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User-Centered Design in the AIRAF Interface: Reducing Cognitive Load and Supporting Self-Regulated Learning

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Abstract: This study aims to evaluate the usability, user experience, and cognitive load of the AIRAF interface using a User-Centered Design (UCD) approach through two iterative evaluation phases. In the first evaluation phase (UE1), eight undergraduate students completed a series of structured interaction tasks using Maze and subsequently responded to the System Usability Scale (SUS), User Experience Questionnaire (UEQ), and External Cognitive Load (ECL) questionnaire. The data were analyzed descriptively by calculating task performance indicators, mean questionnaire scores, and comparative changes between UE1 and UE2. The results of UE1 showed a marginal SUS score of 62, a UEQ mean score of 1.45, and an ECL mean score of 7.28, indicating usability issues related to typography, navigation, visual clarity, and feature recognition. Following the interface redesign, a second evaluation phase (UE2) involving ten participants demonstrated substantial improvements. The SUS score increased to 80, the UEQ mean score improved to 1.97, and the ECL mean score increased to 8.75, with improvements observed across all UEQ dimensions. These findings suggest that the UCD approach effectively simplifies complex AI-supported learning interfaces by enhancing visual hierarchy, interaction clarity, and feedback presentation, thereby reducing students' confusion and unnecessary cognitive effort during interaction.

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Introduction

Education must continuously evolve to respond to societal needs and technological advancements while simultaneously shaping new learning paradigms. In recent years, there has been a growing interest in AIED among researchers, educators, and educational institutions (Mahadih et al., 2025). This interest has significantly increased following the rapid emergence of generative artificial intelligence technologies, which demonstrated the capacity to replicate higher-order cognitive processes such as explanation, reasoning, and knowledge generation (Rahiman & Kodikal, 2024). As a result, many instructional practices that traditionally require considerable effort from instructors — such as the personalization of learning activities, provision of feedback, and support for learner self-regulation — can now be partially supported through AI-driven systems (Mejeh & Sarbach, 2025). These developments open opportunities for designing intelligent learning environments that assist both instructors and learners in managing complex learning processes. This development can be understood through the AIED adoption curve, which illustrates how different AI-based technologies have progressed from early experimentation toward broader educational implementation.

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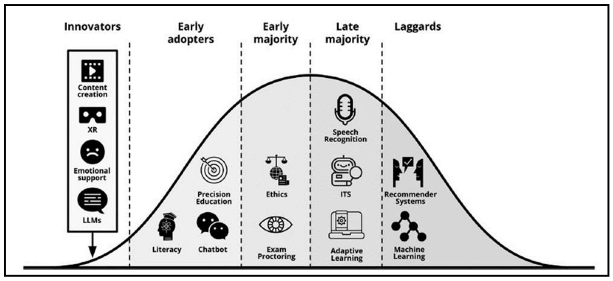

Figure 1. AIED adoption curve

As illustrated in Figure 1, the AIED adoption curve shows that several AI-based technologies have reached different levels of maturity within educational practice. Technologies such as recommender systems, machine learning, Intelligent Tutoring Systems (ITS), adaptive learning, and personalized learning support demonstrate how AI has gradually moved from experimental use toward more integrated learning applications (Pal et al., 2025). These developments create opportunities for AI-supported systems to provide real-time feedback, adaptive learning pathways, and personalized instructional support that are often difficult to implement consistently in traditional instructional settings. In particular, these systems can enable the implementation of Adaptive Assessment (AA), Adaptive Gamification (AG), and Personalized Feedback (PF), which collectively support the learning cycle of Self-Regulated Learning (SRL).

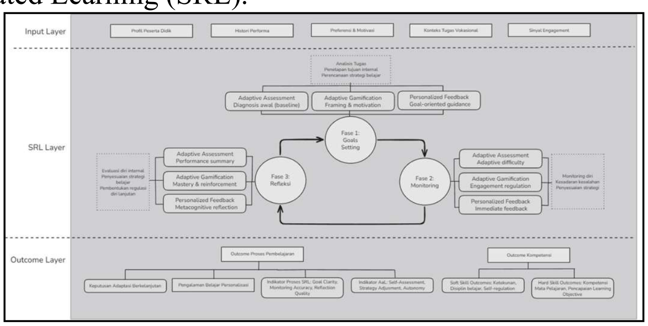

Figure 2. Conceptual Model Structure

Figure 2 presents the conceptual model structure of AIRAF, showing how AA, AG, and PF are interconnected to support the SRL cycle. In this model, AA adjusts learning tasks based on learner performance, AG supports motivation and engagement, and PF assists learners in monitoring and reflecting on their progress. These relationships provide the theoretical basis for positioning AIRAF as an AI-supported learning platform that strengthens students' planning, monitoring, and reflection activities.

