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A Dual-Framework Approach to Evaluate Marker less AR Application: Insights from SUS and HARUS Questionnaires

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Abstract: This study evaluated a marker-less AR application for learning Engineering Drawing using SUS and HARUS to assess both general and AR-specific usability. Results showed high user satisfaction (SUS score: 88.6) and highlighted the application's effectiveness in engaging learners and supporting understanding of complex concepts. The findings emphasize the value of combining usability measures to guide the design of effective AR-based educational tools.

Keywords: Augmented Reality, Usability, Engineering Drawing, System Usability Scale, Hand-Held AR Usability Scale

1. Introduction

Augmented Reality (AR) is increasingly used in education to create immersive and interactive learning experiences (Azuma et al., 2001; Carmigniani et al., 2011; Lee, 2012). In visually intensive subjects like Engineering Drawing (ED), marker-less AR allows students to explore complex 3D models without physical markers, enhancing flexibility and engagement (Cheng et al., 2017; Chytas et al., 2020; Tiwari et al., 2024). Despite its potential, the usability of such tools remains underexplored, which can affect their educational impact. This study addresses this gap by evaluating a marker-less AR-based ED application using two instruments: the System Usability Scale (SUS) (Brooke, 1995) for general usability and the Hand-held AR Usability Scale (HARUS) (Santos et al., 2014) for AR-specific aspects like immersion and intuitiveness. Combining both tools offers a comprehensive assessment (Carrera et al., 2018; Derby & Chaparro, 2021; Law & Heintz, 2021). The study aims: (1) to assess general usability using SUS, (2) to evaluate AR-specific heuristics using HARUS, and (3) to compare both frameworks to derive insights for improving marker-less AR applications in education.

2. Methodology

The study involved 15 undergraduate students (9 males and 6 females) with prior knowledge of Engineering Drawing (ED), selected through random sampling to ensure diversity and reduce selection bias. Participants came from varied academic backgrounds but shared a basic understanding of ED concepts. They interacted with a previously developed marker-less AR application (Tiwari et al., 2024) (see Figure 1), which allowed them to visualize and manipulate 3D projections of engineering components in real-world settings without physical markers. Developed using Unity, the application featured a minimalistic, touch-based interface with intuitive gestures like pinch-to-zoom, swipe-to-rotate, and drag-to-move, making it accessible for first-time users. The marker-less functionality provided flexibility in model interaction from multiple angles. After a 10-minute session with the application, participants completed two usability questionnaires—SUS and HARUS—to assess both general and AR-specific usability factors. All responses were collected with assurances of confidentiality and voluntary participation.

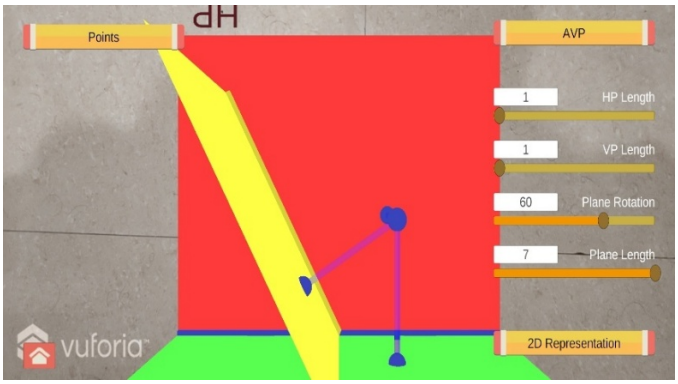

Figure 1. Projection of points.

3. Results

3.1 SUS Scores

We calculated SUS score using technique proposed by (Bangor et al., 2009). The overall SUS score for the AR-based application was calculated to be approximately 88.6. This score indicates that the application is perceived as highly usable and satisfactory by the participants (see Figure 2). The usability of the marker-less AR application was evaluated across two key dimensions: Manipulability and Comprehensibility, based on participant responses. The overall mean score for Manipulability was *4.34*, indicating that users generally found the application physically easy to use. Most participants agreed that operating the app required minimal effort, was comfortable for the hands and arms, and was simple to control. However, some noted slight discomfort in holding the device or potential grip issues. In terms of Comprehensibility, the application received an overall mean score of *4.10*, reflecting a generally positive cognitive experience. Users found the information clear, readable, and consistent, although a few noted minor concerns regarding screen clutter and display response time. Overall, both physical and cognitive usability aspects were rated favorably, suggesting that the application was user-friendly and accessible.

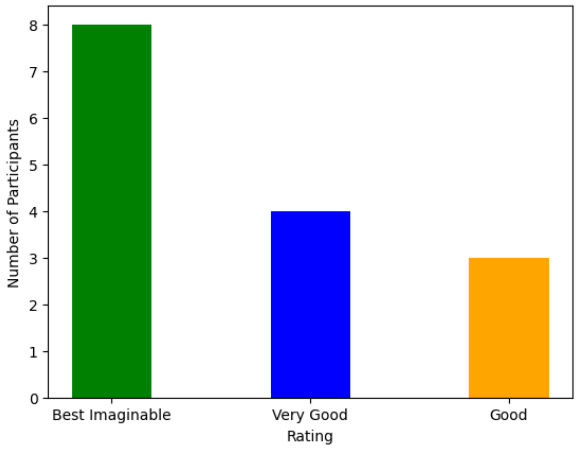

Figure 2. SUS Rating of AR Based application.

3.2 HARUS analysis

The evaluation of the marker-less AR application showed positive user perceptions in both manipulability (Mean = 4.34, *SD* = 1.48) and comprehensibility (Mean = 4.10, *SD* = 1.37). Participants generally found the application physically comfortable, easy to handle, and simple to operate, indicating minimal physical strain during interaction. Similarly, users perceived the

displayed information as readable, consistent, and responsive, suggesting manageable cognitive demands. However, slightly lower ratings on control precision, the appropriateness of displayed information, and system responsiveness highlight minor areas for improvement to further enhance the overall user experience.

4. Discussions and conclusions

This study investigated the usability of a marker-less AR application for learning Engineering Drawing (ED), guided by three research questions and evaluated using SUS and HARUS questionnaires. The high SUS score of 88.6 reflected excellent general usability, with participants describing the application as engaging and effective. HARUS results further highlighted the importance of AR-specific factors like immersion and interaction, while also revealing areas for improvement, such as interface sensitivity and the need for more advanced 3D models. Comparing SUS and HARUS underscored the value of using both tools for a comprehensive evaluation of usability and user experience. Despite promising results, the study's limitations—such as a small, homogenous sample, short interaction time, and reliance on self-reported data—suggest caution in generalizing findings. Future research should expand the participant pool, increase interaction duration, and integrate learning outcome assessments and adaptive features to better evaluate AR's long-term educational impact.

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