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User Experience Improvement (MSMEs and Buyers) Mobile AR Using Design Thinking Methods

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Abstract.
Purpose: This research aims to improve the User Experience (UX) of Augmented Reality (AR) mobile applications for MSMEs and buyers through the Design Thinking method. This research solves the problem of suboptimal UX in AR-based mobile applications. This study hypothesizes that the application of Design Thinking can result in significant improvements in the UX of AR mobile applications, which is evidenced by an increase in heuristic evaluation scores.
Methods: The Design Thinking approach (Empathize, Define, Ideate, Prototype, Test) is implemented. Data were collected through interviews, observations, and heuristic evaluation questionnaires.
Result: Initial heuristic testing showed several usability problems in the developed AR mobile applications, such as Help and Documentation (H10), Recognition Rather than Recall (H6), and Error Prevention (H5). After the application of the Design Thinking method and design iteration, the heuristic testing showed that the results of the evaluation comparison before and after the improvement showed a high effectiveness of the corrective actions taken, with an average decrease in severity score of 37% based on the Nielsen scale (0–4), indicating that the most critical and major issues were successfully reduced to cosmetic or minor levels.
Novelty: This research contributes in the form of a practical framework to improve the UX of AR mobile applications for MSMEs and buyers by utilizing the Design Thinking method. The results of this research can be a reference for developers in designing user-friendly AR mobile applications.

Keywords: Design thinking, User experience, Mobile AR, MSMEs products, Heuristic evaluation, Usability
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INTRODUCTION

Digital transformation has driven the adoption of innovative technologies in various business sectors, including the use of Augmented Reality (AR). AR has emerged as a promising technology to improve shopping and marketing experiences, especially for Micro, Small, and Medium Enterprises (MSMEs). AR mobile application allows customers to virtually visualize products in a real environment before making a purchase, thereby improving engagement and driving purchasing decisions [1]. However, the adoption of the AR mobile application by MSMEs is still relatively low. One of the main inhibiting factors is user experience (UX) that is less than optimal [2]. Interface personalization issues are common among users of AR mobile applications, characterized by a lack of feedback and unsatisfactory interaction. The absence of a universal UX definition, along with the general uncertainty surrounding these issues, intensifies them, leading to diverse design and evaluation approaches [3]. Developers and designers must tackle numerous obstacles before they can transform functional systems into engaging, intuitive, and satisfying user experiences [4].

AR presents a unique opportunity to increase competitiveness in ways that were previously only accessible to large companies. IKEA is a retail company present in Indonesia, and created an Augmented Reality (AR) mobile application in 2017 that lets prospective customers see products, like furniture models in the living area [5]. This includes letting customers see items in their own homes before buying them, which has been shown to increase sales and customer satisfaction, especially for more affordable or disliked products, and

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thus decrease the possibility of frustrating return items [6]. These findings have the potential for AR technology to be increasingly used by retail businesses to enhance the online purchasing experience [7].

The importance of superior UX in mobile applications has become a major focus in the development of digital products, especially in the highly competitive realm of e-commerce. Various studies have explored methods for evaluating and improving UX. Example [8] consistently emphasizes the crucial importance of Intuitive Interface (UI) design, smooth navigation, and fast load times as the foundation of a positive user experience on mobile platforms. Furthermore, evaluation methodologies such as Heuristic Evaluation have been proven to be effective in identifying problems in usability systematically. This approach, as demonstrated by [9], allows expert evaluators to assess the user interface's suitability against widely recognized design principles, thus providing concrete and evidence-based improvement recommendations. On the other hand, to ensure the design solution truly addresses the needs of the user, user-centered approaches such as Design Thinking are increasingly adopted. [10] describes how the iterative process of Design Thinking—which includes the stages Empathize, Define, Ideate, Prototype, Test is able to facilitate the creation of digital solutions that are not only functional but also relevant and satisfying for their target users. This method encourages a deep understanding of the user before designing the solution.