Although AA, AG, and PF have been widely recognized for their potential to support adaptive and self-regulated learning, most previous studies examine these components independently or implement them only partially within learning systems (Mahmoud & Al, 2023). As a result, their combined role in supporting SRL within a unified adaptive learning environment remains insufficiently explored. Furthermore, although ITSs have demonstrated the potential of AI to support adaptive learning, research indicates that the effectiveness of such systems is strongly influenced by the quality of the user interface (UI) design. Poor interface design may impose unnecessary cognitive load on users, which can negatively affect comprehension, interaction efficiency, and learning performance (Faudzi et al., 2023; Skulmowski & Xu, 2022).

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To address these challenges, this study proposes the integration of AA, AG, and PF within a generative AI-supported learning platform called AIRAF. The system is designed to support adaptive learning processes by providing dynamic assessment, motivational support through gamification, and personalized feedback within a single learning environment. The development of AIRAF follows a UCD approach that places users' needs, experiences, and perceptions at the center of the design process (Tractinsky, 2023). In this study, students as primary users are actively involved in the evaluation stage to ensure that the platform achieves satisfactory usability, ease of interaction, and positive learning experiences.

In addition to usability, this study examines the AIRAF interface from the perspective of CLT, as ineffective interface design may increase ECL and hinder learners' information processing (Sweller, 1988). This evaluation is important because AIRAF generates dynamic AI responses, adaptive feedback, and changing visual information that may confuse users if not presented clearly. Therefore, SUS, UEQ, and an ECL questionnaire were used to evaluate usability, user experience, and cognitive effort during interaction (Ahmad et al., 2024; Brooke, 1996; Schrepp et al., 2014).

This study aims to evaluate the AIRAF interface through an iterative UCD approach, focusing on usability, user experience, and cognitive efficiency. Its contribution lies in showing how user-centered interface evaluation can help translate complex AI-supported learning features into clearer, more understandable, and less cognitively demanding learning interactions.

Research Method

This study employed a UCD approach to develop and evaluate AIRAF, an AI-assisted educational prototype designed to support students' SRL through AA, AG, and PF. Participants were undergraduate students in the Information Technology field, aged 20–22 years, with varying familiarity with AI-based tools. They were selected through purposive sampling because they represented the intended users of AIRAF and had relevant experience with digital learning platforms.

Data were collected through structured interaction tasks, SUS, UEQ, an ECL questionnaire, and interviews. The questionnaires were distributed after participants completed the assigned interaction tasks, while interviews were conducted to obtain additional insights into users' experiences, difficulties, and perceptions of the interface. The results from UE1 were used as the basis for redesigning the interface, and the same evaluation procedure was then applied in UE2 to compare changes in usability, user experience, and cognitive load.

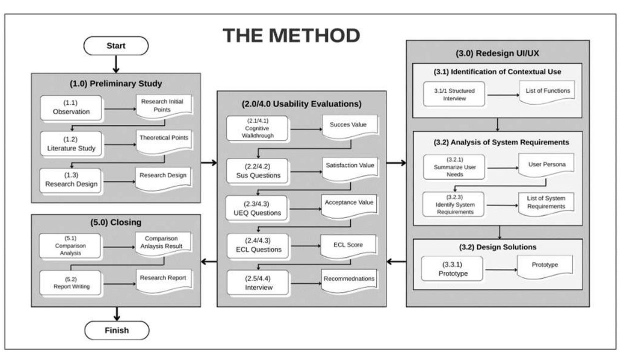

Figure 3. Research Procedure

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As shown in Figure 3, the evaluation process consisted of task preparation, usability testing, questionnaire distribution, interviews, interface redesign, and comparison between UE1 and UE2. The initial CW tasks in Table 1 were developed based on AIRAF's functional flow and were designed to assess users' ability to navigate the interface, complete learning tasks, understand automated feedback, and reflect on their learning outcomes.

