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A quantitative study of user feedback on online education software from an interaction design perspective

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ABSTRACT

With the rapid development of technology, the rise of the mobile internet era, and the widespread use of smartphones, online education apps focused on user experience have become the main platforms for delivering online learning. As demand for online education continues to grow, interface design has become a key factor in the success of these apps, often shaping users' first impressions. A well-designed interface not only gives users easy access to a wide range of courses and learning materials but also improves the overall user experience. This study reviews articles from the SSCI database to examine connections between key terms, highlighting important themes in interaction design and the possible relationships among various factors. Based on this analysis, the study identifies key dimensions and develops a questionnaire to assess user satisfaction. The findings from the questionnaire provide a clearer picture of the current state of online education app interfaces and offer practical insights for improving intelligent interaction design, with the goal of increasing user satisfaction.

1. Introduction

Online education is gradually becoming a supplementary means to traditional offline education. It addresses the problem of insufficient educational resources and makes teaching more flexible. However, several issues have surfaced, such as the limited variety of teaching models, poor interactivity in the teaching process, students' short attention spans and lack of self-discipline, and teachers' unfamiliarity with platform functionalities (Kong et al., 2009). These challenges contribute to inconsistent educational quality. Among these factors, interactivity within educational software is one of the key elements that influence students' motivation to learn and the ultimate educational outcomes (Martín-Sómer et al., 2024). Therefore, exploring the interactive design in online education can assist teachers in optimizing the teaching process, ensuring the quality of online education, and improving its efficiency. In line with this, productivity in complex systems can benefit from structured multi-criteria strategies such as the synergy between the balanced scorecard and the analytic network process (Fanati Rashidi, 2020). While a large number of educational apps can be found in various app stores today, some with massive user bases and rich learning resources, many still face significant challenges. Issues such as low engagement, limited interactivity, severe content homogenization, and cluttered interface design hinder the widespread adoption and effective use of these apps (Liu and Yu, 2024). These problems highlight the importance of researching the interactive design of university-level online education apps from the perspective of user experience (Wang et al., 2021). Enhancing the richness of user experience during app usage is necessary for improving both the interactive design of higher education apps and their interface design based on user experience.

With the development of manufacturing, science, and technology, more and more industrial products have entered our lives, changing the world. These products are constantly being updated and upgraded toward being more intelligent and multifunctional, leaving people amazed at their rapid evolution (Burzagli et al., 2022). Humans have also learned to "communicate" with these electronic products through their built-in media to better serve themselves (Gómez-Carmona et al., 2024). This process of communication with machines is known as "interaction," and the medium that enables human-machine interaction is the "interface." The

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essence of interaction interface design lies in collecting and analyzing users' functional needs and suggestions, ultimately designing smarter and more user-friendly product operating systems (González et al., 2021). "Interaction design is a field focused on interaction behavior, user experience, and effective communication between humans and machines in digital products. It encompasses usability research, user analysis, emotional design, interface design, cognitive psychology, industrial design, ergonomics, and many other areas." The more intuitive and aligned with human logical thinking the system is, the simpler and more convenient its operation, and the more successful the interaction interface design (Hui and Li, 2014). A well-designed interaction interface can often bring tremendous benefits to a product, even disrupting the development model of an entire industry.

The content provided by online education apps differs from that offered by apps released by enterprises and companies today (DeWitt et al., 2022). Each platform has distinct academic and instructional strengths, offering unique content and resources. By integrating existing resources and effectively transforming them into the functionalities, content, and interactive platforms of online education apps, these platforms enhance communication between online and offline learning (Chaw and Tang, 2018). This integration allows online education to serve as a valuable complement to traditional classroom settings, helping students access more learning resources and better achieve their educational goals (Amponsah et al., 2024). It also fosters the combination of offline activities and interactions with online courses, adding more engagement to the learning process.

Despite the vast number of online education apps, many suffer from low user retention rates (Liu et al., 2023). A significant portion of these apps offer highly homogeneous content, with limited independent content creation capabilities. While some apps do provide abundant learning resources, they often lack strong connections between these resources, and the content is not sufficiently systematic (Mohammadhossein et al., 2024). There is a noticeable gap in the integration of resources within the same academic discipline (Al Kez et al., 2024). Additionally, many online education apps consist of long courses with numerous videos, making them seem too time-consuming and extensive for learners who aim to study during short, spare moments (Pike et al., 2022). This structure negatively impacts student engagement and leads to lower course completion rates. Relatively few online education apps are designed to help users effectively utilize fragmented time for learning, resulting in low usage frequency, insufficient motivation, and slow progress. The root cause of these issues often lies in the limited content creation capacity of many online education providers, their lack of understanding of user needs, and a deficiency in teaching experience (Karunathilake and Galdolage, 2021). This paper focuses on the interface design of online education apps, with a particular emphasis on enhancing user experience. By examining multiple aspects, including resource integration, content production, and interface design, it explores how to improve the user experience of online education apps and assist users in learning more effectively. The study first conducts a textual analysis to identify the main trends and issues in the current interface design of online education apps. Subsequently, a detailed questionnaire is designed to gather user feedback, which further verifies and supplements the initial analysis. This provides quantitative support for the key influencing factors, which are then explained and thoroughly analyzed using statistical methods.

2. Materials and methods

2.1. Text analysis

A search was conducted using the term TI = (interactive design for online education software) in the SSCI section of the Web of Science Core Collection, without any restrictions on the search period. The literature download date was October 3, 2024. After filtering the results, a total of 741 valid papers were obtained. For the different word associations, we set the confusion matrix as follows in Fig. 1.

This study employs the user experience theory of interaction design to analyze the co-occurrence patterns of core interaction vocabulary in user feedback on online education software. By constructing a word confusion matrix, the research examines the semantic relationships between different feedback dimensions, extracts high-frequency co-occurring word clusters, and identifies key areas of user concern regarding online education software. It investigates whether the observed word co-occurrence patterns align with the information processing characteristics described in cognitive load theory and social cognition theory. The confusion matrix analysis helps determine which words exhibit higher degrees of confusion, potentially revealing user misunderstandings of certain functionalities, thereby contributing to the optimization of interaction design. Additionally, by integrating the preferential attachment mechanism, the study explores which high-frequency keywords are more likely to integrate with new concepts, providing insights into potential future trends in user feedback.

