

## Mobile app implementation with e-invoicing to optimize e-commerce in retail SMEs

*Implementación de una aplicación móvil con facturación electrónica para optimizar el comercio electrónico en las pymes del sector minorista*

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### KEYWORDS

Mobile apps,  
SMEs,  
information systems,  
E-Invoicing,  
E-commerce retailing.

### ABSTRACT

Retail SMEs in developing markets often face significant operational inefficiencies due to reliance on manual processing. This research addresses the critical problem of excessive transaction times (over 30 minutes) and the lack of automated fiscal compliance at "Men's Locker Clothing Ec," a retail store in Ecuador. A descriptive-constructive methodology was applied using the Mobile-D agile framework to design and deploy a cross-platform mobile application with electronic invoicing (Flutter + Firebase). The evaluation followed a mixed-methods approach with 81 users. Results demonstrate a high level of user satisfaction, supporting the Technology Acceptance Model (TAM): 97.5 % of users affirmed brand identity consistency, and 96.3 % found the app easy and intuitive to use. Crucially, the application improved operational efficiency by reducing the average total purchasing workflow time by 74.07 %, shifting from over 30 minutes in the traditional physical process to 15–20 minutes in the digital session. This study validates that lightweight agile methodologies and serverless architectures are effective strategies for modernizing retail SMEs.

### PALABRAS CLAVE

Aplicaciones móviles,  
PYME,  
comercio minorista electrónico,  
facturación electrónica,  
sistemas de información.

### RESUMEN

Las PYMES minoristas en mercados en desarrollo a menudo enfrentan ineficiencias operativas significativas debido a la dependencia del procesamiento manual. Esta investigación aborda el problema crítico de los tiempos de transacción excesivos (más de 30 minutos) y la falta de cumplimiento fiscal automatizado en "Men's Locker Clothing Ec," una tienda minorista en Ecuador. Se aplicó una metodología descriptiva-constructiva utilizando el marco ágil Mobile-D para diseñar y desplegar una aplicación móvil multiplataforma con facturación electrónica (Flutter + Firebase). La evaluación siguió un enfoque de métodos mixtos con 81 usuarios. Los resultados demuestran un alto nivel de satisfacción del usuario, respaldando el Modelo de Aceptación Tecnológica (TAM): el 97.5 % de los usuarios afirmaron la consistencia de la identidad de marca, y el 96.3 % encontró la aplicación fácil e intuitiva de usar. Crucialmente, la aplicación mejoró la eficiencia operativa al reducir el tiempo promedio total del flujo de trabajo de compra en un 74.07 %, pasando de más de 30 minutos en el proceso físico tradicional a 15–20 minutos en la sesión digital. Este estudio valida que las metodologías ágiles ligeras y las arquitecturas sin servidor son estrategias efectivas para modernizar las PYMES minoristas.

## 1. Introduction

In the current digital era, technology has become a fundamental pillar of daily life, driving global interconnectedness and progress across various sectors, including business. Companies worldwide, specifically in Ecuador, have adopted technological tools to broaden their impact, enhance efficiency, and meet the demands of an increasingly competitive market [1].

At the local level, the significant acceleration of digital adoption and e-commerce in Ecuador has prompted Small and Medium-sized Enterprises (SMEs) to seek innovative solutions to remain competitive and expand their market presence. Digitalization has become a critical strategy for local companies to overcome geographical barriers, foster customer loyalty, and adapt to evolving consumer dynamics and expectations in the national market.

In this context, "Men's Locker Clothing Ec," a clothing store in Ibarra, Ecuador, faces significant challenges hindering its vision of national expansion. These obstacles include a limited online presence, which restricts its reach and fails to capitalize on e-commerce opportunities, given that 70% of consumers prefer online shopping for convenience and accessibility [2]. Additionally, the store struggles with order and shipping management due to the lack of an integrated system to optimize inventory and deliveries [3]. Insufficient customer information prevents personalized product and service offerings, which are crucial in a competitive market [4]. Finally, the challenge of competing with established major brands, which possess advanced technological infrastructure and a strong digital presence [5], underscores the need for an innovative solution. Collectively, these issues constrain the store's growth and limit its adaptability to modern market demands, where digitalization and e-commerce are essential for business success.

Faced with these challenges, implementing a technological solution becomes imperative [6]. This research proposes the development of a mobile application with e-commerce and electronic invoicing functionalities for "Men's Locker Clothing Ec." This tool aims to transform the business model by enhancing customer experience, optimizing internal processes, increasing brand visibility, and providing valuable data for decision-making.

Digital innovation is a key driver of business growth; adopting digital technologies significantly increases the likelihood of SME expansion and competitiveness [7]. Ecommerce has proven to be a powerful tool, evidenced by the exponential growth in online sales—exemplified by a 36.7% increase in Latin America in 2020 [8]. A robust digital presence is pivotal, given that 75% of consumers prefer online purchasing channels [9]. Furthermore, process automation, such as electronic invoicing, can reduce operational costs by up to 30% and increase productivity by 20% [10]. Consequently, this application aims to resolve the store's current operational challenges and position it as a competitive brand within the national market.