Table 1. Initial Cognitive Walkthrough

No	Task	Element
1	Access the system by logging in through the Login page. Then navigate to the Learning Goals menu and create a new learning target using the 'Add Target' button. Ensure the target is successfully saved before starting the learning session.	SRL, AG, PF
2	In the Assessment session, try different answer scenarios (correct and incorrect) to observe how the system provides adaptive feedback. Pay attention to the AI responses after pressing 'Submit', and how the system directs you to 'View Results' or 'Next Question' until the session is completed.	AA, AG, PF
3	After reviewing the results on the Performance Summary page, complete the Self-Reflection section to evaluate your learning progress. Claim your reward through the 'Level Up Achieved' pop-up, then view your achievements using 'View Badges' or return via 'Back to Dashboard'.	SRL, AG
4	Observe the system behavior when a task deadline is missed. The system will display an Overdue status and request a reason through 'Submit Reason for Missed Deadline'. Enter a reason and press 'Submit' to see whether access is granted or restricted.	SRL, PF
5	Personalize the gamification interface by accessing the Gamification Settings menu. Choose which UI elements you want to display or hide according to your learning preferences and observe how these changes affect the Dashboard interface and learning experience.	AG, PF

Participants completed the assigned tasks sequentially, including answering scenarios, reviewing automated feedback, and using the self-reflection feature. They then completed the SUS, UEQ, and ECL questionnaires and joined interviews to provide feedback on usability, cognitive effort, and user experience. The UE1 findings guided the redesign, while UE2 used the same procedure to evaluate the improvements.

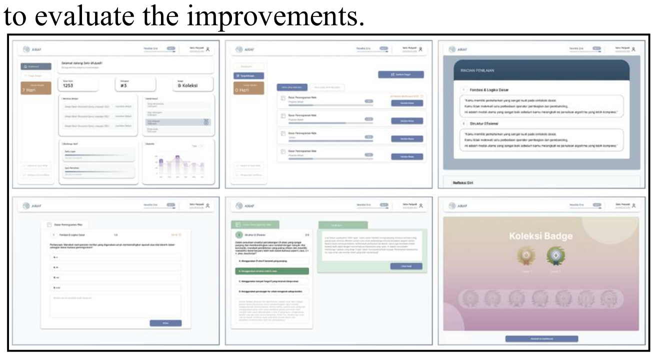

Figure 4. Initial User Interface Design

Furthermore, the usability evaluation was conducted in five stages: (1) *Cognitive Walkthrough* (CW) was applied to examine users' step-by-step interaction during task completion and to measure the success rate of the UI/UX elements; (2) SUS, consisting of 10 items, was administered to assess overall usability and user satisfaction (Brooke, 1996); (3)

the UEQ, comprising 26 seven-point scale items, was utilized to evaluate user experience dimensions and acceptance levels (Schrepp, Hinderks, & Thomaschewski, 2017); with data analyzed using *Maze* and the UEQ Benchmark tools; (4) An ECL questionnaire with 17 items was administered to measure extraneous cognitive load during interface interaction (Faudzi et al., 2023) and (5) unstructured interviews were conducted to obtain deeper insights into users' experiences, capturing emotional responses, contextual interpretations, and latent usability issues that may not have emerged through structured instruments.

Results and Discussion

First User Evaluation

The first user evaluation UE1 revealed several usability issues in the initial AIRAF interface. Although participants were generally able to complete the assigned tasks, the interaction data indicated problems related to misclicks, navigation clarity, task efficiency, and users' initial understanding of several interface features. The summarized results of UE1 are presented in Table 2.

Table 2. Results of User Evaluation 1 (UE1)

Task of CW	Succes Rate (%)	Drop Off (%)	Misclick Rate (%)	Duration (seconds)	Person	SUS Score	UEQ Score					
							AT	PE	EF	DE	ST	NO
1	100	-	59.7	90.9	1	45	1.50	-0.50	0.75	2.00	0.50	0.25
2	100	-	66.1	76.8	2	55	1.17	0.50	0.00	0.50	1.00	0.50
3	100	-	70.3	73.2	3	58	2.83	2.50	0.75	2.25	3.00	2.50
4	100	-	78.2	48	4	65	0.83	1.00	1.75	-0.25	-0.50	0.50
5	100	-	93.4	56	5	83	2.83	2.00	2.50	2.00	2.75	2.25
Average	100	-	73.54	68.98	6	63	2.67	2.25	2.75	2.50	2.50	2.75
					7	95	2.33	2.75	2.25	2.50	2.50	1.25
					8	33	0.33	-0.50	0.25	0.25	0.25	0.50
					Total	62	1.81	1.25	1.37	1.46	1.50	1.31

