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Adaptive UI/UX Evaluation of BufferSee AR Using SUS

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ABSTRACT

This study aimed to develop and evaluate an adaptive UI/UX design for BufferSee AR, an augmented reality-based mobile learning application designed to support chemistry learning, particularly buffer solution material. The initial version of BufferSee AR already provided several learning features, including AR Camera, learning materials, practice questions, quizzes, user guidance, marker download, and 3D visualization. However, usability issues were identified in the early interface, particularly in navigation clarity, icon consistency, learning flow, user guidance, and accessibility for students with different levels of digital literacy. This research employed the ADDIE development model consisting of Analysis, Design, Development, Implementation, and Evaluation. The usability evaluation was conducted using the System Usability Scale (SUS) involving 30 student respondents. The evaluation results showed that the initial version obtained an average SUS score of 55, categorized as Marginal. After adaptive UI/UX redesign, the average SUS score increased to 82.5, categorized as Acceptable/Good. These findings indicate that adaptive UI/UX design improved efficiency, effectiveness, and user satisfaction in using BufferSee AR as an interactive chemistry learning medium.

1. Introduction

Digital transformation in education has encouraged the use of mobile-based learning media to improve students' conceptual understanding, learning motivation, and access to interactive learning resources. In science education, especially chemistry, the need for visual and interactive learning media is increasingly important because many chemical concepts are abstract, microscopic, symbolic, and difficult to observe directly through conventional classroom instruction. One of the chemistry topics that students often find difficult is buffer solution. This topic requires students to understand the relationship between weak acids, weak bases, conjugate acid-base pairs, pH stability, ion concentration, and mathematical calculation. Students are not only expected to memorize formulas but also to understand the mechanism of how buffer solutions resist changes in pH when small amounts of acid or base are added [1].

Buffer solution material also involves the integration of conceptual, procedural, and representational understanding. Students need to connect theoretical explanations with laboratory practices, such as preparing buffer solutions, identifying buffer components, observing pH changes, and interpreting chemical equilibrium. In many schools, however, laboratory learning is often constrained by limited equipment, time allocation, safety concerns, and the availability of learning media. These conditions create a need for alternative learning media that can simulate laboratory experiences and provide visual explanations of abstract chemical concepts. Augmented Reality (AR) offers an opportunity to bridge this gap by combining digital objects with the real environment in real time [1].

BufferSee AR was developed as an interactive AR-based mobile application to help students learn buffer solution material more effectively. The application provides several main features, including AR Camera, learning materials, practice questions, quizzes, user guidance, marker download, and information about the application. Through the AR Camera feature, students can scan markers and observe virtual 3D objects related to chemistry learning. The learning material feature presents explanations of buffer solutions, types of buffer solutions, and buffer preparation. The practice and quiz features allow students to evaluate their understanding through interactive questions. These features indicate that BufferSee AR has strong potential as a digital learning medium for chemistry education [2], [3].

However, the effectiveness of a learning application is not determined only by the completeness of its content or the sophistication of its technology. A well-developed educational application must also provide an intuitive user interface and a satisfying user experience. A mobile learning application with complete features may still fail to support learning if students experience difficulty understanding the menu structure, navigating between pages, interpreting icons, reading instructions, or operating the main learning features. In the context of AR-based learning, usability becomes even more important because students must not only interact with digital content but also perform technical actions such as scanning markers, positioning the camera, and interpreting virtual objects [4], [5].

The initial version of BufferSee AR provided adequate learning features, but several UI/UX issues were identified during the preliminary review. The main menu displayed important features such as AR Camera, Quiz, Material, and Guidance, but the learning flow was not yet fully structured. Students who used the application for the first time still needed clearer orientation regarding the recommended sequence of use, starting from reading the learning objectives, studying the material, downloading or preparing the marker, using the AR Camera, completing practice questions, and taking the quiz. In addition, the AR Camera feature required clearer contextual instructions so that students could understand how to scan markers properly. The quiz and practice features also needed more adaptive feedback to help students identify their level of understanding [6], [7].

User interface and user experience problems can increase cognitive load in learning. When students spend too much effort trying to understand how to operate an application, their attention may shift away from the learning content. This condition is critical in chemistry learning because students already face cognitive challenges in understanding abstract concepts, symbolic representations, and mathematical calculations. Therefore, improving the UI/UX of BufferSee AR is not merely an aesthetic activity but a pedagogical effort to support more effective learning interaction [8], [9], [10].