From Fig. 1, it can be observed that there are three groups with significantly strong correlation characteristics:

1. Teaching/learning strategies and pedagogical issues: Teaching/Learning Strategies mainly focus on how to design and implement different teaching methods to enhance learning outcomes. Interactive design plays a crucial role in this field, as it helps realize these strategies through various forms of interaction, such as teacher-student interaction, collaboration among students, and

interaction with content. Pedagogical Issues emphasize the application of educational theories and teaching principles. Interactive design helps translate these theories into real learning environments. For example, a constructivist-based pedagogy might require the design of a student-centered interactive system that encourages autonomous exploration and interaction with content. The interactive design of Teaching/Learning Strategies and Pedagogical Issues must ensure a seamless integration of educational theories with actual interactive experiences. This allows learners to engage in effective interactions and apply different learning strategies.

Fig. 1: Keyword confusion matrix

2. Interactive learning environments and media in education: Interactive Learning Environments emphasize learners' acquisition of knowledge through interaction with learning materials, teachers, other learners, and the environment. Media play a critical role in this process, serving as the medium for interaction. For example, the use of multimedia, virtual reality (VR), or augmented reality (AR) technologies can create more immersive learning experiences for students. Media in Education involves various forms of media, such as videos, images, animations, and interactive applications, which enhance educational outcomes. Interactive design here must consider how to design these media to interact intuitively and smoothly with learners, adjusting content based on their feedback. Interactive Learning Environments and Media in Education integrate technology and content through interactive design, enhancing the immersion and interactivity of learning experiences. When applying media in interactive learning environments, interactive design should ensure that learners can easily navigate and control media content.
3. Interactive learning environments and teaching/learning strategies: Interactive Learning Environments support the implementation of various Teaching/Learning Strategies. For example, strategies like collaborative learning, inquiry-based learning, and flipped classrooms can be realized through interactive tools such as online discussion boards, interactive games, and simulation systems, thereby enhancing learners' engagement and initiative. Teaching/Learning Strategies are specific teaching methods that emphasize how to help students better understand knowledge by designing different learning pathways. Interactive design can support these strategies by creating personalized interactive learning experiences, such as using adaptive learning systems to adjust content based on students' learning progress, or providing interactive exercises and simulations. The combination of Interactive Learning Environments and Teaching/Learning Strategies, supported by interactive design, enables the implementation of

various teaching methods, helping learners engage in personalized and interactive learning. To facilitate the effective implementation of Teaching/Learning Strategies, interactive design should consider how learners can experience diverse learning pathways in interactive environments. For instance, in project-based learning, the design should allow students to choose their own paths based on their pace and interests, and use interactive tools to communicate with learning materials and peers. Moreover, interactive design can provide real-time feedback mechanisms to help learners better understand and apply the knowledge acquired through interaction.

We conduct co-occurrence analysis of words at different levels, study user satisfaction feedback on educational software interaction at different levels (function level, interface level, teaching content level), and form a multi-scale confusion matrix. From Fig. 2, it is evident that the early research hotspots included Flipped Classroom, Media in Education, and Interactive Learning Environments. Flipped Classroom emphasizes students' self-directed learning by watching videos or engaging with other learning materials before class, while class time is reserved for interaction, discussion, and applying knowledge.

Interactive design in this context should provide students with easy-to-use learning resources, ensuring that they can efficiently access materials before class. This includes designing video players, tracking learning progress, and offering in-class exercises that allow students to control their own learning pace. In the classroom, interactive design can facilitate student-teacher and peer interactions through real-time feedback systems, discussion boards, and group interaction tools. For example, using instant polling, online quizzes, and virtual discussion spaces can significantly enhance classroom engagement.