As shown in Table 2, the initial interface achieved a 100% task success rate, but this result was accompanied by a high average misclick rate of 73.54% and varied task completion times across tasks. These findings indicate that users could complete the tasks, but the interaction process was not yet efficient. The SUS score of 62 also placed the system in the marginal usability range, suggesting that the interface still required improvement, particularly in navigation clarity, typography, and feature recognition. The ECL analysis was then conducted to determine whether the initial interface imposed unnecessary cognitive effort during interaction. The results are presented in Table 3.

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Table 3. ECL Results

Dimension	Mean Score	Interpretation
Structure & Content Organization	7.53	Good (Low ECL)
Navigation & Scrolling	7.29	Good (Low ECL)
Clarity of Instructions & Visual Signaling	7.83	Good (Low ECL)
Visual Appearance & Load	7.56	Good (Low ECL)
Typography	5.94	Moderate (Medium ECL)
Visual & Graphic Elements	7.50	Good (Low ECL)
Overall Mean	7.28	Good – Low External Cognitive Load

As shown in Table 3, the initial AIRAF interface generally imposed low ECL, with an overall mean score of 7.28 in the "good" category. However, typography obtained the lowest score (M = 5.94), indicating that font size, contrast, and text readability still required improvement. To complement these findings, interview data were analyzed to identify users' difficulties and positive responses during interaction. The summarized interview results are presented in Table 4.

Table 4. Summary of User Interview Findings

Type	Positive	Example of Positive Statement	Negative	Example of Negative Statement	Frequency Total
Typography & Readability (TR)	0	-	7	"The font size is too small and difficult to read."	7
Visual Appearance (VA)	1	"The overall layout is well organized."	6	"The interface looks too plain and dominated by white space, making it appear monotonous."	7
Navigation & Interaction (NI)	1	"The green (correct) and red (incorrect) indicators help users understand the answer results."	5	"I was confused because I did not realize that I needed to scroll down to see the rest of the content."	6
Feature Clarity (FC)	1	"The gamification features are generally easy to understand and not confusing."	5	"I was initially confused about the function of several features when I first saw them."	6
User Guidance (UG)	0	-	4	"The instructions in the self-reflection section are unclear, so I had to reread several parts."	4
Engagement & Gamification (EG)	3	"The gamification feature is very helpful because it allows users to monitor their progress and supports	1	"Adding animations or celebration effects would make the experience more engaging."	4

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Type	Positive	Example of Positive Statement	Negative	Example of Negative Statement	Frequency Total
		self-evaluation."			
AI Representation	0	-	2	"The AI element is present but not very prominent in the user experience."	2
Total Response	6		30		36

As shown in Table 4, most interview responses were negative, particularly in TR, VA, NI, and FC. These findings indicate that users mainly experienced problems related to text readability, visual monotony, navigation clarity, and feature recognition. However, positive responses in EG suggest that the gamification elements were useful for monitoring progress and supporting self-evaluation. Overall, the interview results confirmed the main usability issues found in the task performance and questionnaire data, and these findings became the basis for the redesign phase.

Redesign UI/UX

The UE1 findings identified key usability problems in readability, visual appearance, navigation, and feature recognition. These issues became the basis for the redesign phase, as summarized in Table 5.

Table 5. Interface Redesign Improvements

System Feature	Design Improvement
System Navigation	Improved the visibility and structure of navigation elements to make them easier for users to recognize and access.
Assessment Interface	Added clearer visual feedback when users select an answer during the assessment process.
AI Feedback	Refined the display and placement of the AI feedback panel to make explanations easier to understand.
Self-Reflection	Added brief instructions to clarify the purpose of the reflection input field.
Deadline & Reason Submission	Simplified the interaction flow for submitting reasons when learning deadlines are missed.
Gamification	Improved the visual presentation of badges and achievement indicators to make them more recognizable.

Table 5 shows that the redesign focused on improving clarity, navigation, feedback visibility, and gamification presentation to make AIRAF easier to understand and use. Figure 5 presents the proposed user persona that functioned as a guiding reference during the design and evaluation stages of the AIRAF platform. The persona was developed to ensure that the redesigned interface aligned with the actual goals and needs of its intended users.