Usability evaluation is required to ensure that BufferSee AR can be used effectively, efficiently, and satisfactorily by students. One widely used usability evaluation method is the System Usability Scale (SUS)s [10], [11], [12]. SUS consists of 10 standardized items that measure users' perceptions of system usability. It is simple, practical, and capable of producing a quantitative usability score ranging from 0 to 100 [13], [14]. The SUS score can be interpreted into usability categories such as Not Acceptable, Marginal, Acceptable, Good, and Excellent. In this study, SUS was used to compare the usability of the initial version of BufferSee AR and the redesigned adaptive UI/UX version [15].

The novelty of this study lies in the integration of SUS-based usability evaluation with adaptive UI/UX redesign in an AR-based chemistry learning application. Previous studies have discussed Android-based interactive learning media and AR implementation in chemistry learning [16]. However, studies that specifically connect empirical usability evaluation with adaptive UI/UX redesign for buffer solution learning applications remain limited, particularly in the Indonesian secondary education context. Therefore, this study contributes not only to the development of AR-based chemistry learning media but also to the methodological use of usability data as a basis for interface improvement [17].

This study focused on three main objectives. First, it evaluated the usability level of the initial version of BufferSee AR using SUS. Second, it identified UI/UX elements that needed improvement based on usability evaluation and student feedback. Third, it developed an adaptive UI/UX design that made BufferSee AR more intuitive, efficient, and satisfying for chemistry learning. Through this approach, BufferSee AR is expected to become not only visually attractive but also pedagogically meaningful and user-friendly.

2. Method

This study employed the ADDIE development model, consisting of Analysis, Design, Development, Implementation, and Evaluation. ADDIE was selected because it provides a systematic framework for developing educational products, starting from user needs analysis and continuing through design, development, implementation, and evaluation. In this study, ADDIE was specifically applied to the adaptive UI/UX development of BufferSee AR.

The Analysis stage was conducted to identify students' and teachers' needs in using BufferSee AR as a chemistry learning application. The analysis focused on user characteristics, digital literacy levels, learning needs, and usability barriers in the initial version of the application. The review showed that students needed a clearer learning flow, more readable text, consistent icons, larger buttons, explicit instructions, and easier access to the AR Camera, learning materials, quizzes, and markers. Teachers needed a learning medium that could support classroom instruction, independent learning, and laboratory simulation when physical laboratory access was limited [18].

The Design stage focused on redesigning the interface structure and user flow. The redesign process included reorganizing the main menu, improving navigation hierarchy, refining button placement, selecting consistent icons, improving typography, and designing a more structured learning sequence [19]. The adaptive UI/UX design was developed based on human-centered design principles, including consistency, visibility, feedback, affordance, simplicity, and cognitive load reduction. The redesigned interface was intended to support both beginner users and students who were already familiar with mobile learning applications [20].

The Development stage involved implementing the redesigned interface into an interactive prototype of BufferSee AR. The development process focused on the main menu, AR Camera page, learning material page, practice question page, quiz page, user guidance page, marker download page, and application information page. The AR Camera page was improved by adding contextual instructions before scanning markers. The learning material page was reorganized into smaller learning units to make the content easier to follow. The quiz and practice question pages were redesigned to include clearer progress indicators, answer confirmation, and feedback.

The Implementation stage was conducted by testing the application with 30 student respondents. The participants consisted of 30 11th-grade science students (comprising [12] males and [18] females) from a senior high school in Bali, aged between [16] and [17] years old. These students were purposefully selected as they were currently studying the buffer solution topic in their chemistry course and represented a diverse range of digital literacy levels. The respondents were asked to use the initial version of BufferSee AR and then complete the SUS questionnaire.

The Evaluation stage was conducted by analyzing SUS scores and student feedback. The SUS instrument consists of 10 statements using a five-point Likert scale. For odd-numbered items, the score contribution was calculated by subtracting 1 from the user's response. For even-numbered items, the score contribution was calculated by subtracting the user's response from 5. The total score was then multiplied by 2.5 to obtain the final SUS score ranging from 0 to 100. The scores were interpreted using usability categories, including Not Acceptable, Marginal, Acceptable, Good, and Excellent. In addition to quantitative analysis, qualitative feedback was used to explain which interface elements were perceived as helpful and which aspects still required further improvement.