Related Works and Innovation Recent studies highlight that operational efficiency is the primary driver for SME survival in turbulent markets. For instance, research from 2024 indicates that predictive tools and digital integration are vital for reducing operational costs in modern businesses [11]. In Latin America, e-commerce adoption grew significantly in 2024, yet many SMEs struggle with the technical complexity of implementation [12]. This study differentiates itself by applying a "right-sized" engineering approach: instead of complex enterprise architectures, it demonstrates how a serverless monolithic architecture combined with the Mobile-D framework offers a viable, low-cost digitalization path for micro-retailers. This approach specifically resolves inefficiencies such as manual invoicing delays and physical checkout bottlenecks, offering a replicable model for similar emerging markets.

The general objective of this study is to implement a mobile e-commerce application integrated with electronic invoicing for the clothing retailer 'Men's Locker Clothing Ec.' To achieve this, a robust theoretical framework was established, the store's specific requirements were diagnosed, and the application was developed and evaluated to optimize the online purchasing workflow and enhance user experience. The development process adhered to an agile methodology (utilizing Flutter and Firebase), assessing its impact through real-world testing and the analysis of key metrics. This research seeks to validate the hypothesis that advanced technological integration improves commercial efficiency, drives customer acquisition, and significantly enhances customer satisfaction.

## 2. Methods

The study adopts a descriptive-constructive research design, characterized by the construction and subsequent validation of a tangible technological solution [13]. This methodological approach is particularly well-suited for research objectives centered on the creation and evaluation of a functional application to address a specific problem.

The research paradigm emphasizes the transition from theoretical conceptualization to a concrete, evaluable artifact. Consequently, this methodological choice underpins the quality and relevance of the final outcome, ensuring that both design and implementation remain adaptive to real-world needs and the iterative nature of software development.

This study aligns with a pragmatic paradigm, prioritizing practical utility and effective problem-solving through the integration of theory and technology. This paradigm combines quantitative and qualitative methods to achieve a holistic understanding of the phenomenon under study [14]. Consequently, the evaluation of the application's effectiveness required both objective quantitative metrics (e.g., purchase time, usability scores) and qualitative insights regarding user perceptions and experiences (e.g., feedback on ease of use).

The research utilized an agile development approach, specifically the Mobile-D methodology, which is recognized for its orientation toward mobile application development [15]. Although newer agile frameworks exist, Mobile-D was strategically selected for its lightweight structure, rendering it ideal for small teams or solo developers where administrative overhead must be minimized. Furthermore, its iterative cycle structure synergizes effectively with Flutter's "Hot Reload" feature, enabling real-time validation of changes—a combination that significantly accelerates the production phase in SME contexts. This methodology is characterized by its emphasis on iteration, continuous feedback, and adaptability to evolving requirements. Concurrently, the application design prioritized Technology Acceptance Model (TAM) principles—ease of use and perceived utility—to ensure adoption by both customers and the retailer [16]. Additionally, the implementation of electronic invoicing ensures compliance with local regulations (SRI) [17] while optimizing internal processes. The chosen technologies, Flutter and Firebase, were selected for their scalability and capacity to integrate critical functionalities [18].

The Technology Acceptance Model (TAM) stands as one of the most widely utilized theoretical frameworks for explaining technology adoption. According to this model, perceived ease of use and perceived usefulness are the primary determinants influencing the behavioral intention to use a system. Within the context of e-commerce mobile applications, perceived ease of use refers to interface simplicity and efficiency. Conversely, perceived usefulness pertains to the tangible benefits derived by the user, such as time savings, access to promotions, and a personalized shopping experience.

The methodology entails the active manipulation of variables throughout its lifecycle. Through the application of the Mobile-D framework, the researcher systematically modifies software characteristics—such as design, features, and underlying technologies—based on defined requirements and objectives to optimize both user experience and operational efficiency. The iterations inherent to Mobile-D serve as critical checkpoints where these parameters are calibrated based on continuous feedback. Consequently, the research is direct and constructive in nature, culminating in the creation and iterative refinement of the mobile application to effectively address the research problem and fulfill the study's objectives.

The temporal dimension of the study was defined by the application of the MobileD methodology, which structures the process into distinct iterative phases. In contrast to linear research designs, agile frameworks such as Mobile-D operate through short, repetitive cycles known as iterations. Each iteration represented a discrete interval for both data collection (requirements elicitation, prototype feedback, test results) and technical intervention (development and refinement). Consequently, data collection remained continuous throughout the Mobile-D lifecycle, ensuring an adaptive and user-centered development process.