The pursuit of an enhanced user experience (UX) in mobile applications is a well-established area of research, with numerous studies addressing various facets of usability and engagement, including those focused on e-commerce platforms. For instance, according to [11], the fundamental importance of intuitive interface design and seamless navigation for achieving positive user interactions on mobile devices. In addition, [12] demonstrated the practical application of evaluation methodologies to systematically identify usability problems within mobile applications, subsequently offering concrete recommendations for improvement. Furthermore, the broader context of user-centered design is also addressed by [13], who explained how frameworks like Design thinking can be instrumental in creating solutions that are deeply aligned with user needs during digital product development, a principle highly relevant to improving the UX of emerging mobile technologies. While the contributions of previous research in the fields of mobile UX, AR, and Design Thinking are invaluable, there are significant research gaps when integrating these three domains specifically for the context of MSMEs and their buyers. Most of the research that exists tends to focus on just one aspect. For example, [14] have explored the impact of AR on sales metrics or engagement in large retail companies, but often do not explicitly implement or evaluate structured design methodologies such as Design Thinking, and may not pay enough attention to the unique needs of MSMEs. In contrast, research that applies Design Thinking, as described in [15], [16], [17], may focus on developing products or services in other domains (e.g., education, healthcare) and have not yet applied them to specific challenges in developing AR mobile applications to improve UX for MSMEs (as content/service providers) and buyers (as end-users). This gap becomes important because the AR user experience is influenced by unique factors such as 3D interaction, environmental tracking, and device performance, which require a tailored, user-centric design approach holistically, covering both sides of the market (MSMEs and buyers).

The research gap identified is the lack of studies that systematically apply the Design Thinking framework to improve the UX of AR mobile applications specifically designed for interaction between MSMEs and their buyers, as well as empirically validate the effectiveness of such improvements through a usability evaluation structured like Heuristic Evaluation. This research aims to fill this gap by developing, implementing, and testing a UX improvement framework for AR mobile applications based on Design Thinking. Specifically, this study will conduct an initial Heuristic Evaluation to identify UX problems in existing AR mobile applications (or early prototypes) for MSMEs and buyers. Then, the Design Thinking method will be applied thoroughly (from Empathize to Test) to design UX improvement solutions centered on the needs of both user groups. Finally, the effectiveness of the implemented solution will be revalidated using Heuristic Evaluation to quantitatively and qualitatively measure the level of UX improvement.

The main objective of this research is to explore the efficacy of the Design Thinking method in identifying specific user experience (UX) problems within Augmented Reality (AR) mobile application tailored for Micro, Small, and Medium Enterprises (MSMEs) and their buyers, and subsequently, in generating appropriate solutions to meet their distinct needs. Quantitatively assess the significance of any improvements in the UX of these AR mobile applications by comparing Heuristic Evaluation results obtained before and after the implementation of the solutions derived from the Design Thinking process. Furthermore, this research contributes to the development of user-based design methods for interactive technology, as well as providing practical solutions for MSMEs in adopting AR technology effectively.

METHODS

This study adopts an approach, Design Thinking, adapted from [18], [19], which consists of five iterative stages: Empathize, Define, Ideate, Prototype, and Test. Modifications are made at the stage test by adding a heuristic evaluation to measure the usability application quantitatively. An explanation of the processes in Design Thinking as a method can be seen in Figure 1.