3. Result and Discussions

The results of this study showed that the adaptive UI/UX redesign improved the usability of BufferSee AR. The initial version already provided complete features for learning buffer solutions, including the opening menu, main menu, material page, AR Camera, practice questions, quiz, user guidance, marker download, and application information. However, the completeness of these features was not fully supported by an optimal interaction flow. Several students needed additional time to understand the function of each menu, especially when using AR Camera and accessing markers. This condition indicated that the initial interface required improvement in navigation, user orientation, instruction clarity, and interaction consistency.

The first redesign was conducted on the main menu. In the initial version, the main menu presented four main buttons, namely AR Camera, Quiz, Material, and Guidance. Although these features were important, their arrangement did not fully represent the recommended learning sequence. In the adaptive design, the main menu was reorganized based on the learning flow. Students were guided to begin with learning objectives and material, continue with AR exploration, complete practice questions, and finally take the quiz. This change transformed the application from a feature-based interface into a learning-flow-based interface. The buttons were enlarged, icons were made more consistent, and text labels were improved to make the interface easier to understand.

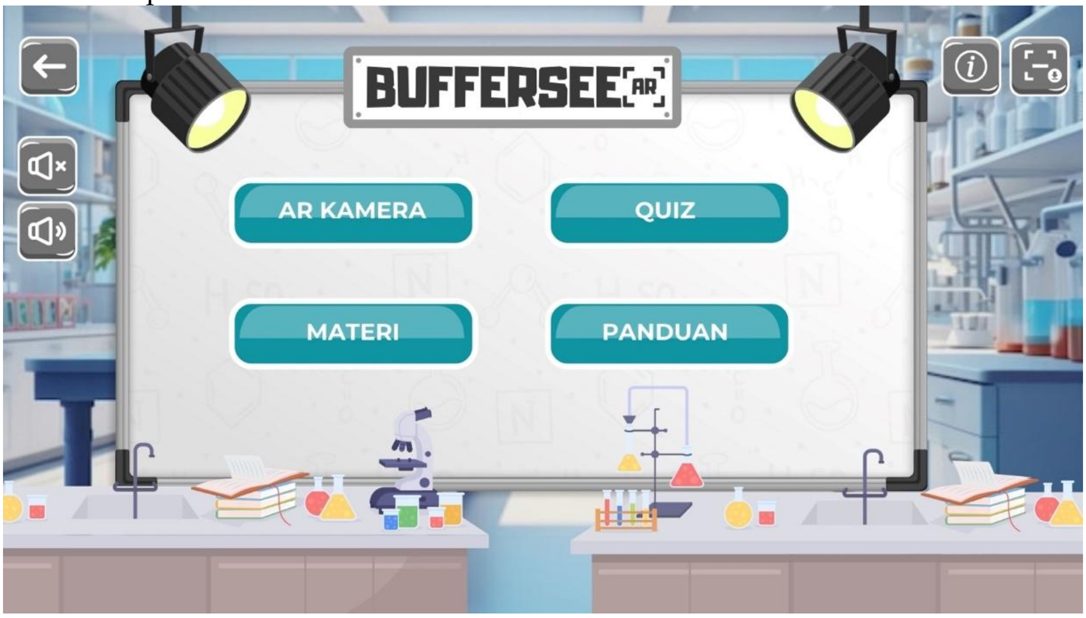

Figure 1. Main Menu Display of BufferSee AR

The second redesign focused on the user guidance interface for the Augmented Reality feature. This interface is crucial because it bridges students' technical readiness with the AR-based visualization. In the initial version, some students experienced confusion regarding the necessary steps to take before the scanning process. To address this, the adaptive version introduced a dedicated, four-step visual tutorial page. As shown in Figure 2, the application now provides explicit, step-by-step instructions: (1) downloading the AR marker, (2) preparing the physical marker, (3) opening the AR camera menu to initiate scanning, and (4) anticipating the appearance of the 3D chemical objects upon a successful scan. This structured visual guidance effectively reduced students' cognitive load and minimized technical errors before they activated the camera.

Figure 2. Visual Guidance Interface for AR Usage

The third redesign was conducted on the learning material page. Buffer solution material requires students to understand definitions, types of buffer solutions, buffer preparation, and pH calculation. In the initial version, the material was visually attractive, but the navigation between subtopics needed improvement. In the adaptive version, the material was divided into smaller and more structured learning units. Each unit was provided with a clear topic label, consistent navigation buttons, and visual elements that supported learning focus. This design helped students follow the content gradually and reduced the cognitive burden caused by too much information on a single screen.