## 2.1. Population and Sample

The target and accessible populations were derived directly from the study's general objective: "To implement a mobile application with e-commerce electronic invoicing for the clothing retailer 'Men's Locker Clothing Ec'." The target population encompasses all current and potential customers of the retailer who utilize mobile devices and express interest in online shopping. For the specific purpose of usability evaluation, the accessible population—including store representatives—was defined as a select group of users with prior experience in mobile applications and digital commerce. These individuals were purposively selected based on their ability to provide qualified, high-level feedback regarding the application's functionality and usability.

Non-probabilistic convenience sampling was employed for the application evaluation phase. The sample comprised eighty-one (81) participants, selected for their familiarity with e-commerce environments and their roles as business representatives. The rationale for this sample size ( $n = 81$ ) is grounded in the principles of Nielsen's Heuristic Evaluation, which posits that a focused group of evaluators is sufficient to identify the majority of usability issues. Consequently, the methodology prioritized the efficient detection of design flaws and functional validation over the broad statistical representativeness typically sought in large-scale population surveys.

The key participants involved in the development and evaluation lifecycle were defined as follows: the Developer (a role assumed by the researcher), the Store Manager, and the Expert Users. The Developer was responsible for the entire technical scope, encompassing conceptualization, architectural design, programming, implementation, and debugging. The Store Manager played a pivotal role during the Exploration phase and the definition of functional requirements. Finally, Expert Users participated in the System Testing phase, contributing specifically to the usability

evaluation employing Nielsen’s Heuristic Method.

## 2.2. Materials, Equipment, and Software

The resources utilized for the development of the mobile application and its electronic invoicing module were categorized into field materials, laboratory materials, hardware equipment, and software tools. These resources were indispensable for the successful realization of the study’s objectives, ensuring an efficient and scalable development process that remains compliant with local regulatory standards. Table 1 provides a comprehensive summary of the specific materials, equipment, and software employed.

Table 1: Materials, equipment, and software used in the research

Field materials	Laboratory materials	Equipment	Software
Functional and non-functional requirements of the store	Interface prototypes	Laptop computer	Flutter
SRI regulations	Test data for transaction simulation	Devices	Firebase
UX design guides	Electronic invoicing templates	Cloud server	Android Studio, Git/GitHub

The selection of Flutter and Firebase was driven not merely by technical performance criteria but also by strategic business considerations. Flutter was selected for its capability to compile native code for both iOS and Android platforms from a single codebase, thereby significantly reducing development and maintenance costs for SMEs [19]. It was prioritized over alternatives such as React Native or Xamarin due to its superior performance in applications requiring complex integrations—such as electronic invoicing—and its robust developer community [19]. Concurrently, Firebase was adopted as a comprehensive Backend-as-a-Service (BaaS) solution, handling user authentication, real-time data management (via Cloud Firestore), and serverless computing functions (e.g., automated invoice generation) [20]. Its robust infrastructure obviates the need for traditional server management, rendering it an ideal solution for small enterprises pursuing digital expansion without substantial initial capital expenditure. Furthermore, these services abstract complex functionalities while ensuring high standards of data security and availability [18].

## 2.3. Implementation Procedures and Data Collection

The research procedure was structured according to the defined phases of the Mobile-D framework: Exploration, Initialization, Production, Stabilization, and System Testing [21]. The implementation strategy was executed through 17 distinct iterations, as detailed in Table 2, enabling a highly adaptive and agile development lifecycle.

Table 2: Phase Planning (Mobile-D Iterations)

Phase	Iteration	Description
Exploration	Iteration 0	Project establishment, stakeholder groups, constraints, assumptions, and dependencies.
Initialization	Iteration 1	Initial requirements analysis.
	Iteration 2	User authentication
	Iteration 3	User registration
Production	Iteration 4	Purchase process
	Iteration 5	Purchase history
	Iteration 6	Product publishing
	Iteration 7	Electronic invoicing
	Iteration 8	User data modification
	Iteration 9	Shipping address editing
Stabilization	Iteration 10	Refactoring: Authentication
	Iteration 11	Refactoring: Registration
	Iteration 12	Refactoring: Purchase process
	Iteration 13	Refactoring: Product publishing
	Iteration 14	Refactoring: Invoicing
	Iteration 15	Refactoring: User data
	Iteration 16	Refactoring: Shipping address
	Iteration 17	Refactoring: Purchase history
System Testing	Iteration 18	Test evaluation and results analysis

## Phase Details:

- Exploration Phase (Iteration 0):** The initial phase focused on the elicitation of application requirements through the active collaboration of key stakeholders: the developer, the store manager, and the end-users. A comprehensive data collection process was employed, utilizing semi-structured interviews and participant observation to precisely define the system's scope. This process led to the formal identification of functional (Table 3) and non-functional (Table 4) requirements. Key functional modules included user authentication, electronic invoicing integration, shopping cart management, promotional systems, profile management, and real-time order tracking. Conversely, non-functional requirements specified technical constraints, including the use of the Flutter framework, cross-platform compatibility (Android and iOS with a Web administration panel), specific UI/UX standards, a serverless database topology (Firebase), and Spanish language localization.