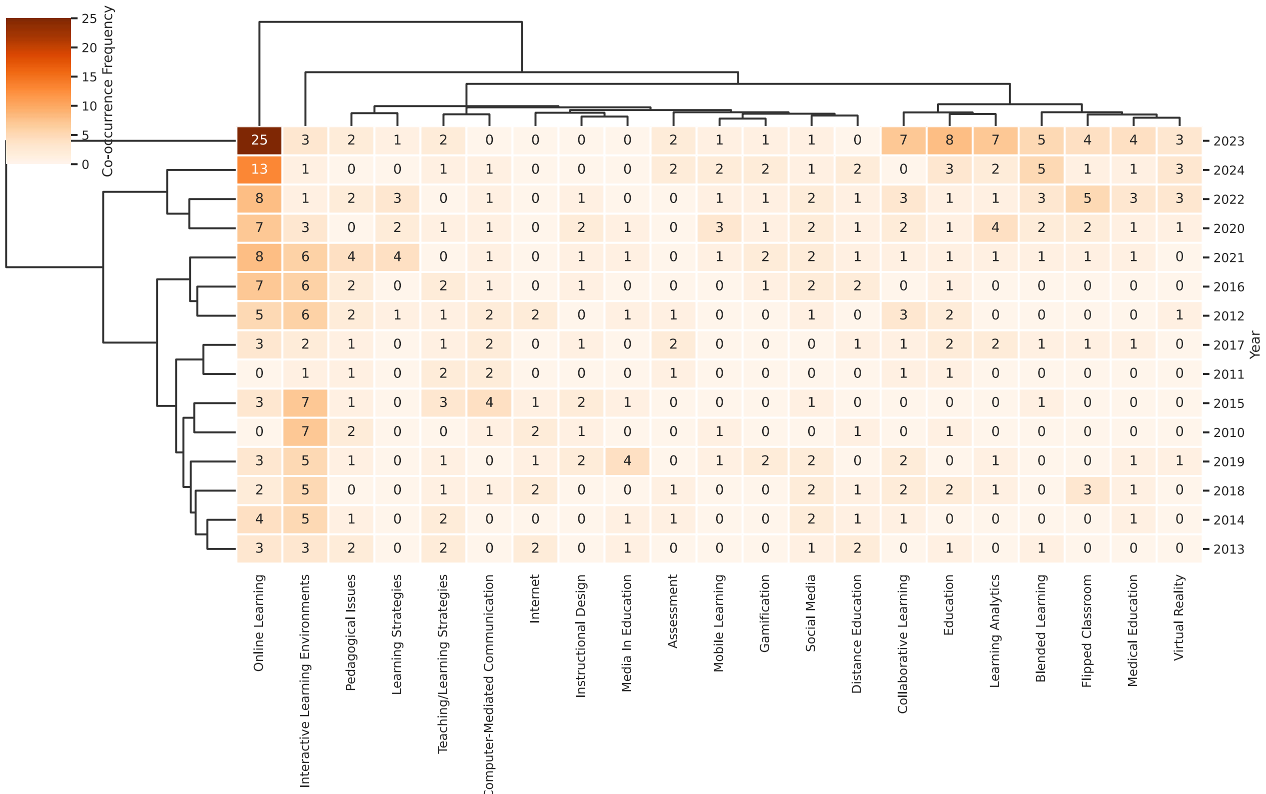


Fig. 2: Year evolving two-modular matrix

Media in Education refers to the use of various digital tools and resources, such as video, audio, animations, and simulations, to support teaching activities. Interactive design needs to ensure that the presentation of media content is closely aligned with learning objectives, with intuitive and straightforward user interfaces that avoid distracting students with complex navigation or redundant steps. The design can enhance learning effectiveness by incorporating interactive media, such as videos with embedded quizzes or virtual laboratories, to foster student interaction with the content. Interactive Learning Environments allow students to engage in self-directed exploration and learning through interaction with digital content, teachers, and peers. The design should provide flexible, open-ended learning environments, enabling students to choose their own learning paths. For instance, non-linear navigation and modular content presentation can allow students to adjust their learning process based on personal needs and interests. Interactive design should ensure that learners receive instant feedback during system interactions, such as real-time scoring, instructor guidance, or peer feedback, to help students quickly adjust their learning strategies.

2.2. Questionnaire design and coding

Through the standard and strict compiling process, and through the test of a large sample survey, the quality of the final questionnaire has been fully guaranteed. The questionnaire consists of 25 questions and is scored on a 5-point scale, from very inconsistent to very consistent, from 1 to 5 points in turn, as detailed in Table 1 below. The applicability of the questionnaire and implications of the survey results for research and practice are further discussed below.

The usability (Usability) issues numbered A1 to A5 aim to evaluate the ease of use of a product or system, including the user experience and satisfaction during the usage process. The logic (Logic) issues numbered B1 to B5 focus on the logical coherence of the product or system, assessing whether its design is reasonable and whether its functions align with user expectations and thought processes. The convenience (Convenience) issues numbered C1 to C5 aim to measure the convenience of using the product or system, including accessibility, availability, and the simplicity of tasks users need to complete. The advanced features (Advanced Features) issues numbered D1 to D5 evaluate the advanced functionalities provided by the product or system, exploring the practicality of these features and their contribution to enhancing the user experience. The interactivity (Interactivity) issues numbered E1 to E5 focus on the interactivity of the product or system, assessing the quality of interactions between users and the system as well as the level of user engagement. These classifications help to systematically collect user feedback to improve various aspects of the product or system.

Table 1: Questionnaire content and coding

No.	Question
A1	For users unfamiliar with technology, are the basic functions of this app (such as registration, login, watching videos, taking quizzes, etc.) easy to use? How much learning effort is required?
A2	When using the app for the first time, does it take significant time to learn how to use the main features?
A3	Do you often encounter operational errors or misuse of features when using this app?
A4	Do you think the app’s learning process (such as watching videos or doing exercises) is seamless, avoiding unnecessary operations and repetitive steps?
A5	When you encounter problems (such as filling out a form incorrectly), are the error messages clear enough to guide you to a quick resolution?
B1	When looking for different features, can you clearly understand the hierarchical structure of the functions? For example, finding courses, downloading materials, discussion areas, etc.?
B2	When operating different modules, do you feel that the workflows and layouts of the functions are consistent?
B3	In multi-step operations (such as registering or enrolling in a course), do you find the logical relationships between the steps clear and reasonable?
B4	When you perform an action (such as clicking a button), does the app provide clear feedback (such as success messages or loading status) to confirm that the operation was successful?
B5	Do the app’s notifications (such as assignment reminders, course updates) match your learning progress logically and provide timely and appropriate prompts?
C1	Can the app’s interface or shortcut operations be customized to improve learning efficiency?
C2	Is it convenient to perform batch operations (such as batch downloading or submission) in the app?
C3	Can you easily switch between different learning modes in the app and save progress in each mode?
C4	Does the app quickly adapt to network changes between Wi-Fi and 4G/5G and ensure that the learning process is not interrupted?
C5	Does the app provide data management options and ensure that these actions do not affect learning progress?
D1	Does the app’s design follow the latest technological developments (such as real-time data analysis, intelligent assessment systems) to enhance learning effectiveness?
D2	Does the app have a modern and tech-forward feel in terms of visual and interaction design?
D3	Does the app support multi-device collaboration, such as syncing progress across phones, tablets, and computers seamlessly?
D4	Does the app offer learning reminders or task management features, and can these reminders and notifications be customized according to personal needs (e.g., study time, study frequency)?
D5	When performing complex learning tasks (such as programming or math calculations), can the app use AI tools to help you correct mistakes in real-time, give tips, or provide additional learning resources?
E1	Do you feel that the app’s interactive design enhances engagement and positivity during the learning process, effectively preventing distraction?
E2	During the learning process, can you use the app’s interactive tools for group collaboration or discussions?
E3	Does the app’s notification system promptly remind you of updates on learning tasks or group discussions?
E4	After completing an action (such as submitting an assignment or answering a question), do you feel the app promptly provides personalized learning suggestions or further content?
E5	Can you gain a deeper learning experience through interaction with AI, such as simulating real-life situations, participating in interactive case studies, or receiving personalized AI learning assessment reports?