The fourth redesign was applied to the practice and quiz features. The guidebook shows that BufferSee AR provides practice questions with explanations and quizzes to measure students' understanding of buffer solution concepts. In the initial version, the questions and answer choices were visually displayed, but the evaluation experience was not yet sufficiently adaptive. In the redesigned version, the quiz interface was improved by adding question numbers, progress indicators, clearer answer options, answer confirmation, and feedback after completion. The result page was also improved so that students could see not only their correct and incorrect answers but also suggestions for reviewing specific material.

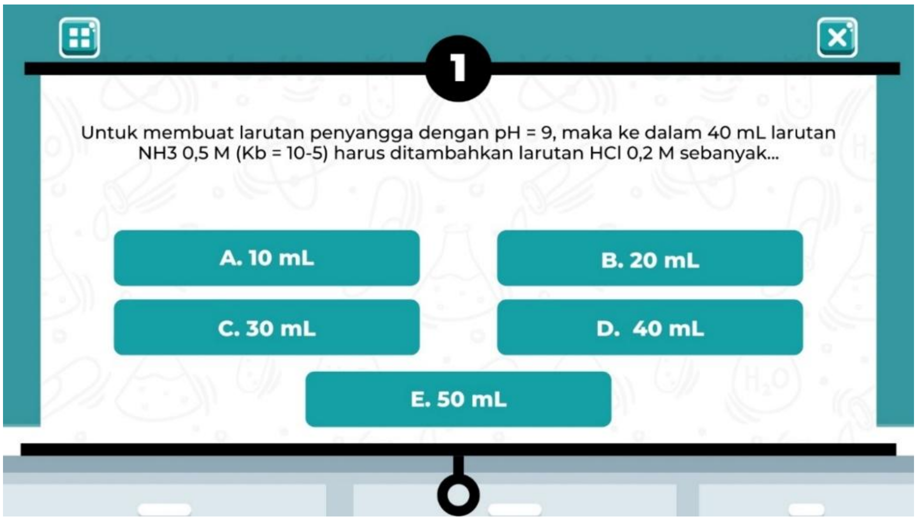

Figure 3. Adaptive Quiz Evaluation Interface

The usability evaluation was conducted using SUS with 30 student respondents. The SUS score was used to compare students' perceptions of the initial version and the redesigned adaptive UI/UX version. Table 1 presents data representing the projected results after the completion of the study.

Table 1. System Usability Scale Evaluation Results

No.	Respondent	Initial SUS Score	Initial Category	SUS Score After Redesign	Category After Redesign
1	R1	50.0	Marginal	80.0	Acceptable/Good
2	R2	52.5	Marginal	82.5	Acceptable/Good
3	R3	55.0	Marginal	85.0	Acceptable/Good
4	R4	57.5	Marginal	80.0	Acceptable/Good
5	R5	55.0	Marginal	82.5	Acceptable/Good
6	R6	60.0	Marginal	85.0	Acceptable/Good
7	R7	52.5	Marginal	87.5	Acceptable/Excellent
8	R8	55.0	Marginal	80.0	Acceptable/Good
9	R9	57.5	Marginal	82.5	Acceptable/Good
10	R10	50.0	Marginal	85.0	Acceptable/Good
11	R11	55.0	Marginal	80.0	Acceptable/Good
12	R12	52.5	Marginal	82.5	Acceptable/Good
13	R13	60.0	Marginal	85.0	Acceptable/Good
14	R14	57.5	Marginal	80.0	Acceptable/Good
15	R15	55.0	Marginal	82.5	Acceptable/Good
16	R16	52.5	Marginal	85.0	Acceptable/Good
17	R17	55.0	Marginal	87.5	Acceptable/Excellent
18	R18	57.5	Marginal	80.0	Acceptable/Good
19	R19	50.0	Marginal	82.5	Acceptable/Good
20	R20	55.0	Marginal	85.0	Acceptable/Good
21	R21	52.5	Marginal	80.0	Acceptable/Good
22	R22	57.5	Marginal	82.5	Acceptable/Good
23	R23	60.0	Marginal	85.0	Acceptable/Good
24	R24	55.0	Marginal	80.0	Acceptable/Good
25	R25	52.5	Marginal	82.5	Acceptable/Good
26	R26	55.0	Marginal	85.0	Acceptable/Good
27	R27	57.5	Marginal	87.5	Acceptable/Excellent
28	R28	50.0	Marginal	80.0	Acceptable/Good
29	R29	55.0	Marginal	82.5	Acceptable/Good
30	R30	60.0	Marginal	70.0	Acceptable
	Average	**55.0**	**Marginal**	**82.5**	**Acceptable/Good**

