Enhancing the User Interaction of Online Students: Analysis of an Interaction Concept for a Learner Dashboard

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Abstract: This paper describes the systematic development, evaluation, and iterative refinement of an interaction concept for a Learner Dashboard (LD) to enhance intuitive and user-centered engagement for online students. The core of this concept is represented by precisely designed interaction elements such as icons, navigation mechanisms and adaptive features, each iteratively refined through a feedback loop. The concept emphasizes the crucial role of intuitive icons and clear navigation, aligning with established design principles and user expectations. The implementation of text buttons with arrow icons is particularly notable, enhancing affordances and signifiers and significantly improving the clarity of navigation paths and user guidance. Proactive support elements like alerts and confirmation prompts significantly reduced user errors. The findings highlight the essential role of iterative design and user feedback in tuning the interaction design to resonate with the cognitive and emotional needs of online students, enhancing the user experience. The paper argues the evolved interaction design represents a significant step towards a user-centered and intuitive learning environment. Future work should focus on real-world testing to evaluate the technical feasibility and user acceptance of the developed concept in different learning scenarios.

1 INTRODUCTION

The advance of digitization has permanently changed the way education is delivered. Platforms, such as Moodle, have become central tools in this context, as they represent the transition from traditional learning methods to technology-enhanced approaches that enable a more individualized and self-directed learning experience (Siemens, 2013). Moodle is a widely-used open-source learning management system (LMS), offering a variety of tools for course management and delivery, collaborative learning, and assessment. A particular feature of these platforms are learner dashboards (LDs), which provide a comprehensive view of student learning by transforming data into visual representations. An LD is a digital interface that provides learners with an overview of their learning activities, progress and performance within a LMS and can provide support in their studies (Corrin and de Barba, 2015). Visualizing learning through effective interaction concepts helps learners better understand progress and areas that need improvement (Klerkx et al., 2014). However, extensive information provision can also present difficulties. For example, data overload can be more of a barrier than a help to students, as it can create an additional cognitive load that makes it difficult to absorb and process relevant information. In addition, students show significant differences in learning behaviors and technological abilities that must be considered. Variance presents an additional challenge that it can affect the effectiveness of LDs if they are not adjusted accordingly (Parpala et al., 2022).

A research project of a university network is currently developing an LD that integrates an innovative interaction concept. This concept aims to optimize the presentation of information and improve usability to address the identified challenges and improve the overall user experience (UX).

1.1 The Role of Usability

The increasing complexity and information overload of digital learning platforms consequently bring usability to the forefront. An effective UX is determined not only by the quality of the data presented, but also by how that data can be presented and interpreted

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(Nielsen, 1994). An intuitive dashboard design that minimizes cognitive load and facilitates information intake can greatly enhance learning (Sweller, 1988; Few, 2006). The combination of aesthetics, functionality, and adaptability is therefore crucial. The LD and integrated interaction concept to be developed addresses exactly this issue and attempts to optimize usability through an improved design.

1.2 Interaction as the Core of Digital Learning Tools

Understanding the relationship between users and digital platforms is not limited to the aesthetic design of user interfaces. Rather, the depth and quality of this relationship are crucially shaped by the underlying interaction concepts (Few, 2006). In environments like Moodle, the interactions significantly influence the learning experience (Siemens, 2013). These determine how users retrieve, interpret, and respond to information-especially in digital learning environments such as Moodle, where such interactions influence the learning experience (Siemens, 2013). Interaction and engagement in learning in online environments are complex and influenced by multiple factors, such as learner self-efficacy and emotional aspects, that can shape the learning process (Wang et al., 2022).

Many of the dashboards currently available (Kokoc and Altun, 2021; Jivet et al., 2017) often rely on generic interaction models. While these models are useful, they may not adequately address the unique challenges and requirements of online students. One key aspect where generic models often fall short is in supporting the self-regulation needs of online students. Online students need tools to help them set and track personal learning goals, manage their time effectively, and self-assess their understanding and progress. Self-regulation in an online learning environment is crucial, as students are often expected to take more responsibility for their learning journey. The lack of personalized self-regulation tools in LDs can lead to a mismatch between the student's learning needs and the support provided by the platform, potentially affecting motivation and overall learning outcomes. The interaction concept introduced here aims precisely to address these aspects. Here, we aim for a design that addresses the real-world needs of online students (Harder and Drzyzga, 2023) and enables them to access information smoothly.

Against this background, the development of interaction concepts should always be based on well-founded research and regular feedback. User-centered design (UCD) approaches that place online students at the center of the development processes help to ensure the effectiveness and relevance of the interaction.

1.3 Objectives

Considering the listed challenges and the importance of usability, this work focuses on the iterative development and evaluation of a specific interaction concept for an LD in Moodle. In the process, the three-stage evaluation approach according to Drzyzga and Harder (2023) is used to continuously optimize the usability of the concept. With this background, this work poses two central research questions that shed light on this development and optimization process:
RQ1. How can iterative feedback cycles from user testing directly influence and improve the design and functionality of the interaction concept in the LD?
RQ2. In what ways does the refinement of the interaction concept though iterative development impact of the usability and user experience (UUX) in the LD?