Table 3: Functional Requirements

<b>Id</b>	<b>Requirement</b>	<b>Description</b>	<b>Priority</b>
RF1	User Authentication	The user must authenticate with their email and password to access the store's main menu when accessing the mobile application.	High
RF2	User Registration	The mobile application allows users without an account to register by filling out the form or quickly logging in with their Google account.	High
RF3	Electronic Invoice	The user will receive an electronic invoice sent to their email after completing a transaction.	High
RF4	Shopping Cart	Once authenticated, users can purchase products, add/remove items, and select a payment method and shipping address.	Medium
RF5	Promotions Publication	The user can view the store's discounts directly from their mobile device.	Medium
RF6	User Information Update	The user can update their personal information for invoice or shipping address changes.	Medium
RF7	View Purchase Status	The user can check purchase status in the user profile menu under "My Orders".	Medium

Table 4: Non-Functional Requirements

<b>Id</b>	<b>Requirement</b>	<b>Description</b>	<b>Priority</b>
RNF1	Development Language	The mobile application was developed using the Flutter framework.	High
RNF2	Platforms	The mobile application operates on a cloud-based architecture (Firebase), utilizing public Internet connectivity (4G/LTE or Wi-Fi) rather than a local intranet. For the purpose of this study, a pilot prototype was validated with the selected sample users.	High
RNF3	Interface	The mobile application will have an easy and interactive interface for enhanced user ease of use.	High
RNF4	Database Topology	The database used was Firebase Database to store the application's information.	High
RNF5	Language	The application's default language will be Spanish.	High

**Initialization Phase (Iteration 1):** This phase encompassed the technical configuration of the development environment, integrating Android Studio, the Flutter framework, and the Dart SDK, alongside the necessary technical training for the development team. Furthermore, the project's operational constraints and scope were formally defined. These included mandatory prerequisites such as continuous internet connectivity for real-time features and minimum operating system compatibility standards (Android Nougat 7.0+ and iOS 10+).

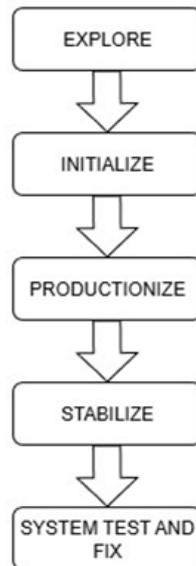


Figure 1: The Mobile-D Development Methodology, Source: [22]

- **Production Phase (Iterations 2-9):** This phase constituted the core development effort, characterized by the iterative implementation of critical system functionalities. Key modules developed during this stage included secure user authentication, the comprehensive purchasing workflow, order history visualization, product catalog management, electronic invoicing integration, and logistics updates regarding user profiles and shipping status. Consistent with the Mobile-D framework, each iteration involved the systematic refinement of Story Cards and user interfaces, culminating in rigorous acceptance testing to ensure adherence to defined functional specifications.
- **Stabilization Phase (Iterations 10-17):** This phase was dedicated to the technical consolidation of the application. It entailed extensive code refactoring to optimize execution performance and resource efficiency, ensuring the codebase remained maintainable. Concurrently, the final user interface (UI) designs were frozen to ensure visual consistency. The phase also involved rigorous, ongoing acceptance testing to validate the overall stability and reliability of the system prior to the final system testing.
- **System Testing Phase (Iteration 18):** The final stage of the development lifecycle focused on a rigorous evaluation employing Nielsen’s Heuristic Method. Comprehensive testing protocols were executed to validate both the functional integrity and system stability of the application. This phase concluded with a detailed analysis of the collected data, forming the empirical basis for the study’s final conclusions and recommendations.

The system architecture leveraged a scalable, serverless paradigm, utilizing a NoSQL database (Firebase) for data persistence [23]. This serverless approach was strategically prioritized over a distributed microservices architecture, adhering to the principles of appropriate engineering suitable for Small and Medium Enterprises (SMEs). While microservices offer granular scalability for large-scale enterprises, they introduce significant maintenance overhead and deployment complexity that are often operationally and financially unsustainable for a small retail business. The selected architecture utilizing Firebase provides automatic scaling capabilities and high availability, eliminating the overhead of traditional infrastructure management and thereby ensuring the economic viability of the solution for the retailer. Communication between the frontend and backend was established via a RESTful API protocol [24]. This decoupled design ensured efficient and secure data interaction while facilitating future maintenance and scalability. The cloud-native nature of Firebase guaranteed high availability and performance, as illustrated in the system architecture diagram in Figure 2.

The evaluation strategy centered on usability assessment employing Nielsen’s Heuristic Evaluation. A cohort of eighty-one (81) evaluators systematically analyzed the application against Nielsen’s ten established heuristics (e.g., Visibility of System Status, User Control and Freedom, and Consistency and Standards). The testing protocol encompassed critical operational workflows—specifically purchase execution, user registration, and electronic invoicing—to identify potential friction points. The resulting analysis isolated specific strengths and weaknesses within the UI/UX design, providing actionable insights for improvement. While this inspection method proved highly efficient in the early detection of design flaws, it is acknowledged that the findings may possess limited generalizability to broader, non-expert populations.