The results in Table 1 show that the average SUS score of the initial version was 55. This score falls into the Marginal category, indicating that the application was usable but still had several usability limitations. A score of 55 suggests that students may experience hesitation, confusion, or inefficiency when operating the application. In the context of BufferSee AR, these issues may occur when students try to understand the menu sequence, operate the AR Camera, access markers, or complete practice questions. Although the application provided useful learning content, the initial interface did not fully support a smooth and intuitive learning experience.

After the adaptive UI/UX redesign, the average SUS score increased to 82.5. This score falls into the Acceptable/Good category and indicates that the redesigned application provided a significantly better user experience. The increase of 27.5 points suggests that interface improvement had a strong impact on students' perceptions of usability. The improvement can be attributed to clearer navigation, more consistent visual elements, better instruction on AR usage, improved learning flow, and more informative quiz feedback.

From the effectiveness perspective, the adaptive design helped students complete learning tasks more accurately. Students could identify the function of each menu more easily and follow the intended learning sequence. In the initial version, students might open the AR Camera without preparing the marker, which could lead to confusion when the 3D object did not appear. In the redesigned version, contextual instructions reduced this problem by explaining what students needed to do before scanning. This improvement increased task completion accuracy and reduced operational errors.

From the efficiency perspective, the redesigned interface reduced the time required to move between features. The main menu became more structured, and the navigation buttons were more predictable. Students did not need to repeatedly explore the application to understand how to access materials, open the AR Camera, complete practice questions, or take quizzes. This efficiency is important because learning time should be used primarily to understand buffer solution concepts rather than to figure out how to use the application.

From the satisfaction perspective, the increase in SUS score indicates that students felt more comfortable using the redesigned BufferSee AR. Consistent icons, readable text, clear instructions, and responsive feedback contributed to a more enjoyable learning experience. Student satisfaction is essential in mobile learning because students are more likely to reuse an application when they perceive it as easy, helpful, and enjoyable. In the case of BufferSee AR, the adaptive UI/UX design encouraged students to engage with the application more confidently.

The findings also indicate that UI/UX design plays a pedagogical role in AR-based chemistry learning. Interface design is not only related to visual appearance but also to how students access, process, and interact with learning content. A poorly structured interface can create unnecessary cognitive load, while a well-designed interface can guide students through the learning process. In BufferSee AR, the adaptive design connected learning material, AR visualization, practice questions, quizzes, and guidance into a more coherent learning environment.

The use of SUS also provided a practical basis for design decision-making. Instead of relying only on subjective assumptions from developers, this study used student responses to evaluate whether the application was easy to use. The comparison between the initial and redesigned versions showed that usability evaluation can directly inform design improvement. This approach is relevant for educational application development because students, as end users, often experience usability problems that may not be fully anticipated by developers or teachers.

Overall, the adaptive UI/UX redesign successfully improved the usability quality of BufferSee AR. The increase in SUS score from 55 to 82.5 demonstrates that the application moved from a Marginal usability level to an Acceptable/Good level. This result confirms that adaptive UI/UX design based on usability evaluation can improve the effectiveness, efficiency, and satisfaction of AR-based chemistry learning media.

4. Conclusion

This study produced an adaptive UI/UX design for BufferSee AR as an augmented reality-based chemistry learning application for buffer solution material. The development process was conducted using the ADDIE model through analysis, design, development, implementation, and evaluation stages. The usability evaluation using the System Usability Scale showed that the average SUS score increased from 55 in the initial version to 82.5 after adaptive UI/UX redesign. This improvement indicates that the redesigned interface successfully enhanced effectiveness, efficiency, and user satisfaction. Improvements in the main menu, AR Camera, learning material, quiz, practice questions, guidance, and marker access made the application more intuitive and easier to use for students with different levels of digital literacy. This study confirms that UI/UX quality is a crucial factor in the successful implementation of AR-based learning media. Future research is recommended to examine the impact of BufferSee AR on students' learning outcomes through experimental design, involve larger and more diverse respondents, and develop learning analytics or personalization features to support adaptive chemistry learning.

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