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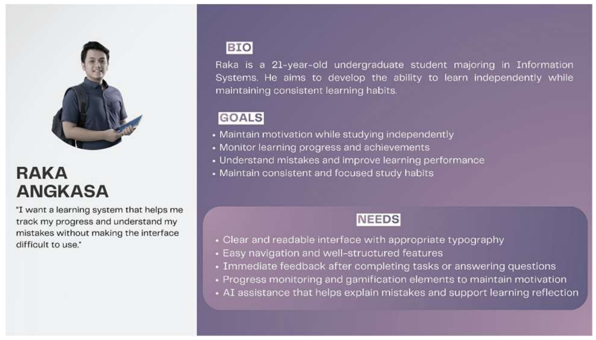

Figure 5. User Persona

Based on the UE1 findings, the AIRAF interface was redesigned to improve usability, clarity, feedback visibility, and user engagement. Figure 6 shows the redesigned interface.

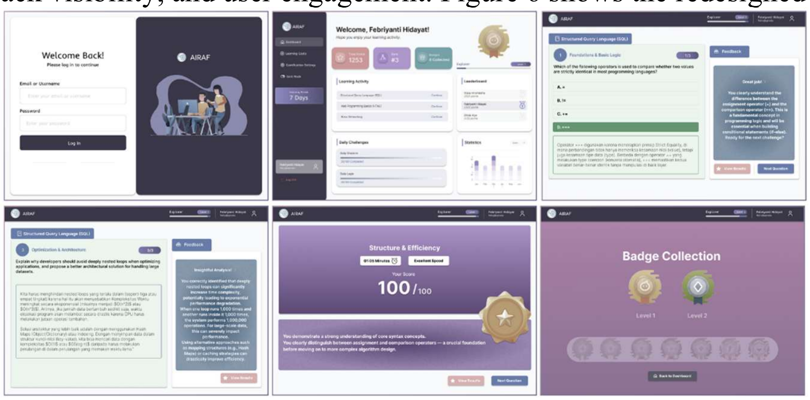

Figure 6. Interface of AIRAF after Redesign

Second User Evaluation

UE2 involved ten participants with characteristics similar to those in UE1 and used the same task scenarios to evaluate whether the redesigned interface improved usability, user experience, and cognitive efficiency. The results of UE2 are presented in Table 6.

Table 6. Results of User Evaluation 2 (UE2)

Task of CW	Succes Rate (%)	Drop Off (%)	Misclick Rate (%)	Duration (seconds)	Person	SUS Score	UEQ Score					
							AT	PE	EF	DE	ST	NO
1	100	-	20.4	44.3	1	93	2.33	2.00	2.33	1.67	2.67	1.33
2	100	-	18.0	67.2	2	95	2.33	2.33	2.00	1.33	2.00	1.33
3	80.0	20.0	63.7	77.3	3	73	2.67	2.33	2.67	1.67	2.67	1.33
4	100	-	18.9	33.9	4	70	2.33	2.00	2.33	1.33	2.00	1.33
5	100	-	79.6	21.7	5	80	1.67	1.33	1.67	1.00	1.67	0.67
Average	96	4	40.12	48.88	6	58	1.67	1.33	1.67	1.33	1.67	1.00
					7	83	2.00	1.67	2.00	1.33	2.00	1.00

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8	78	2.00	1.67	2.00	1.33	2.00	1.00
9	78	2.33	2.00	2.33	1.67	2.33	1.33
10	93	2.67	2.33	2.67	2.00	2.67	1.67
Total	80	2.18	1.77	2.15	1.97	2.00	1.77

As shown in Table 6, UE2 showed improved usability after the redesign. The success rate remained high at 96%, the misclick rate decreased to 40.12%, and the SUS score increased to 80. These results indicate that the redesigned AIRAF interface was easier to use and supported more efficient interaction than the initial version.

Table 7. ECL Result after Redesign

Dimension	Mean Score	Interpretation
Structure & Content Organization	8.73	Good (Low ECL)
Navigation & Scrolling	8.63	Good (Low ECL)
Clarity of Instructions & Visual Signaling	8.73	Good (Low ECL)
Visual Appearance & Load	8.85	Good (Low ECL)
Typography	8.65	Good (Low ECL)
Visual & Graphic Elements	8.93	Good (Low ECL)
Overall Mean	8.75	Good – Low External Cognitive Load

As shown in Table 7, the redesigned AIRAF interface achieved an overall ECL mean of 8.75, indicating low external cognitive load after the redesign. All dimensions were categorized as good, with the highest score found in Visual & Graphic Elements and the lowest in Navigation & Scrolling. These results suggest that the redesign improved cognitive efficiency by making the interface clearer, more readable, and easier to process during interaction. To complement the quantitative findings, interview responses from UE2 were analyzed to identify users' perceptions after the redesign. The summarized results are presented in Table 8.