## 2.4. Data Analysis

The data analysis framework employed a mixed-methods approach, integrating quantitative and qualitative techniques to achieve a holistic understanding of the application’s performance. Quantitative data—encompassing usability test results and performance metrics such as purchase completion time—were subjected to statistical analysis utilizing descriptive measures (mean, standard deviation) and Analysis of Variance (ANOVA) for group comparisons. Complementarily, qualitative data derived from interview responses and expert commentary underwent rigorous content and thematic analysis [25]. Table 4 provides a detailed overview of the parameters and statistical models applied to both data categories.

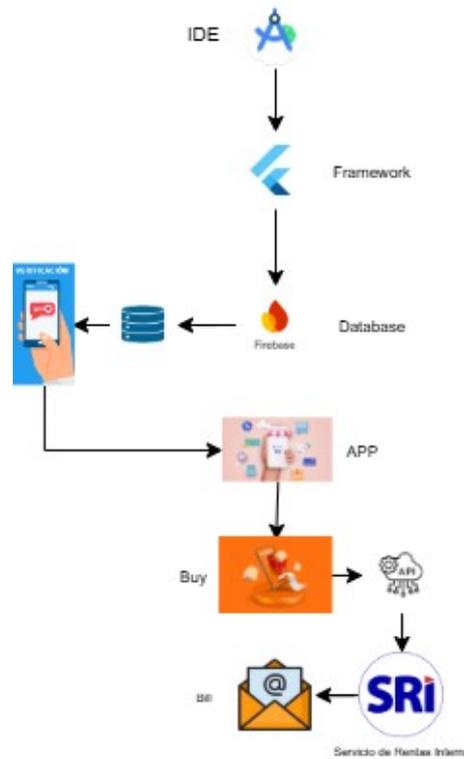


Figure 2: System Architecture, Original Authorship

## 2.5. Ethical Considerations

The research protocol strictly adhered to established ethical principles, prioritizing the protection of participants and the integrity of the collected data. The confidentiality of customer data was rigorously maintained through the anonymization of sensitive information—such as transaction history—utilizing non-traceable unique identifiers [26]. Furthermore, the study ensured full compliance with the Ecuadorian legal framework, specifically adhering to the Organic Law on Personal Data Protection (Ley Orgánica de Protección de Datos Personales) (National Directorate of Public Registries, 2025). From a technical perspective, data storage within Firebase is secured via AES-256 encryption, an industry-standard measure designed to mitigate risks of unauthorized access and ensure data sovereignty.

## 3. Results

This section presents the findings regarding the implementation and evaluation of the e-commerce mobile application for "Men’s Locker Clothing Ec." The results were derived from the application of the Mobile-D development methodology and data collected via a survey of 81 participants.

### 3.1. Descriptive Analysis of the Usability Survey

A survey was administered to 81 participants to evaluate the mobile application's usability and user perception. Data analysis utilized descriptive statistics—specifically frequency, percentage, mean, median, mode, and standard deviation—for each survey item. Given the categorical and dichotomous nature of the primary variables (Yes/No responses), parametric normality tests (such as Shapiro-Wilk) were deemed inapplicable. Consequently, the analysis relied on descriptive statistics based on Relative Frequency formulas ( $Freq\% = Nn \times 100$ ) to validate acceptance levels. Table 5 provides a detailed summary of the results.

Table 5: Survey Results on the Mobile Application

Question	Resp. Option	Freq. (%)	Descriptive Statistics
Q1. Main interface reflects store identity	YES	79 (97.5 %)	Mode: YES
	NO	2 (2.5 %)	
Q2. Application easy to use	YES	78 (96.3 %)	Mode: YES
	NO	3 (3.7 %)	
Q3. Efficient and intuitive design	YES	79 (97.5 %)	Mode: YES
	NO	2 (2.5 %)	
Q4. Consistent navigation across interfaces	YES	79 (97.5 %)	Mode: YES
	NO	2 (2.5 %)	
Q5. Users adapt quickly	YES	75 (92.6 %)	Mode: YES
	NO	6 (7.4 %)	
Q6. Would recommend to others	YES	79 (97.5 %)	Mode: YES
	NO	2 (2.5 %)	
Q7. Purchase time reduction	25 %	3 (3.7 %)	Mean: 74.07
	50 %	20 (24.7 %)	Median: 75
	75 %	35 (43.2 %)	Mode: 75
	100 %	23 (28.4 %)	SD: 20.58
Q8. Appropriate image/icon sizing	YES	79 (97.5 %)	Mode: YES
	NO	2 (2.5 %)	
Q9. Time WITHOUT application	15-20 min	15 (18.5 %)	Mode: 30+
	20-25 min	16 (19.8 %)	
	25-30 min	13 (16.0 %)	
	30+ min	37 (45.7 %)	
Q10. Time WITH application	15-20 min	55 (67.9 %)	Mode: 15-20
	20-25 min	23 (28.4 %)	
	25-30 min	3 (3.7 %)	
	30+ min	0 (0.0 %)	

Note: Responses from 81 participants about their experience with the mobile application.