3. Results

3.1. Reliability and validity test

Cronbach's and KMO of each dimension index were tested and analyzed in Tables 2 and 3. The Cronbach's α coefficient value of the model was 0.915 in Table 2, indicating that the reliability of the questionnaire was very good. The results of the total statistics of items showed that the two indicators of the overall correlation after item deletion (CITC) and the α coefficient after item deletion performed better, and the scale items were not modified. The results of the split-half reliability showed in Table 3 that the number of items in the first half was 13.0, which was not equal to the number of items in the second half was 12.0, so the split-half coefficient of different lengths should be adopted. The split-half coefficient of the model was 0.854, indicating that the reliability of the questionnaire was good. The results of intra-class correlation coefficients for individual measurements show that the significant P-value is 0.000*** in Table 4, indicating a significant level of consistency, rejecting the null hypothesis, and confirming that the reliability of consistency is trustworthy. The intra-class correlation coefficient is 0.302, indicating that the reliability of the data is moderate. The results of intra-class correlation coefficients for average measurements show that the significant P-value is 0.000***, indicating a significant level of consistency, rejecting the null hypothesis, and confirming that the reliability of consistency is trustworthy. The intra-class correlation coefficient is 0.915, indicating that the reliability of the data is very strong. The result of the KMO test in Table 5 showed that the value of KMO was 0.952. Meanwhile, the result of Bartlett's spherical test showed that the significance P-value was 0.000***, indicating that the level was significant, and the null hypothesis was rejected. There was a correlation between each variable; the factor analysis was effective, and the degree was suitable. The scree map is plotted through Table 5. In Fig. 3, the data flattens out after the sixth principal component, so we think we can weigh the first five principal components. Therefore, the five aspects of this paper are more scientific and reasonable. The data flattens out after the sixth principal component, so we think we can weigh the first five principal components. Therefore, the five aspects of this paper are more scientific and reasonable. According to the heat map in Fig. 4 of the load matrix above, the importance of hidden variables in each principal component can be analyzed, and it can be seen that each index has a good effect.

Table 2: Reliability test of the α coefficient

Cronbach's α coefficient	Standardized Cronbach's α coefficient	Number of items	Sample size
0.915	0.916	25	1587

Table 3: Double half reliability coefficient table

Metric	Value
Cronbach's α coefficient (first half)	0.89
Number of items (first half)	13.00
Cronbach's α coefficient (second half)	0.80
Number of items (second half)	12.00
Total number of items	25
Correlation between the two halves	0.75
Spearman-Brown coefficient (equal length)	0.75
Spearman-Brown coefficient (unequal length)	0.85
Guttman split-half coefficient	0.84

Table 4: Intra-group correlation coefficient analysis

Metric	ICC type	95% confidence interval		The F-test with truth value 0 is used			
		Lower limit	Upper limit	F-value	df1	df2	P
Single measure ICC (1,1)	0.302	0.286	0.319	11.825	1586	38064	0.000***
Average measure ICC (1,k)	0.915	0.909	0.921	11.825	1586	38064	0.000***

***: Represent 1% significance level

Table 5: KMO's test and Bartlett's test

Test	Metric	Value
KMO test	KMO value	0.952
Bartlett's test of sphericity	Approx. Chi-square	15642.002
	df	300
	P-value	0.000***

