicate that users perceived the workshop as more professional, responsive, and supportive after TRIZ-based changes.

Figure 2 SERVQUAL Gap Analysis



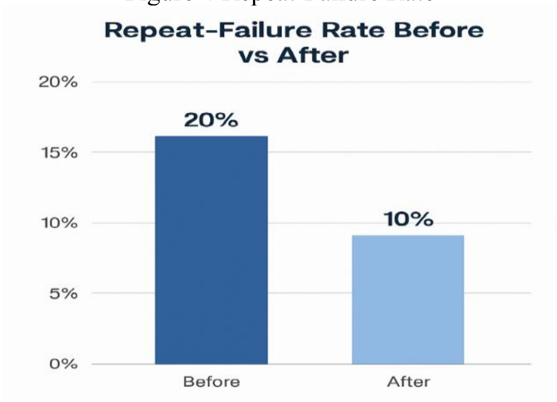
4.2 Maintenance Time and Repeat-Failure Rates
Average maintenance time per device decreased from **120 minutes** pre-TRIZ to **75 minutes** post-TRIZ, a reduction of approximately **37.5%**.

Figure 3 Average Maintenance Time



Repeat-failure rates declined from **20%** to **10%**, representing a **50% reduction** in devices returning with the same fault.

Figure 4 Repeat-Failure Rate



These results suggest that the TRIZ interventions improved both efficiency and reliability of maintenance operations.

V Discussion

The findings of this study demonstrate that the application of TRIZ in a computer maintenance workshop can significantly improve both perceived service quality and operational performance.

5.1 Service Quality Improvement in Light of SERVQUAL

The substantial increases in SERVQUAL dimensions are consistent with theoretical expectations and previous research. Mann (2002) argued that TRIZ structures decision-making processes, leading to more consistent service delivery and fewer ad-hoc responses. [2] Savransky (2000) emphasized that TRIZ reduces variability in human actions by providing clear, principle-based guidance. [4] The observed improvements in Assurance and Responsiveness, in particular, reflect these mechanisms: technicians became more confident and faster in handling user requests once contradictions were clarified and procedures standardized.

From a SERVQUAL perspective, the enhanced Tangibles dimension (e.g., more organized workspace, better labeling, and clearer communication materials) strengthened users' first impressions and trust in the workshop. [6,7,9] Improvements in Empathy indicate that technicians were better able to communicate with users, explain technical issues, and provide individualized support—factors that are strongly associated with higher satisfaction and loyalty in technical services. [9,10]

5.2 Explaining Efficiency Gains with TRIZ

The 37.5% reduction in maintenance time can be attributed to the explicit resolution of workflow contradictions such as "speed versus accuracy." TRIZ tools helped technicians re-engineer the process using principles like **Segmentation** (breaking down diagnostic steps), **Prior Action** (pre-configuring tools and checklists), and **Eliminating Harmful Functions** (removing redundant or low-value activities). [1,3,4] These changes mirror prior findings where TRIZ-based redesigns reduced downtime and bottlenecks in industrial and maintenance settings.[8,11–13]

5.3 Reliability and Repeat-Failure Rates

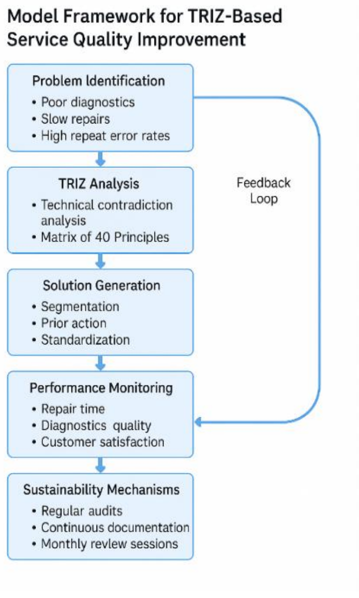
The 50% reduction in repeat-failure rates demonstrates that TRIZ supported a shift from symptom-based fixes to root cause elimination. Altshuller's concept of contradictions emphasizes that recurring faults often stem from deeper design or process issues.[1] By using contradiction analysis and inventive principles (e.g., **Feedback**, **Self-Service**, **Parameter Changes**), technicians were able to develop more robust repair procedures and preventive actions, echoing the outcomes reported by Hsiao and Chiu (2014).[8]

5.4 TRIZ Application Steps and Model Framework

The study implemented TRIZ through a sequence of steps: problem identification, contradiction analysis, mapping to TRIZ tools, solution generation, prototype implementation, evaluation (before/after), and feedback-based standardization. This cycle reflects a structured, iterative approach that aligns well with continuous improvement philosophies. [2–4]

Building on this process, a TRIZ–SERVQUAL **model framework** was developed, starting from service gap diagnosis (using SERVQUAL), moving to TRIZ-based contradiction resolution, and ending with impact assessment and sustainability mechanisms (continuous monitoring, feedback loops, and periodic reassessment). This integrated model addresses both technical and perceptual dimensions of service quality, contributing a novel perspective to the literature.

Figure 5 TRIZ–SERVQUAL model framework



VI Conclusion and Implications

This case study provides empirical evidence that TRIZ can be effectively applied to improve service quality and operational performance in a computer maintenance workshop. Key conclusions include:

1. **Service quality** improved significantly across all SERVQUAL dimensions, particularly in Tangibles, Responsiveness, Assurance, and Empathy.
2. **Maintenance time** was reduced by approximately 37.5%, demonstrating substantial efficiency gains.
3. **Repeat-failure rates** decreased by 50%, indicating enhanced diagnostic accuracy and repair reliability.
4. TRIZ enabled a shift from reactive, ad-hoc troubleshooting to **structured, contradiction-focused problem solving**, supported by standardized procedures.
5. The proposed **TRIZ–SERVQUAL model framework** offers a practical, replicable approach for ICT maintenance environments seeking to integrate innovative problem solving with user-centered quality measurement.

For practitioners and workshop managers, the study suggests:

- Institutionalizing TRIZ training for technicians and supervisors;
- Embedding TRIZ principles into diagnostic workflows and standard operating procedures;
- Using SERVQUAL periodically to monitor user perceptions and target new improvement areas;
- Implementing digital tracking systems to monitor maintenance time, failure modes, and repeat-failure rates.

The main limitation of the study is its single-case design, which restricts generalizability. In addition, the follow-up period was relatively short, limiting insights into long-term sustainability.

Future research could:

- Replicate the TRIZ–SERVQUAL framework in multiple workshops or across different ICT service settings;
- Compare TRIZ-based interventions with other improvement methodologies such as Lean or Six Sigma;
- Examine cost-benefit aspects and long-term organizational impacts of TRIZ adoption.

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