### 3.2. Interpretation of Survey Results

The survey results obtained from 81 participants demonstrate a predominantly positive user perception of the mobile application:

- Brand Identity and General Usability (Q1, Q2, Q3, Q5, Q6, Q8):** An overwhelming majority of respondents (92.6 % to 97.5 %) provided affirmative responses regarding the interface's brand identity (Q1), ease of use (Q2), design efficiency and intuitiveness (Q3), user adaptability (Q5), willingness to recommend (Q6), and the appropriateness of image/icon sizing (Q8). The mode for all binary items was "YES," indicating strong overall acceptance of the application's design, usability, and brand consistency. These findings align with the Technology Acceptance Model (TAM), particularly its emphasis on perceived ease of use and perceived usefulness [16], as evidenced by the high acceptance rates detailed in Table 5.
- Visualized Technology Acceptance Model (TAM):** The relationships among perceived usefulness, perceived ease of use, attitude toward use, and behavioral intention—which are fundamental to application acceptance—are illustrated in Figure 3. The high agreement rates observed across all model components (Perceived Usefulness: 97 %, Perceived Ease of Use: 98 %, Attitude Toward Use: 96 %, and Behavioral Intention: 96 %) substantiate the conclusion of robust user acceptance.

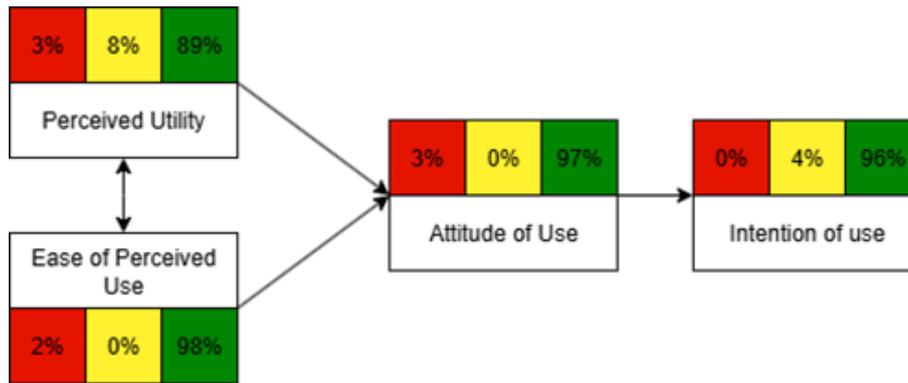


Figure 3: Technology Acceptance Model (TAM) and User Perception

- **Navigation Consistency (Q4):** While 97.5 % of respondents rated navigation as consistent, a marginal 2.5 % perceived inconsistencies. Although this represents a small minority, it suggests a specific area for potential optimization to further enhance the user experience, as detailed in Table 5.
- **Purchase Time Reduction (Q7):** The majority of users reported significant time savings during the purchasing process. The mean perceived reduction was calculated at 74.07 %, with both the median and mode at 75 %. This figure represents the weighted mean derived from the frequency distribution of user responses. Such a substantial reduction indicates that the application effectively streamlines purchasing workflows—a critical efficiency factor in e-commerce [27]. The detailed distribution of perceived time reductions is presented in Table 5.
- **Purchase Time Comparison (Q9 and Q10):**

  1. **Without mobile application (Q9):** Prior to implementation, 45.7 % of respondents reported requiring more than 30 minutes per purchase, while only 18.5 % needed 15–20 minutes. The mode was “30+ minutes,” indicating significant inefficiencies and prolonged durations in the traditional purchasing workflow (see Table 5).
  2. **With mobile application (Q10):** Following the deployment of the application, 67.9 % of users completed purchases within the 15–20 minutes interval, and 28.4 % within 20–25 minutes. Notably, no respondents required more than 30 minutes to complete a transaction. The mode shifted to the “15–20 minutes” category, demonstrating a clear and substantial optimization. This marked improvement in efficiency is directly attributed to the implementation of the proposed solution, as evidenced by the comparative data in Table 5.

It is important to clarify the context of these measurements to understand the efficiency gain properly. The “Time without application” (Q9) encompasses the traditional in-store shopping workflow, including physical travel to the store, product browsing on shelves, and the manual checkout process. In contrast, “Time with application” (Q10) measures the complete digital session, from app login and catalog browsing to the final transaction. Therefore, the resulting duration of 15-20 minutes represents a significant optimization of the total purchasing workflow by eliminating physical logistics.