***: Represent 1% significance level

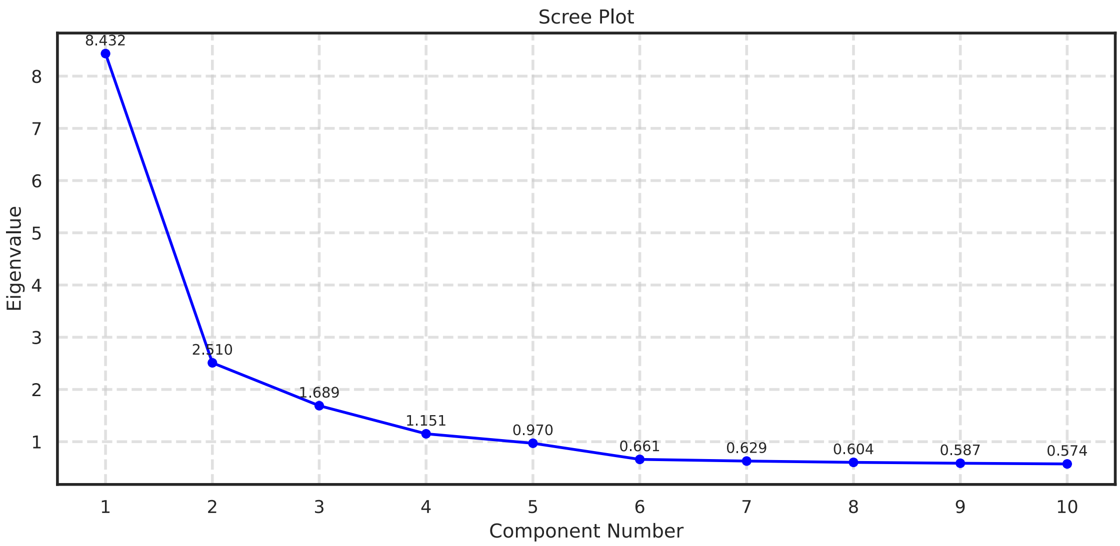


Fig. 3: Scree map

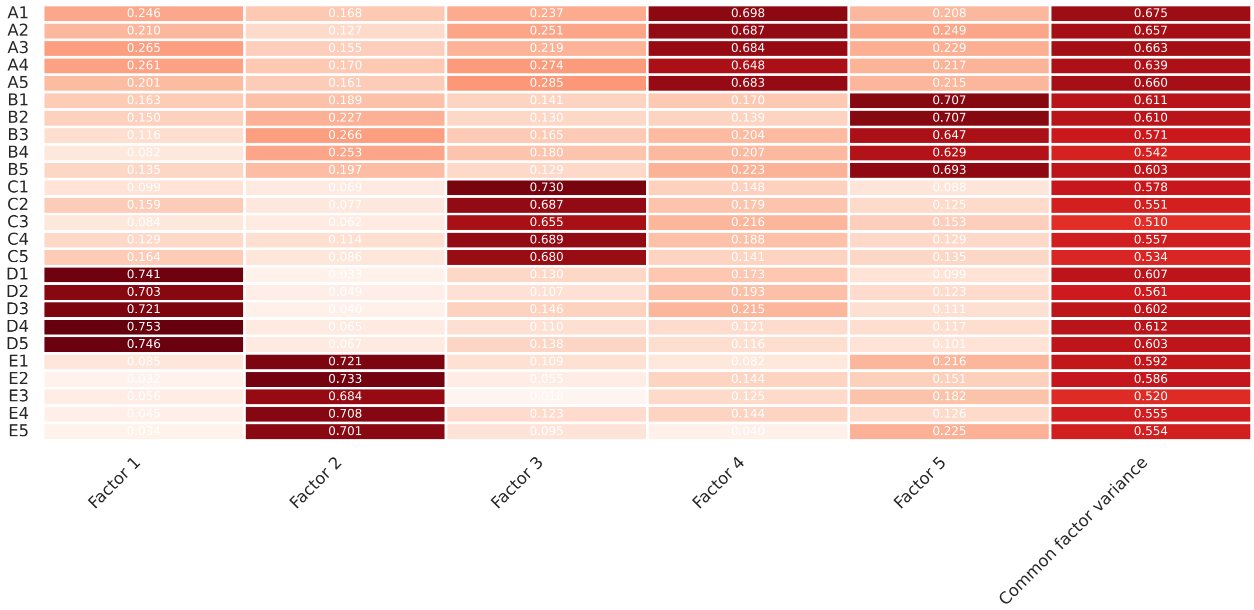


Fig. 4: Factor loading matrix heatmap

3.2. Research on the improvement priority of interaction design elements

We utilize a scatter plot to analyze the improvement priority of various sensory attributes. Specifically, the horizontal axis represents the proportion of users who perceive a given attribute, while the vertical axis represents the penalty coefficient, visually illustrating the impact of different attributes on user experience. The proportion of users indicates the percentage of users who have noticed a particular attribute—higher values suggest that more users are aware of the attribute, thus implying a greater overall influence on user experience. The penalty coefficient, on the other hand, measures the extent to which an attribute deviates from user expectations and its negative impact on satisfaction; higher values indicate that the deviation significantly reduces user satisfaction. Consequently, attributes that are farther from the origin in the scatter plot have a higher priority for improvement.

To further assist in prioritization, we incorporate a reference curve into the scatter plot, defined by |Total mean drops|=0.5, serving as a baseline threshold for evaluating the deviation of different attributes. This curve helps differentiate the extent to which various attributes affect overall satisfaction. Attributes positioned far from the reference curve exhibit greater deviations that are perceived by a larger number of users, indicating a higher need for optimization. In particular, attributes located in the upper-right corner and significantly distant from the reference curve not only affect a broad user base (i.e., have a high user proportion) but also have a substantial negative impact due to their deviations (i.e., high penalty coefficient). These attributes should be prioritized for improvement. The results are shown in Figs. 5, 6, and 7. A2: The learning curve theory in usability engineering emphasizes that the ease of use experienced by users during their first interaction with an application is critical. If the learning cost is too high, users may abandon further use. Therefore, interface design should adhere to the principle of progressive disclosure, which means only showing complex features when necessary, thus avoiding overwhelming users with too much information at the beginning. Interaction design should be based on natural mapping, allowing users to understand how to use features intuitively, without conscious effort. This kind of design, which aligns with mental models, significantly reduces the learning cost for beginners. B2: The principle of consistency in design is crucial in interaction design, especially in a large-scale online education system. The operation flow and interface layout between different modules must remain uniform to reduce confusion when users switch tasks. Visual hierarchy needs to be applied in the design to ensure that each module uses similar navigation, button styles, and interaction methods, so users do not need to relearn the rules for each module. This consistency reduces users' cognitive load and enhances operational coherence. Based on the "principle of similarity" in Gestalt design theory, consistent design enables users to quickly identify the same functionalities and operational patterns, preventing them from getting lost due to differences between modules. In educational software, maintaining visual and functional consistency across the interface ensures that users do not incur additional cognitive costs when switching between learning content, allowing them to focus on the learning tasks themselves. C4: In modern online education software, network adaptability design has become a critical issue. Applications need the capability to quickly switch between networks, and this fault-tolerant design ensures that users can continue their learning process uninterrupted during network changes through seamless connectivity. Responsive design and latency compensation techniques can also be employed to ensure that the app can preload certain content when the network is unstable or use caching to save learning progress, thus avoiding disruptions to the user experience. Distributed cognition theory explains the interaction between users and the technological environment. In online education contexts, network instability is a form of environmental change, and applications should be designed to perceive and adapt to such changes, allowing users to complete tasks in various technical environments. By building robust network adaptability mechanisms, software can shift users' attention away from technical obstacles and toward learning content, ensuring that cognitive activities remain uninterrupted.