Table 8. Summary of Interview Findings after Interface Redesign

Type	Positive	Example of Positive Statement	Negative	Example of Negative Statement	Frequency Total
Typography & Readability (TR)	2	"The text is clear and easy to read."	1	"Some interface elements still appear slightly small."	3
Visual Appearance (VA)	2	"The color combination looks balanced and comfortable."	2	"The dashboard still feels somewhat monotonous."	4
Navigation & Interaction (NI)	1	"The navigation flow is generally easy to follow."	5	"Some elements are not clearly recognizable as clickable buttons."	6
Feature Clarity (FC)	1	"The badge feature helps users track their progress."	4	"Some feature functions are still unclear."	5
User Guidance (UG)	0	-	3	"Notifications and system messages are	3

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Type	Positive	Example of Positive Statement	Negative	Example of Negative Statement	Frequency Total
				not clearly noticeable.”	
Engagement & Gamification (EG)	2	“Gamification elements help motivate learning.”	1	“More visual effects could improve engagement.”	3
AI Representation	0	-	3	“AI feedback is not clearly perceived as originating from the system.”	3
Total Response	8		19		27

As shown in Table 8, the UE2 interview results indicate a more positive user response after the redesign. Negative responses decreased from 30 in UE1 to 19 in UE2, while positive responses increased from 6 to 8. Users reported better readability, more balanced visual appearance, and improved support from gamification elements. However, several issues remained in navigation, feature clarity, user guidance, and AI representation, indicating that some interface elements still need clearer visual cues and system feedback. To further show the effect of the redesign on cognitive efficiency, the ECL results from UE1 and UE2 are compared in Table 9.

Table 9. Comparison of ECL Results

Dimension	UE1 Mean	Interpretation	UE2 Mean	Interpretation	Change
Structure & Content Organization	7.53	Good (Low ECL)	8.73	Good (Low ECL)	+1.20
Navigation & Scrolling	7.29	Good (Low ECL)	8.63	Good (Low ECL)	+1.34
Clarity of Instructions & Visual Signaling	7.83	Good (Low ECL)	8.73	Good (Low ECL)	+0.90
Visual Appearance & Load	7.56	Good (Low ECL)	8.85	Good (Low ECL)	+1.29
Typography	5.94	Moderate (Medium ECL)	8.65	Good (Low ECL)	+2.71
Visual & Graphic Elements	7.50	Good (Low ECL)	8.93	Good (Low ECL)	+1.43
Overall Mean	7.28	Good – Low External Cognitive Load	8.75	Good – Low External Cognitive Load	+1.47

As shown in Table 9, all ECL dimensions improved after the redesign, with the overall mean increasing from 7.28 to 8.75. The largest improvement occurred in Typography (+2.71), indicating that changes in font size, contrast, and readability substantially reduced users’ cognitive effort. These results show that the redesigned interface was clearer and easier for users to process during interaction. Beyond the ECL improvement, the redesign also affected users’ task success and satisfaction, as shown in Figure 7.

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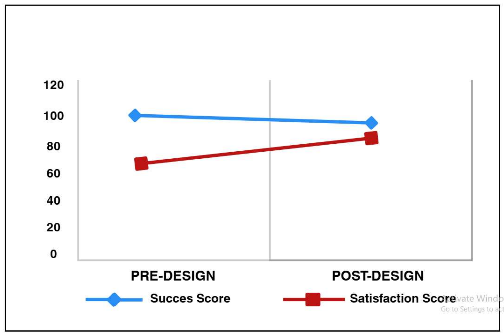

Figure 7. Success and Satisfaction Scores

Figure 7 shows that the success rate slightly decreased from 100% in UE1 to 96% in UE2, while the satisfaction score increased from 62 to 80 after the redesign. This indicates that, although task completion slightly declined, users perceived the redesigned interface as easier and more satisfying to use (Hikmawan, R., 2025).