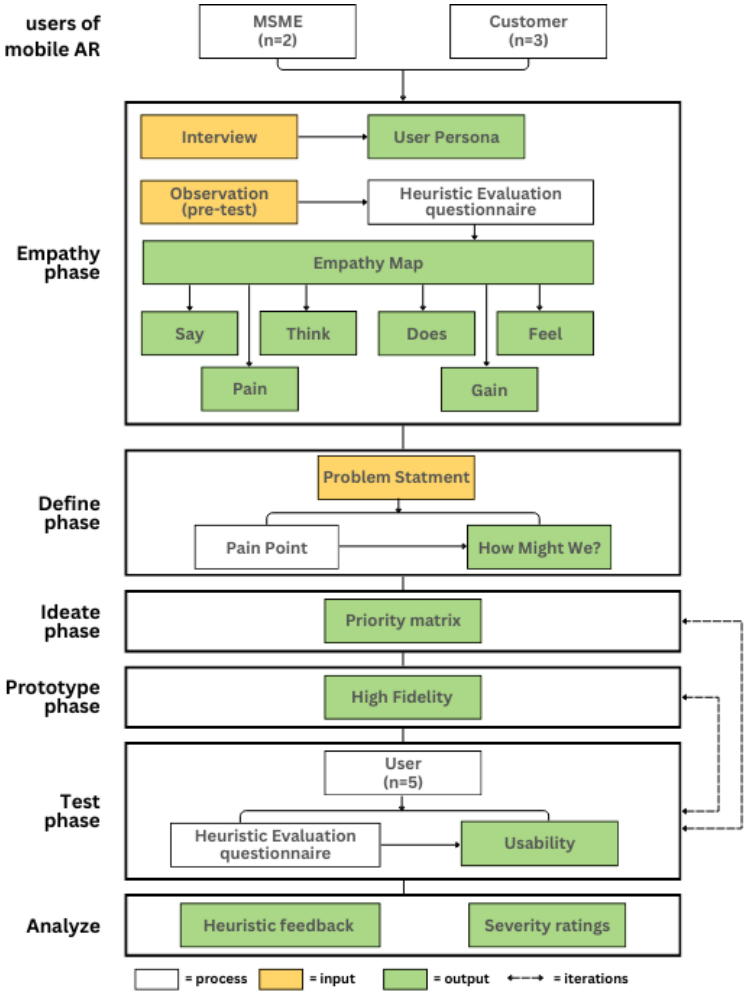

Figure 1. Design thinking process

a) Empathize phase.

This stage aims to understand the needs and problems of users (MSMEs and buyers) related to the use of the AR mobile applications. Each user was asked to perform 3 task scenarios using the AR app prototype. Testing was conducted for 20 minutes per user, with direct observation by the evaluator and a heuristic questionnaire afterward. In addition to interviews, participant observations were carried out to observe user behavior when interacting with the existing mobile AR.

b) Define phase.

The information collected in the Empathize stage is analyzed using affinity diagrams to identify patterns and themes of UX problems. The problem is then formulated in the form of a specific and measurable problem statement.

c) Ideate phase.

This stage aims to produce alternative design solutions to address the identified UX problems. Priority matrices are used to generate solution ideas and know which parts need to be worked on and completed first due to the needs of AR mobile application users [20], [21].

d) Prototype phase.
The selected design solution is implemented in the form of a prototype AR mobile application [22]. By using Figma to create interactive prototypes for AR. The prototype developed is interactive and allows users to simulate the use of the application. Produce high-fidelity prototypes so that they look real (real-time) by AR mobile application [23].

e) Test phase.
The AR mobile applications prototype was tested on 5 users, consisting of 2 business actors and 3 candidates/customers of the same MSME product from the same stage, Empathize. The testing phase consists of two stages: testing usability early on the prototype before revision, and testing usability after the prototype is revised based on the results of the first stage of heuristic evaluation. Heuristic evaluation is carried out using the 10 principles of usability from [24], [25], [26]. Using the Nielsen 0–4 scale, each usability issue that is found is given a unique severity score in the heuristic evaluation. A thorough list of the problems identified, along with a severity rating for each, is the evaluation's final output. The analysis then focuses on the number of issues in each severity level or the average severity score to identify the areas most in need of improvement, rather than to give the application a single final grade [27].

Quantitative data from the heuristic evaluation scores were analyzed using the total heuristic score to compare the usability of the application before and after the implementation of Design Thinking. The focus on app input and output allows for the identification of functional errors, such as crashes and inappropriate results, ensuring the AR mobile application works as intended. Severity assessments using severity ratings in testing are also used to evaluate the usability of the AR mobile application, ensuring mobile AR technology is appropriate to the user's needs. Severity ratings testing ensures that the heuristic evaluation of the AR mobile application not only works well, but can also provide a positive user experience for the user needs that have been identified through the Design Thinking stage. This process produces valuable findings for design improvement, improving application quality, and validating the effectiveness of solutions designed to solve problems faced by entrepreneurs and buyers of MSME products. In addition to quantitative data, qualitative feedback from users was also collected during testing.

Data analysis on qualitative data from interviews and observations was analyzed thematically using an approach, resulting in user personas and empathy maps [28]. Quantitative data from heuristic evaluation was analyzed descriptively by filling out a questionnaire of 10-question instruments related to heuristic evaluation to be filled in the last test in the form of feedback. Table 1 shows some of the question instruments that need to be answered during the observation and questionnaire sessions, as presented in Table 1 [29].