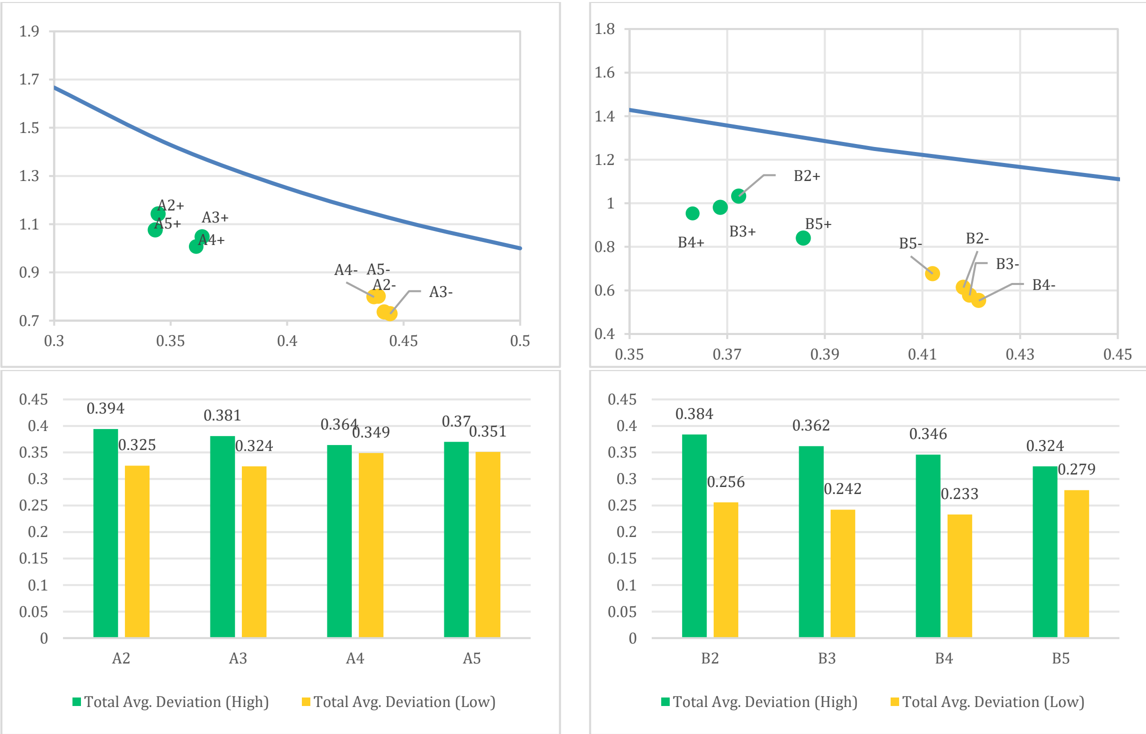


Fig. 5: Class A and B penalty analysis diagrams and improvement priorities

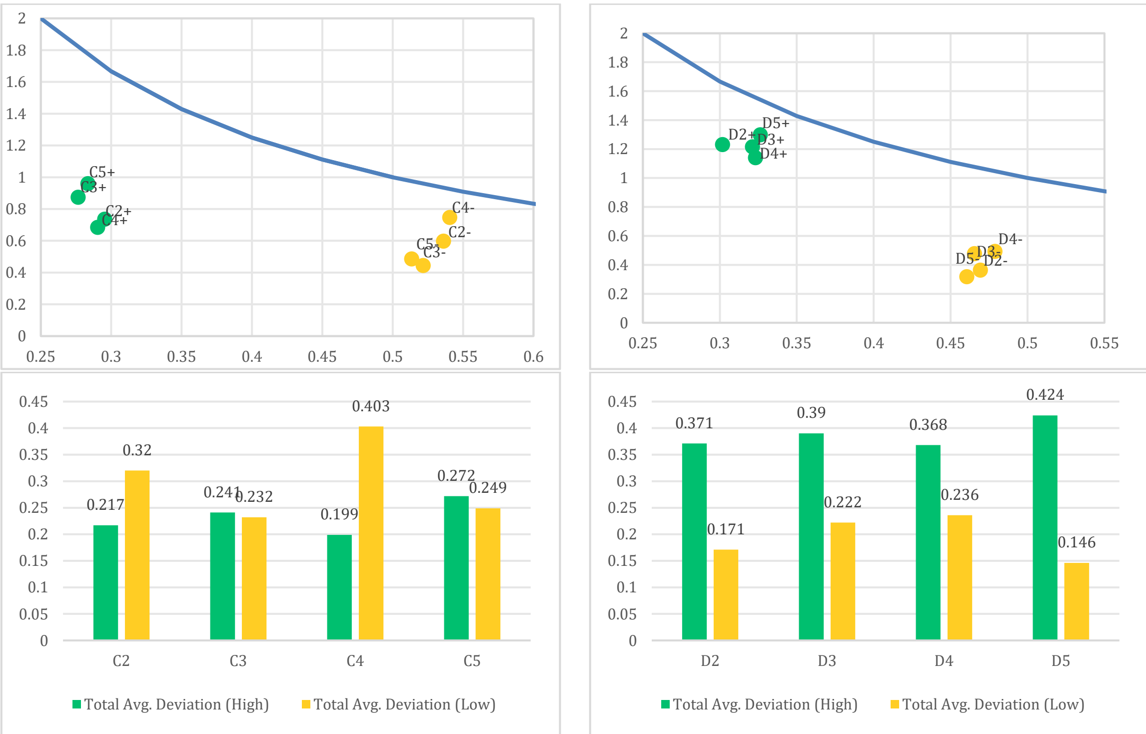


Fig. 6: Class C and D penalty analysis diagrams and improvement priorities

D5: Task-oriented interaction design needs to provide intelligent assistance features for complex tasks (such as programming or mathematical calculations), such as real-time error correction and learning prompts. Vygotsky's Zone of Proximal Development (ZPD) theory emphasizes that external support helps users move from their current cognitive level to the next stage. AI tools, by providing real-time error correction and prompts, effectively act as "cognitive tutors," helping users surpass their current abilities and reach a higher level of understanding.

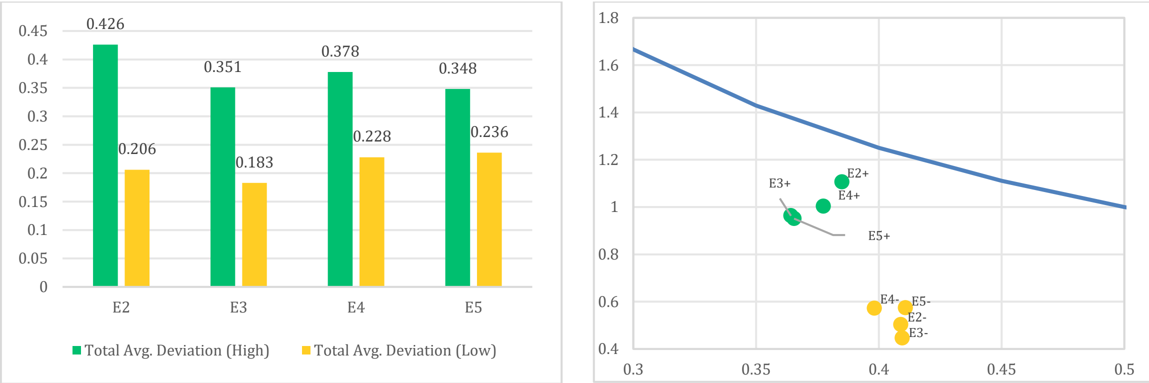
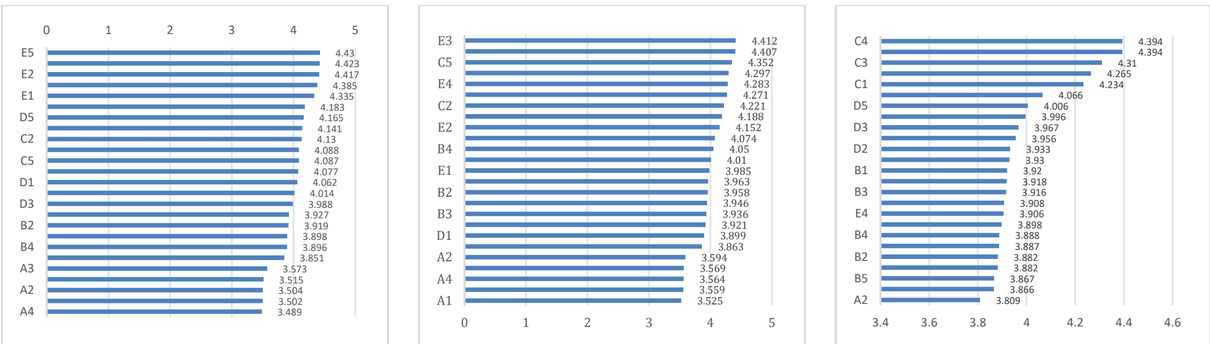