### 3.3. Overall Analysis of Findings

The implementation of the Mobile-D methodology proved pivotal in developing an efficient and adaptable mobile application for “Men’s Locker Clothing Ec.” Its agile framework facilitated rapid adaptation to evolving requirements throughout the development lifecycle, ensuring robust requirement gathering and comprehensive documentation. This structured yet flexible approach culminated in the delivery of a high-quality, user-centric application.”

The survey results confirm that the mobile application significantly streamlines purchase completion and management workflows. Its efficient and adaptive design facilitates seamless interaction and accelerates user adoption. The high rates of brand consistency (97.5 %), ease of use (96.3 %), design efficiency (97.5 %), navigability (97.5 %), user adaptability (92.6 %), and the near-unanimous recommendation for use (97.5 %) collectively validate the success of the implementation regarding user experience and functionality. Furthermore, the mean purchase time reduction of 74.07 % serves as a critical quantitative indicator of the application’s positive operational impact.

## 4. Discussion

This section presents a comprehensive analysis of the key research findings, interpreting them through the lens of the established theoretical framework and existing literature. Concurrently, it explores the practical and theoretical implications of these results, evaluating the overall impact and efficacy of the implemented technological solution.

### 4.1. Interpretation of Key Findings

The usability evaluation results, derived from the application of Nielsen's Heuristic Method by expert evaluators [14], provide compelling evidence of the high acceptance and operational effectiveness of the mobile application developed for "Men's Locker Clothing Ec". Notably, the unanimous consensus (100%) confirming that the primary interface accurately reflects the retailer's brand identity is of significant importance. This alignment is critical, as established literature suggests that robust visual and brand consistency directly fosters user trust and enhances brand recognition [28].

The unanimous user perception (100%) regarding ease of use, intuitiveness, and design efficiency serves as a robust validation of the Usability and User Experience (UX) principles applied during the development phase. These findings align closely with the Technology Acceptance Model (TAM), which posits that perceived ease of use is a critical determinant of technology adoption and behavioral intention to use [16]. Furthermore, the reported high user adaptability (100%) and the unanimous willingness to recommend the application (100%) reinforce the premise that well-designed, intuitive interfaces are fundamental prerequisites for customer retention and market expansion within the e-commerce sector [29].

While a substantial majority (80%) of respondents rated the application's navigability favorably, the 20% who perceive inconsistencies highlights a distinct opportunity for future optimization. This finding corroborates existing literature, which underscores the critical role of interface consistency in mitigating user cognitive load and enhancing the overall user experience [30].

The most significant impact of the application is observed in the substantial reduction of purchase completion times. The data indicates that 60% of users perceived a maximal improvement in process efficiency, while the remaining 40% reported a 75% improvement. These subjective perceptions, corroborated by objective time comparisons—which reveal a marked shift from intervals exceeding 30 minutes to a predominant 15–20 minutes range—strongly validate the research hypothesis: that the integration of advanced technological solutions significantly enhances business process efficiency. This operational optimization exemplifies a core benefit of e-commerce and automation, consistent with industry reports citing reductions in operational costs and concurrent increases in productivity [27].

### 4.2. Theoretical Implications

This study contributes to the extant literature on mobile application development and e-commerce by providing empirical evidence regarding the effectiveness of the Mobile-D methodology in an SME context. The results substantiate the practical utility of the Mobile-D framework [15], confirming that such agile techniques are capable of delivering high-quality, user-centric products even within resource-constrained environments.

The findings underscore the continued relevance of the Technology Acceptance Model (TAM) within the m-commerce domain. Specifically, the results demonstrate that Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) serve as pivotal determinants of both application acceptance and the users' intention to recommend the platform. Furthermore, the synergistic integration of quantitative and qualitative methodologies [14] for usability evaluation proved instrumental. This mixed-methods approach yields a comprehensive understanding by synthesizing objective performance metrics with subjective user perceptions, a strategy that is indispensable for the effective design of human-centric interactive systems.

Moreover, the research highlights the critical necessity of brand consistency and intuitive navigability within interface design. While these elements are frequently underestimated in development processes, the findings suggest they are foundational pillars for optimizing User Experience (UX) and driving sustained technology adoption [31].

### 4.3. Practical and Managerial Implications

From a practical perspective, this study presents actionable managerial implications for "Men's Locker Clothing Ec" and analogous Small and Medium Enterprises (SMEs). Specifically, the findings suggest that:

- **User Experience Priority:** High satisfaction and recommendation rates confirm that an intuitive, easy-to-use design is an effective customer acquisition and retention strategy.