Table 1. Heuristic evaluation questionnaire

Heuristic Variable	Heuristic Evaluation	Questionnaire
H1	Visibility of System Status	Does this shoe AR app provide clear information about what's going on while you're using it (for example, when loading, processing, or completing an action)?
H2	Match Between the System and the Real World	Are the terms and symbols used in the shoe AR app easy for you to understand and feel following your everyday experience?
H3	User Control and Freedom	Do you find it easy to undo or repeat incorrect actions while using this shoe AR app?
H4	Consistency and Standards	Does the design of this shoe AR application feel familiar and consistent with other applications you have used, so that it is easy to understand how it works?
H5	Error Prevention	Does this shoe AR app provide hints or warnings that help you avoid mistakes while using it?
H6	Recognition Rather than Recall	Does this shoe AR app display the information you need clearly, without you having to remember a lot of things or type repeatedly?
H7	Flexibility and Efficiency of Use	Does this shoe AR app offer a faster or more efficient way to perform certain actions, such as shortcuts or additional features?
H8	Aesthetic and Minimalist Design	Does the look of this shoe AR app feel simple, not confusing, and only display information that is important to you?
H9	Help Users Recognize, Diagnose, and Recover from Errors	If you make a mistake while using this shoe AR app, does the app provide clear information about the error and how to fix it?
H10	Help and Documentation	Do you find it easy to find help or instructions for use if you're having trouble or want to learn more about the shoe AR app?

RESULTS AND DISCUSSIONS

At this stage, the author will explain the results of the user experience of the AR mobile application. The 5 phases in user-centered Design Thinking will be explained by the author. Graphic drawings of each stage of Design Thinking, including user personas, empathy maps, HMW statements, priority matrices, prototypes with high fidelity options, as well as validation with test results (initial tests) and final stage testing carried out by users on the AR mobile application.

User Persona

User personas are a vital component of the Design Thinking process, particularly in the empathy and definition phases. More targeted and user-centered design solutions result from designers who better grasp and relate to users. Although their development and evaluation present difficulties, empirical data show their efficiency in improving the design process and outputs [30].

After the interview, some information data in the form of user personas can be seen in Figure 2, which provides information about, User Profile, Goals (which is the main goal related to buying shoes or using AR), Description (is a brief explanation of the user profile), Motivation (is the main motivation for the use/view of AR), Quotes (is the desire and expectation for AR technology), AR features (expressing desired AR features or concerns about AR). Frustration (is frustration/concern related to buying and selling through AR), Interests (is the interest/readiness to adopt AR MSME shoe products), these things can be seen in Figure 2.

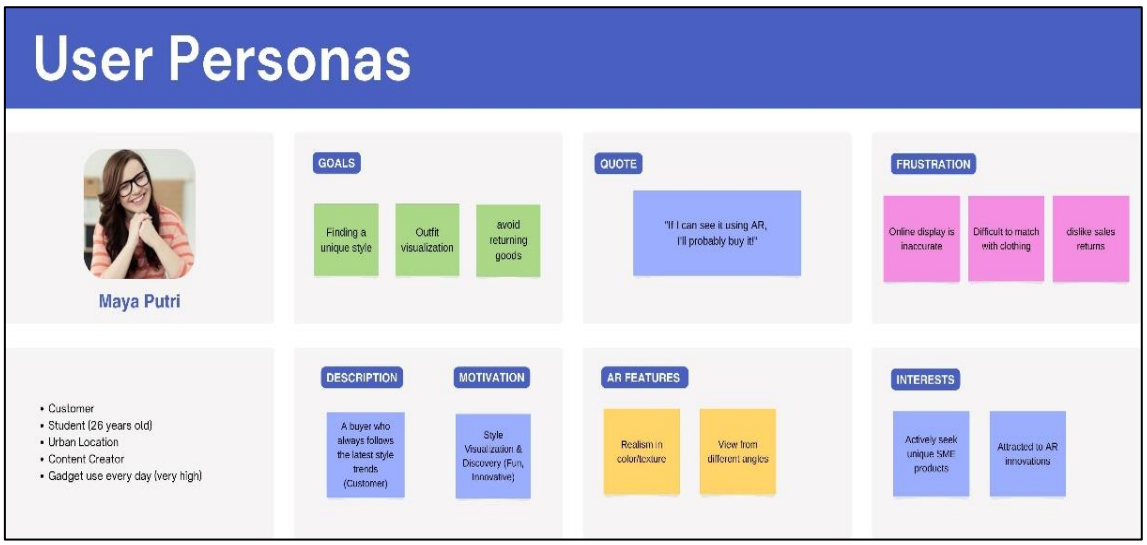

Figure 2. Customer user persona

Empathy Map

The empathy map phase in Design Thinking is a foundational step that provides deep insights into user needs and behaviors. Despite its challenges, the use of empathy maps can significantly enhance the design process, leading to more user-centered and innovative solutions. Advances in technology, such as automated tools and conversational agents, are making this phase more accessible and efficient [31].