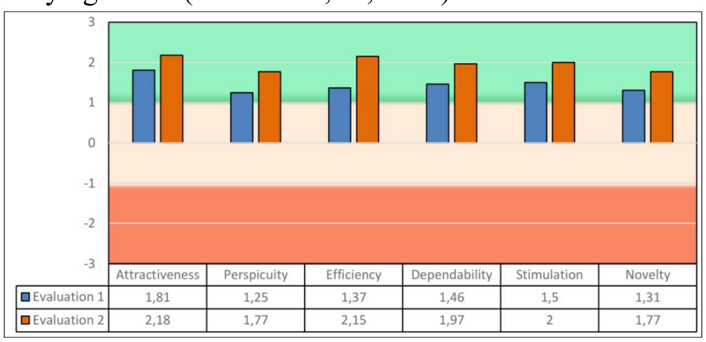

Figure 8. Comparison of UEQ Scores between UE1 and UE2

Figure 8 compares the UEQ scores between UE1 and UE2. All dimensions improved after the redesign, with Attractiveness increasing from 1.81 to 2.18, Perspicuity from 1.25 to 1.77, Efficiency from 1.37 to 2.15, Dependability from 1.46 to 1.97, Stimulation from 1.50 to 2.00, and Novelty from 1.31 to 1.77. These results indicate that the iterative redesign improved users' acceptance and experience of the AIRAF interface across all evaluated dimensions (Laugwitz et al., 2008; Ramírez et al., 2025).

Overall, the results show that the iterative redesign improved the AIRAF interface across usability, user experience, and cognitive load indicators. The improvements in SUS, UEQ, and ECL scores indicate that the revised interface was easier to use, more positively perceived, and less cognitively demanding for users (Ramadhani & Limin, 2023).

Discussion

The improvement from UE1 to UE2 indicates that the iterative UCD process enhanced the overall quality of the AIRAF interface. SUS increased from 62 to 80, ECL improved from 7.28 to 8.75, and UEQ scores increased across all dimensions. From the perspective of CLT, these results suggest that the redesigned interface reduced unnecessary cognitive effort by improving visual clarity, navigation, typography, and feedback presentation. This finding aligns with (Schrepp, Hinderks, Thomaschewski, et al., 2017) who emphasized the role of redesign in improving user experience evaluation results, and with (Limin, 2023; Ramadhani & Limin, 2023) who showed that UCD-based evaluation can support usability improvement in learning applications.

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The findings also show that AA, AG, and PF require clear interface representation to support SRL effectively. Although the adaptive structure, badge system, progress indicators, and feedback features were generally useful, some users still reported difficulties in recognizing clickable elements, understanding feature functions, and identifying AI-generated feedback. This supports (Alé-Ruiz et al., 2024) who highlighted the importance of transparent design signals in adaptive learning environments, and (Civit et al., 2024), who noted that weak interface affordances may limit learners' self-regulation in AI-based systems.

The motivational value of AG and PF was reflected in users' positive responses toward badges, progress indicators, and contextual feedback. These findings are consistent with (Gamarra et al., 2022; Nguyen-Viet & Nguyen-Viet, 2025) who found that gamification elements can increase engagement when connected to learning progress. However, the remaining issue in AI representation suggests that feedback should clearly communicate its source and purpose. This is in line with (Cigdem et al., 2024; Mustafa et al., 2023) who argued that learner trust in AI-driven feedback depends on clear interface cues and understandable feedback presentation.

The largest ECL improvement occurred in Typography, increasing from 5.94 to 8.65. This suggests that font size, contrast, readability, and visual hierarchy helped reduce users' cognitive effort, consistent with (Skulmowski & Xu, 2022). Therefore, interface quality in AIED platforms should be seen as a pedagogical factor that determines whether AI-supported features can be understood and used effectively (Faudzi et al., 2023).

Conclusion

This study shows that the UCD approach improved the usability, user experience, and cognitive efficiency of the AIRAF interface. After the redesign, SUS increased from 62 to 80, UEQ scores improved across all dimensions, and ECL increased from 7.28 to 8.75, indicating lower external cognitive load during interaction. These findings suggest that clearer visual hierarchy, navigation, feedback presentation, typography, and feature clarity help students interact with AI-assisted learning platforms more effectively.

Recommendation

Future research is recommended to involve a larger and more diverse sample size to enhance the generalizability of the findings. For practitioners and policymakers, AIED development must integrate usability and cognitive load into quality assurance through iterative user evaluations.

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