Fig. 7: Class E penalty analysis diagrams and improvement priorities

E2: Social design has become increasingly important in online education software, as the provision of interactive tools to support group collaboration and discussion can significantly enhance users' learning motivation and sense of engagement. Tools such as real-time chat, discussion boards, and shared documents can enrich users' collaborative experience. Supporting both synchronous and asynchronous interaction modes is also key, allowing users to choose between real-time discussions or participating asynchronously through message boards, enhancing both interactivity and adaptability in the learning process. According to constructivist learning theory, learning is a process of co-constructing knowledge through collaboration and discussion with others. The collaborative tools provided through interaction design enable users not only to share knowledge but also to engage in critical thinking and reflection through social interactions. Effective design of these interactive tools allows learners to experience the process of knowledge construction in collaboration, thereby enhancing the effectiveness of deep learning. The aforementioned priority improvement areas can be optimized through the application of principles such as consistency in interaction design, task-oriented design, AI assistance, network adaptability design, and social design. These enhancements will improve the overall user learning experience, making the software more usable and functional in supporting complex learning tasks, network stability, learning collaboration, and intelligent feedback, thereby meeting the diverse needs of online education.

Usability ensures that users can quickly get started and minimize operational errors, while logical design enhances operational fluidity through consistent functional layouts. Convenience emphasizes the system's flexible design in uncontrollable conditions, such as network changes. Perceptibility, through technologies like AI, provides users with intelligent feedback and support, and interactivity boosts engagement and learning effectiveness through group collaboration and real-time discussion tools. These design elements influence each other, ultimately forming an efficient, intelligent, and user-friendly online education platform.

From the perspective of interaction design in online education software in Fig. 8, the following high-priority improvements can enhance the user experience through refined design strategies and theoretical support.



CRITIC weighting method | Independent weight coefficient method | Coefficient of variation method

Fig. 8: Ranking of weight calculation results

E5: Intelligent interaction design has become a key trend in online education. Through AI interaction, users can receive personalized learning paths, such as adjusting difficulty based on their progress and abilities or receiving real-time AI feedback for error correction, thus improving learning outcomes. Context-sensitive design can help users simulate real-life scenarios, making learning content more applicable to practical use. For instance, AI can simulate real-world cases, allowing users to engage in interactive learning and receive instant feedback.

E3: Notification system design plays a crucial role in online education software, helping users keep track of learning tasks and participate in group discussions in a timely manner. Timeliness and relevance are the core elements of notification design. The notification system should have contextual awareness, offering personalized and relevant reminders based on users' learning progress and behavior data. The principle of non-intrusive design emphasizes that notifications should be delivered at appropriate times to avoid interrupting the user's learning. Additionally, the format, frequency, and content of notifications should be carefully designed to effectively remind users without distracting them.

C2: Bulk operation design is one of the key functions that impact user efficiency in online education software. To enhance the user experience, the interaction design should ensure that the interface for bulk operations is simple and easy to use. By reducing the number of steps and providing clear feedback for bulk actions, user efficiency can be significantly improved. Streamlining task flows helps users minimize repetitive clicks or selection steps during bulk operations. For example, the bulk download feature should support selecting multiple files at once, and the bulk submission of assignments should offer a one-click upload function. The visibility principle emphasizes that interface elements for bulk operations should be prominent, allowing users to intuitively understand how to select files and perform operations.

Additionally, clear feedback, such as confirmation prompts after completing an operation, should be provided to enhance users' confidence in the outcome. According to Fitts' Law, the efficiency of user operations depends on the distance between interface elements and the size of the targets. In bulk operation design, reducing the distance between clicks and minimizing steps can improve overall efficiency and reduce the likelihood of errors during operations.

4. Discussion and conclusion

4.1. Research result

In the interaction design of online education software, usability, logic, convenience, perception, and interactivity are closely related and complement each other. First, the connection between usability and logic is reflected in the consistency of the user's operational process; a well-structured logical flow can reduce the user's learning cost and improve operational smoothness. Usability is also closely tied to advancement, particularly when AI tools are used for real-time error correction and intelligent prompts, which enhance operational efficiency and the learning experience. The combination of logic and interactivity strengthens user engagement and collaboration through a clear functional structure. In terms of prioritizing interaction design improvements, the consistency of functionality, AI-supported real-time feedback, and cross-network adaptability are seen as key areas for improvement, as they directly impact the user's operational experience.

Intelligent interaction design enables online education platforms to provide personalized learning path adjustments based on user learning data, thereby enhancing learning efficiency. The AI feedback system not only corrects user errors in real time but also optimizes the adaptability of learning content, allowing learners to achieve a higher-quality learning experience in an immersive environment. This study highlights the principles of timeliness and non-intrusiveness in notification system design, ensuring that notifications do not disrupt users' normal learning while providing intelligent reminders based on their learning progress. Such a design not only improves users' information reception efficiency but also enhances task management capabilities, reducing the interference effect caused by information overload. Furthermore, social interaction tools (such as real-time discussions and asynchronous collaboration) provide users with a richer collaborative learning experience, aligning with the knowledge co-construction principles of constructivist learning theory. By optimizing the social features of online education software, learners not only acquire knowledge but also deepen their understanding, enhance critical thinking skills, and improve deep learning outcomes through interactive engagement.

When considering factors such as enhanced engagement through interaction design and the clarity of error messages in consumer experience surveys, these elements are more strongly linked to user experience since they directly affect the user's focus and operational fluency during the learning process. In contrast, the priority for the logic of the notification system and other auxiliary features is lower because their impact is more indirect, primarily supporting the transmission of information and assisting the learning process.