The next step is to summarize each user persona and include it in each section of the empathy map, which can be seen in Figure 3. The explanation of each part is as follows:

- Says (what is said), in the form of comments about features, complaints, compliments, questions, or statements about their needs and wants.
- Thinks, the internal thoughts and beliefs of a person that they may not express directly, include what they think about the experience.
- Does (what is done) refers to the actual actions and behaviors observed of the persona. Direct observation and analysis of user behavior are the main sources of information.

- Feelings (what is felt) are the emotions and feelings experienced by a persona during an interaction or in a relevant context, in the form of joy, frustration, confusion, hope, disappointment, or uncertainty.
- Pain (difficulty/frustration) describes the problems, obstacles, pains, or frustrations experienced by the persona.
- Gain (profit/expectation) is a positive outcome, benefit, or expectation desired by a persona.

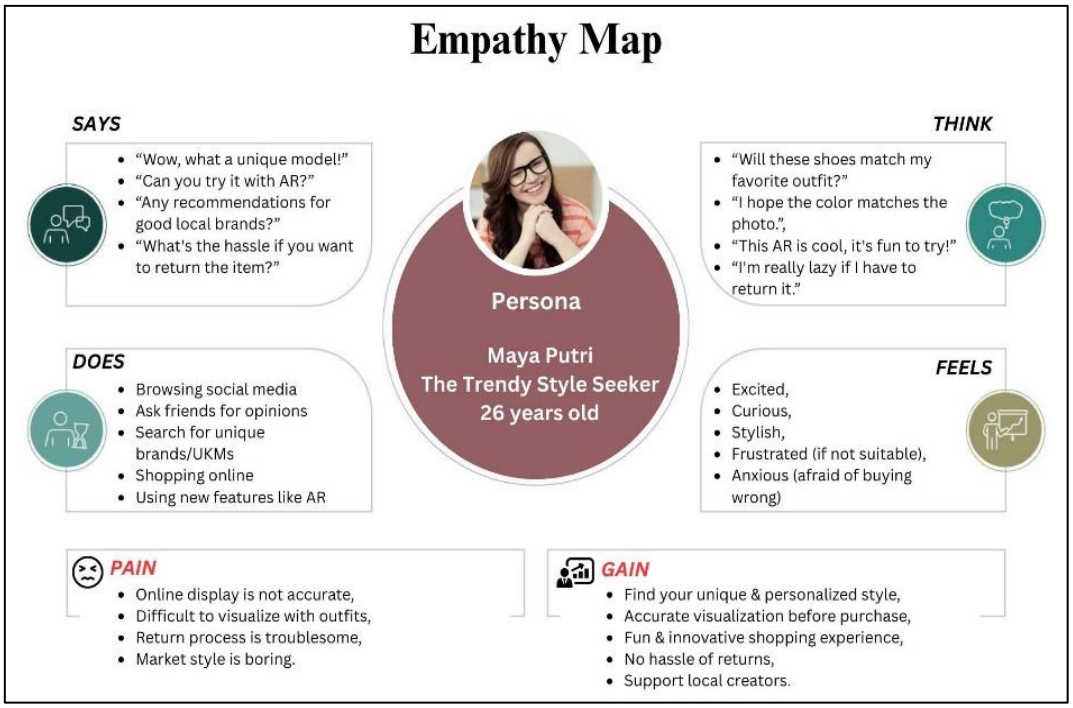

Figure 3. Customer empathy map

Problem Statement

The problem statement phase in Design Thinking is essential for setting a clear and focused direction for the design process. By precisely articulating the issue from the user's viewpoint, employing structured templates, and comprehending the cognitive effects of various problem statement kinds, designers can augment their creativity and problem-solving efficacy. This phase not only influences the quality of the solutions generated but also plays a significant role in educational and industrial applications, fostering innovation and practical outcomes [32].