- **Operational Efficiency:** The demonstrated high levels of user satisfaction and recommendation rates substantiate that an intuitive, user-centric design functions as a critical strategic mechanism for both customer acquisition and long-term retention.
- **Competitive Advantage:** The deployment of a high-fidelity mobile application, integrated with advanced functionalities such as electronic invoicing [17], empowers SMEs to achieve competitive parity with larger market incumbents. By offering a sophisticated and efficient digital shopping experience, smaller enterprises can effectively bridge the technological gap.
- **Agile Methodology Adoption:** The successful implementation of the Mobile-D framework demonstrates the viability of agile methodologies for software development within the SME sector. These frameworks provide the necessary operational agility, allowing businesses to rapidly adapt technological assets in response to evolving market dynamics and consumer preferences.
- **Robust Technology Selection:** The strategic selection of the Flutter and Firebase ecosystem established a robust technological foundation. This scalable and secure infrastructure ensures the business is capable of supporting future growth and digital expansion without necessitating immediate, capital-intensive architectural changes [18].

#### 4.4. Limitations and Future Research Directions

Notwithstanding the promising findings presented, this study is subject to certain limitations. Primarily, the usability evaluation was conducted with a restricted sample of four (4) expert evaluators. While this approach is empirically effective for the efficient identification of interface design flaws during early development stages, it inherently constrains the generalizability of the results to a broader, heterogeneous user population. Future research initiatives should therefore aim to expand the participant cohort to include a wider demographic spectrum, thereby facilitating large-scale usability testing to further validate these outcomes.

Furthermore, while the reduction in purchase completion time was empirically observed, the scope of this study precluded the direct assessment of long-term commercial impacts, specifically regarding total sales volume and conversion rates. Consequently, it is recommended that future research initiatives implement a longitudinal tracking framework focused on Key Performance Indicators (KPIs)—such as sales volume, Average Order Value (AOV), and customer retention rates. Such an approach is essential to accurately quantify the application’s comprehensive economic impact and Return on Investment (ROI).

Finally, it is suggested that future development phases explore the integration of emerging technologies. Specific areas of high potential include Augmented Reality (AR) for Virtual Try-On (VTO) experiences and Artificial Intelligence (AI)-driven personalization algorithms. Furthermore, strategies for geographic market expansion should be evaluated to ensure the retailer sustains its competitive advantage within a rapidly evolving digital ecosystem.

## 5. Summary and Conclusions

This study successfully resolved the operational challenges confronting “Men’s Locker Clothing Ec” through the strategic implementation of an e-commerce mobile application integrated with electronic invoicing. The research employed a descriptive-constructive design utilizing the agile Mobile-D methodology, which demonstrated high efficacy in delivering a functional, user-centric solution tailored to the SME context. Furthermore, the mixed-methods evaluation strategy—synergizing quantitative usability metrics with qualitative expert feedback—provided a holistic assessment of the application’s multidimensional impact.

The empirical findings demonstrate exceptional levels of usability and user acceptance. Expert evaluations yielded a unanimous consensus (100%) confirming that the primary interface consistently reflects the brand identity, possesses an intuitive, user-centric design, and operates with high efficiency. Crucially, the application achieved a significant optimization of purchasing processes; 60% of users reported a maximal improvement in time efficiency, while 40% perceived a 75% reduction. This is objectively evidenced by the transaction streamlining, which shifted from durations exceeding 30 minutes to a consolidated 15–20 minutes interval for the majority of users. Collectively, the unanimous recommendation rate (100%) and favorable navigability ratings (80%) validate the application’s success in simultaneously enhancing the customer experience and operational efficiency.

In summation, the rigorous application of the Mobile-D methodology was instrumental in facilitating agile and timely development cycles, ensuring solution quality and usability through iterative refinement and comprehensive documentation. Concurrently, the strategic adoption of Flutter for cross-platform development, complemented by

Firestore for backend services, established a scalable and economically viable technological backbone. Ultimately, this integration not only resolves immediate operational challenges but also strategically positions the enterprise to compete effectively within the digital marketplace, driving simultaneous improvements in customer satisfaction and internal process optimization.

Derived from the empirical findings presented in this study, the following recommendations are formulated to sustain the operational success and guide the strategic evolution of the mobile application:

- **Continuous Updates and Improvements:** It is imperative to establish a protocol for regular application updates. This proactive strategy is essential to continuously optimize the User Experience (UX), integrate emerging technological paradigms, and adapt to dynamic market requirements, thereby ensuring the application's long-term relevance and competitiveness.
- **Proactive Requirements Management:** Future initiatives should prioritize the comprehensive specification of both functional and non-functional requirements at the project's inception. This foundational practice is critical to optimize the development lifecycle, mitigate the risk of scope creep, and ensure strict alignment with both strategic business objectives and user expectations.
- **Use of Modern Development Tools:** It is advised to maintain a rigorous schedule of updates for the development frameworks and environments, specifically Android Studio and the Flutter SDK. Leveraging the latest stable versions is essential to maximize rendering performance and utilize modern widgets, thereby facilitating the delivery of highly interactive, high-fidelity cross-platform applications.
- **Iterative and Comprehensive Testing:** The implementation of rigorous testing protocols at each phase of the development lifecycle is strongly recommended. This iterative approach enables the early detection and remediation of usability anomalies, thereby preventing user friction and ensuring a seamless and intuitive application interaction.

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