4.2. Improvement direction

While identifying key areas for optimization in interaction design is crucial, it is equally important to consider the practical challenges in evaluating and implementing these improvements. User experience testing often takes place in controlled environments, which may not fully replicate real-world usage conditions. This gap between test conditions and actual user experiences can introduce discrepancies in measurement results, necessitating further refinements and validation in practical applications. To ensure that the proposed improvements effectively address real user needs, it is essential to design evaluation methods that closely simulate authentic usage scenarios and integrate iterative feedback mechanisms.

The test is carried out in a specific situation, which cannot simulate the real usage situation of users, and there may be some errors in the real usage experience of users. In this kind of test, the tester should try to create a relaxed environment to restore the use of the situation more realistic. The design scheme uses a paper prototype for usability testing. There are some differences between the paper prototype and the actual application, and there may be some errors in the measurement results. The practical application, measurement, and design iterative optimization should be carried out later.

List of abbreviations

SSCI	Social sciences citation index
UI	User interface
VR	Virtual reality
AR	Augmented reality
AI	Artificial intelligence
KMO	Kaiser-Meyer-Olkin
ICC	Intra-class correlation
df	Degrees of freedom
F-value	F-statistic value
A1–A5	Usability questions in the questionnaire
B1–B5	Logic questions in the questionnaire
C1–C5	Convenience questions in the questionnaire
D1–D5	Advanced features questions in the questionnaire
E1–E5	Interactivity questions in the questionnaire
ZPD	Zone of proximal development
CITC	Corrected item-total correlation

Compliance with ethical standards

Ethical considerations

In this study, all participants were given complete information about the purpose, methods, potential risks, and benefits of the study before they gave written consent to participate. The identities and personal information of the participants will be kept confidential, and the data will be anonymized in the research report. In addition, participants were given the right to withdraw from the study at any time without negative consequences.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Al Kez D, Lowans C, and Foley A (2024). Sustainable development in third level programs: Distilling a pathway to a true net-zero education. Sustainability, 16: 1998. https://doi.org/10.3390/su16051998

Amponsah KD, Mensah RO, Aheto SPK, Commey-Mintah P, Danquah CT, and Cobbinah D (2024). Digital revolution in higher education: Unveiling the impact of online learning versus traditional classroom instruction in a Ghanaian university, west Africa. African Journal of Social Issues, 7(1): 185-207. https://doi.org/10.4314/ajosi.v7i1.13

Burzagli L, Emiliani PL, Antona M, and Stephanidis C (2022). Intelligent environments for all: A path towards technology-enhanced human well-being. Universal Access in the Information Society, 21: 437–456. https://doi.org/10.1007/s10209-021-00797-0 **PMid:33746688 PMCid:PMC7956403**

Chaw LY and Tang CM (2018). What makes learning management systems effective for learning? Journal of Educational Technology Systems, 47(2): 152-169. https://doi.org/10.1177/0047239518795828

DeWitt A, Kientz J, and Liljenquist K (2022). Quality of mobile apps for child development support: Search in app stores and content analysis. JMIR Pediatrics and Parenting, 5(4): e38793. https://doi.org/10.2196/38793 **PMid:36346656 PMCid:PMC9682452**

Fanati Rashidi S (2020). Studying productivity using a synergy between the balanced scorecard and analytic network process. Opsearch, 57(4): 1404-1421. https://doi.org/10.1007/s12597-020-00466-5

Gómez-Carmona O, Casado-Mansilla D, López-de-Ipiña D, and García-Zubia J (2024). Human-in-the-loop machine learning: Reconceptualizing the role of the user in interactive approaches. Internet of Things, 25: 101048. https://doi.org/10.1016/j.iot.2023.101048

González ADM, Morga GRN, and Mena CC (2021). Development of interactive gadgets: Pedagogical, methodological and ergonomic aspects for industrial design. Revista De Ciencias Tecnológicas, 4(4): 412-424. https://doi.org/10.37636/recit.v44412424

Hui K and Li J (2014). Application and research on ergonomics and Kansei engineering in human-computer interface design. Applied Mechanics and Materials, 563: 245-247. https://doi.org/10.4028/www.scientific.net/AMM.563.245

Karunathilake RLP and Galdolage BS (2021). Value co-creation and co-destruction in online education during the COVID19 pandemic: Special reference to Sri Lankan state sector universities. Journal of Business and Technology, 5(2): 14-28. https://doi.org/10.4038/jbt.v5i2.30

Kong SC, Shroff RH, and Hung HK (2009). A web enabled video system for self-reflection by student teachers using a guiding framework. Australasian Journal of Educational Technology, 25(4): 544-558. https://doi.org/10.14742/ajet.1128

Liu M, Wang Y, and Wang Y (2023). Analysis of low user retention rate of fitness technology platforms. Advances in Economics, Management and Political Sciences, 21: 8-17. https://doi.org/10.54254/2754-1169/21/20230227

Liu Z and Yu X (2024). Development of a T2D app for elderly users: Participatory design study via heuristic evaluation and usability testing. Electronics, 13(19): 3862. https://doi.org/10.3390/electronics13193862

Martín-Sómer M, Casado C, and Gómez-Pozuelo G (2024). Utilising interactive applications as educational tools in higher education: Perspectives from teachers and students, and an analysis of academic outcomes. Education for Chemical Engineers, 46: 1-9. https://doi.org/10.1016/j.ece.2023.10.001

Mohammadhossein N, Richter A, and Lukosch S (2024). Augmented reality in learning settings: A systematic analysis of its benefits and avenues for future studies. Communications of the Association for Information Systems, 54(1): 29-49. https://doi.org/10.17705/1CAIS.05402

Pike A, Bunch M, DeGennaro CM, and Parker MJ (2022). Online courses provide robust learning gains and improve learner confidence in the foundational biomedical sciences. Medical Science Educator, 32(6): 1425-1432. https://doi.org/10.1007/s40670-022-01660-4 **PMid:36340046 PMCid:PMC9628398**

Wang S, Liu Y, Song F, Xie X, and Yu D (2021). Research on evaluation system of user experience with online live course platform. IEEE Access, 9: 23863-23875. https://doi.org/10.1109/ACCESS.2021.3054047