Enter the Define Phase, where the problem statement steps are concluded using the formulation of the How Might We (HMW) problem. This is after conducting the information filtering process from the Pain Point. The How Might We Questions are as follows:

- Technical Optimization, "How to provide a more in-depth and informative visual perception of shoe product details to potential online buyers?"
- Content Personalization, "How to present relevant product information without disrupting the AR experience so that it helps potential online shoppers feel more confident in the appearance of the shoes on their feet before buying?"
- Engagement, "How to increase interactivity without increasing the burden on mobile devices to increase the confidence of potential online shoe buyers so that they are more comfortable making purchases without seeing physical products directly?"

Priority Matrix

In Design Thinking, the phase known as the Priority Matrix uses several kinds of matrices to organize, rank, and assess many facets and ideas throughout the design process. These matrices enable efficient decision-making, help control complexity, guarantee thorough analysis, and enable management of complexity, hence producing creative and informed design results [33].

See in Figure 4 the quadrants that divide 4 (four) parts in the Priority Matrix, regarding urgent matters that must be done first according to the user's needs for the AR mobile applications [34]. The explanation of the priority matrix is as follows:

- Key Focus (Q1 - Quick Wins), starting with building a good user experience foundation and core functionality, includes an easy interface, basic product viewing capabilities (rotate/zoom), and integration into purchases.
- Medium/Long Term Investment (Q2 - Major Projects), allocate significant resources to features that deliver transformative impact, high visual realism (foot tracking, advanced rendering), and platforms that make it easier for MSMEs to manage their AR content.
- Additionally, if resources allow (Q3 - Fill-ins), features such as changing backgrounds or sharing can be added later to enrich the experience if time and budget allow, once the top priorities are achieved.
- Avoid or Delay (Q4 – Thankless Tasks), a feature that requires a lot of effort, should be avoided or postponed until there is strong evidence of the need or the technology is more ready.

With this priority, the team can focus on developing AR mobile application solutions that gradually address the pain points of customers and MSMEs, starting from a strong foundation and high-impact features with relatively little effort.

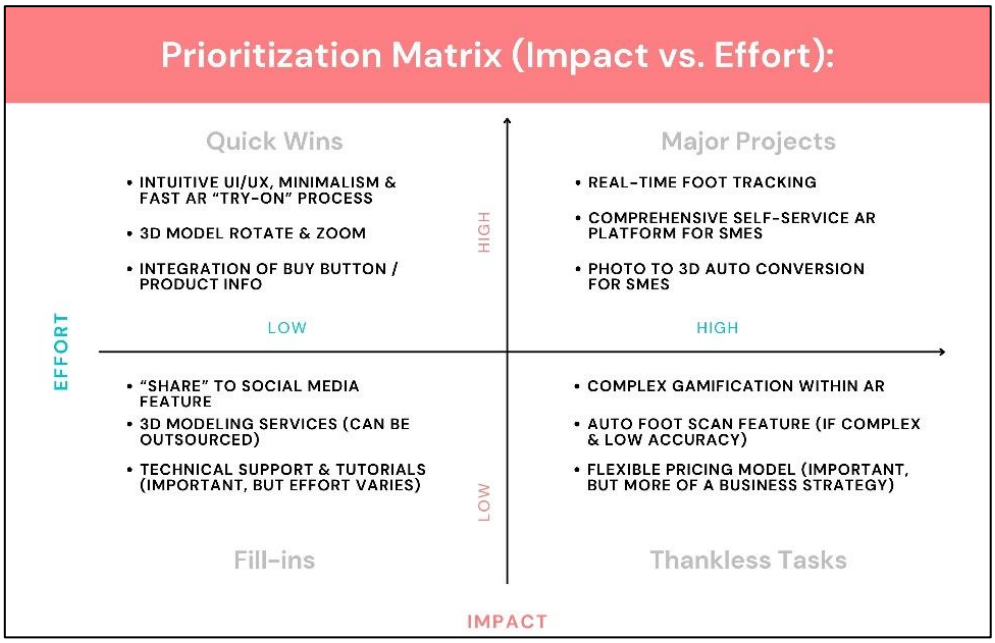

Figure 4. Priority matrix UX mobile AR

Prototype

The prototype phase in Design Thinking is integral to developing innovative and user-focused solutions. It involves iterative testing and refinement, collaborative development, and managing complexity and stakeholder expectations effectively [35]. The prototype phase in Figure 5 can be seen as the process of scanning the product brochure, then the user downloads and installs the AR mobile application on an Android smartphone. The design displayed on this high-fidelity prototype is one of the quick, real-time solutions in the AR mobile application [36].

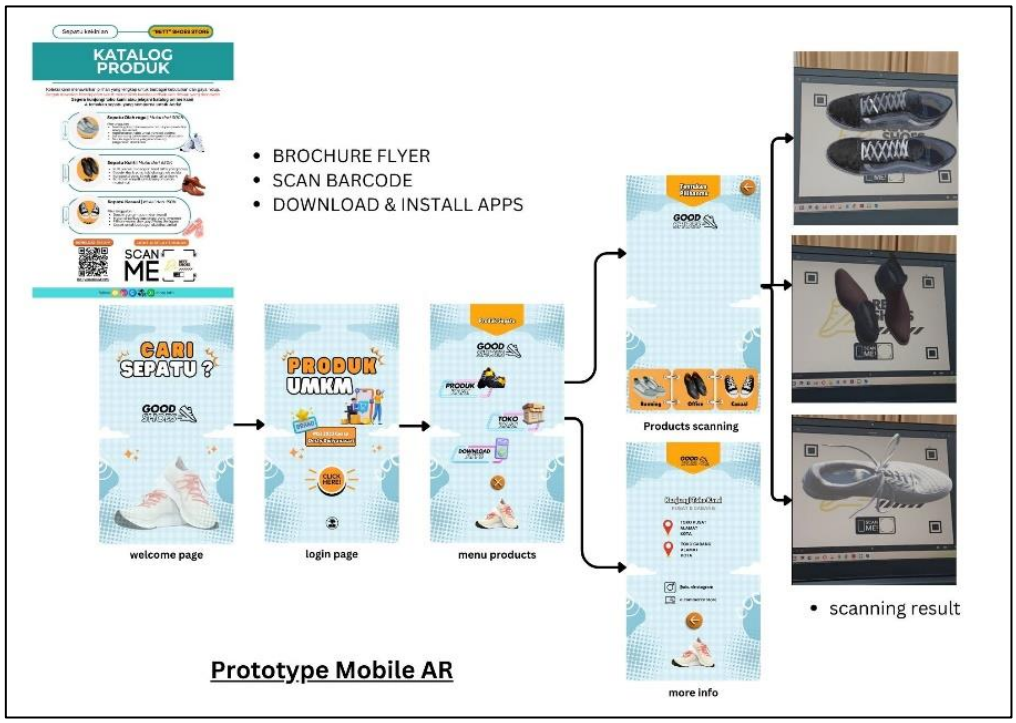

Figure 5. Prototype UX mobile AR

Testing

Heuristic Evaluation Results

Heuristic evaluation was carried out by 5 (five) users as evaluators against 10 (ten) heuristic variables (H1 to H10) that had been predetermined. Each evaluator provides an assessment of potential usability issues found based on a specific severity scale. The results of the Heuristic Evaluation Assessment by each evaluator with the assessment scale used may be 1-5, with the following information: (1) No usability problem, (2) Cosmetic problem only, (3) Minor usability problem, (4) Major usability problem, (5) Usability disaster.

The results of the calculation of the average Severity rating in Table 2 present the quantitative results of the heuristic evaluation conducted by five evaluators. Each cell in the table shows the score given by a particular evaluator for the heuristic in question. This score is assumed to represent the evaluator's initial assessment of the existence or absence of potential usability issues related to the heuristic, or perhaps the frequency/severity of the problem discovered by the evaluator during the evaluation session. For example, Heuristic 10 (H10) consistently received the highest score (5.0) of all evaluators, indicating potential significant or very frequent usability issues related to the "Help and Documentation" aspect (referring to Nielsen's heuristic). In contrast, Heuristic 3 (H3) consistently received the lowest score (1.0), indicating that this aspect was most likely well implemented or that the problem found was very minor.

Improvement Priorities Based on Table Data

Account Severity rating average in Table 2 shows that the H10 heuristic variable was consistently rated as having the highest severity (5.0) by all five evaluators. This indicates the presence of a very critical usability issue or "severity" related to the aspect represented by H10, which requires immediate attention and improvement. Consistency of assessment between evaluators at a high level of severity reinforces the urgency of the problem in the AR mobile application [37]. The H6 variable also showed a high severity (4.0), categorized as a major usability problem. This is followed by H5 (3.4), which falls between minor and major problems. The H2 heuristic (3.0) is rated as a minor problem consistently.

On the other hand, H3 (1.0) and H8 (1.4) scored the lowest average, indicating that evaluators generally did not find significant problems with this heuristic, or that the problems were very minimal. Heuristics H4 (2.0), H9 (2.0), H1 (2.4), and H7 (2.2) are categorized as having cosmetic or minor problems of relatively

low severity. The results of this initial evaluation provide a clear baseline regarding the current usability of AR mobile applications. These findings will form the basis for subsequent iterations of the design and further evaluation to measure the impact of the improvements made.

Table 2. Severity score Heuristic Evaluation

Variable Heuristics	Average Severity Rating (Preliminary)	Average Severity Rating (Post Repair)	Change	Severity Information
H1	2.4	1.6	↓ 0.8	Cosmetics / Minor
H2	3.0	2.2	↓ 0.8	Cosmetics to Minor
H3	1.0	1.0	-	No Problem
H4	2.0	1.4	↓ 0.6	Cosmetics
H5	3.4	2.4	↓ 1.0	Minor
H6	4.0	2.0	↓ 2.0	Cosmetics
H7	2.2	1.8	↓ 0.4	Cosmetics
H8	1.4	1.2	↓ 0.2	No Problem
H9	2.0	1.6	↓ 0.4	Cosmetics / Minor
H10	5.0	1.4	↓ 3.6	Cosmetics

The final heuristic evaluation revealed significant usability improvement in the usability of the system after the implementation of the design change. Overall, the average Severity rating for almost all heuristics decreased, indicating that improvement efforts have been effective in addressing the issues identified in the initial evaluation. The most dramatic improvement was seen on H10, whose average score dropped drastically from 5.0 (Disaster Usability) to 1.4 (Cosmetics). This 3.6-point decrease indicates that the most critical issues identified in the initial evaluation have been fundamentally addressed. These findings are particularly important because they show that resources allocated to high-priority fixes have a substantial impact on the user experience [38]. Similarly, H6, which was originally a major problem (4.0), showed a significant decrease to 2.0 (Cosmetics). This means that the main usability issues related to these heuristics have been reduced to minor issues or just views, which are much less of a hindrance to the user. The H5, which was originally on the border between minor and major (3.4), also experienced a good improvement, dropping to 2.4 (Minor).

Other heuristics, such as H1, H2, H4, H7, and H9, also showed a decrease in average scores, although not as dramatically as H10 and H6. These results highlight the improvements made, either directly or indirectly, that contribute to the overall improvement of usability. The H3 and H8 heuristics, which initially already had very low scores, remained low, confirming that the area was not problematic or not negatively affected by the changes made. After applying the Design Thinking method and iterating the design based on user feedback, there is a significant increase in usability in the revised application prototype. The mean severity score for all heuristic principles decreases, as shown in Table 2. The most significant improvements occurred in the principles of Help and Documentation (H10), Recognition Rather than Recall (H6), and Error Prevention (H5). This shows that the Design Thinking method is effective in guiding the design process to address specific usability problems. By identifying problems, prioritizing them based on severity, making improvements, and then revalidating, the team can systematically improve the quality of product usability [39]. While the final results suggest that most of the issues are now at a cosmetic or minor level, these findings still provide valuable input for further refinement if needed in the future. However, based on a significant decrease in the average severity score, it can be concluded that the improved system now offers a much better user experience than the original version.

CONCLUSION

This study demonstrates that applying the Design Thinking approach effectively improves the User Experience (UX) of Augmented Reality (AR) mobile applications for MSMEs and buyers. By systematically implementing the stages of Empathize, Define, Ideate, Prototype, and Test, this research successfully identified key usability issues and produced design solutions that significantly enhanced the application's usability. The improvement is evidenced by a 37% reduction in the severity of usability problems, particularly in critical areas such as Help and Documentation, Recognition Rather than Recall, and Error Prevention. For future research, it is recommended to conduct studies involving a larger and more diverse group of participants to gain broader user perspectives. Additionally, further exploration on the integration of personalized features or adaptive interfaces in AR applications may provide deeper insights

into enhancing UX. Longitudinal studies to assess the sustainability of UX improvements over time and in real business operations are also suggested to strengthen the applicability of the proposed framework.

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