The primary goal of this work is to develop an interaction concept that can be applied specifically to an LD in Moodle as part of a project for the online degree programs of a university network. The project focuses on the development of a dashboard that supports the learning process of online students through provided information and recommendations. Through an iterative approach and the integration of feedback from the target group, a concept is to be developed that optimally shapes the learning environment for the users. The LD aims to promote self-regulation of online students and reduce dropout rates.

2 METHODOLOGICAL DEVELOPMENT OF THE INTERACTION CONCEPT

The developed interaction concept aims to optimize the UUX by being based on the specific needs and requirements of online students. A particular focus is on avoiding information overload and reducing cognitive load (Drzyzga et al., 2023) to promote efficient and effective interaction. The following sections elaborate on the conceptual basis and the specific design and interaction elements of the interaction concept that were applied during the development process.

2.1 Conceptual Foundation

The conceptual foundation of the interaction concept is based on the design study of Drzyzga and Harder

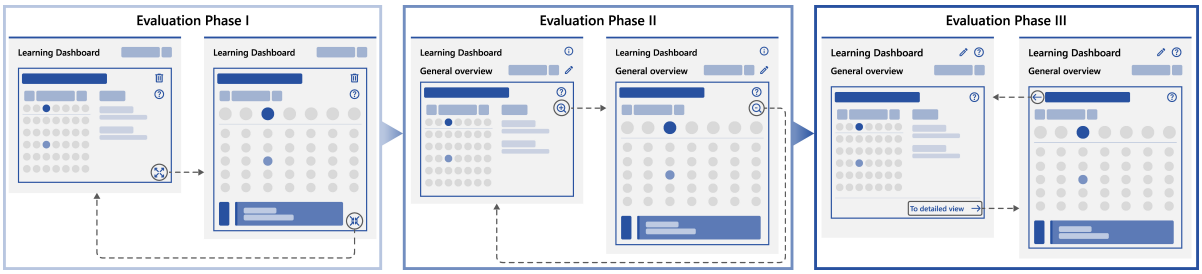

Figure 1: This representation shows the complete evaluation process of the developed interaction process. This is based on the design study according to Drzyzga and Harder (2023).

(2023), who engaged in an iterative UCD process to develop an LD. In the process, three evaluation phases were conducted to continuously optimize the usability of the LD for online students (Drzyzga and Harder, 2023b). The evaluation phases included consideration of design laws and factual and interaction problems, evaluation based on specific interaction principles, and analysis using an eye-tracking study (Drzyzga et al., 2023). Figure 1 illustrates the evolution of the interaction concept resulting from the iterative approach.

During the ongoing evaluation phases of the design study, there was a focus on the specific interaction of the users with the different interaction elements of the prototype, but this has not been considered in detail so far.

In the next sections, interaction and the resulting further development of the interaction concept will be discussed in more depth to improve the UUX of the LD.

2.1.1 Gestalt Laws and Factual and Interaction Problems According to Streitz (1985)

In this phase, similar to the design study by Drzyzga and Harder (2023), the entire LD was not considered. The focus was only on the visual structure of the interaction concept.

For this purpose, both Gestalt laws and Streitz's (1985) factual and interaction problems were examined in one study (Drzyzga and Harder, 2023a). The Gestalt laws, originally derived from Gestalt psychology, serve as essential principles to promote visual clarity and coherence (Wertheimer, 1922). These laws, including the law of proximity, similarity, and good continuation, have been applied to create a clear and logical visual structure that facilitates user navigation and interaction of the LD.

By applying Streitzs model (1985), which differentiates between factual and interactional problems, online students (n = 24) were encouraged to identify potential challenges (Streitz, 1985). Participants documented the identified LD and specific interaction problems so that the interaction concept to be developed could be adjusted accordingly to Drzyzga and Harder (2023).

2.1.2 Evaluation Based on Specific Interaction Principles

The second phase of the design study of Drzyzga and Harder (2023) focused on the practical evaluation of the lot during a half-day workshop. This phase concentrated on applying and assessing the UUX of the low-fidelity LD prototype, evaluated by 24 students. The evaluation was based on the interaction principles defined in the EN ISO 9241-110:2020 standard, and Drzyzga and Harder (2023b) considered all seven interaction principles in their study (DIN, 2020). However, four principles were particularly pivotal for the interaction concept's further development and optimization: Self-descriptiveness, Conformity to User Expectations, Learnability, and Robustness to User Error. These principles formed the methodological basis for evaluating various interaction options in the prototype. The selection was based on the specific context and goals of the LD, with the aim of prioritizing aspects that would provide the most significant improvements in UX and interaction. The remaining three principles, while valuable, were considered to have less immediate impact on improving the interaction concept. This strategic selection allowed for a more targeted and effective improvement of the LD, focusing on areas that would provide the most tangible benefits to users in the learning environment. Self-descriptiveness ensures intuitive understanding of the dashboard's functions, while Conformity to User Expectations ensures the dashboard operates consistently with user expectations. Learnability allows users to learn the system quickly and use it efficiently, while robustness to user error increases the system's resilience to errors and misunderstandings. The focus was on specific interaction capabilities that are essential to the design of interaction concepts.

Drzyzga and Harder's (2023b) research highlighted these interaction principles' importance in the

design process. Applying these principles enabled a solid evaluation and optimization of the interaction concept, allowing the prototype's UUX to be systematically evaluated and refined for intuitive UX.

2.1.3 Evaluation Through Eye-Tracking Study

The final eye-tracking evaluation (n = 10), conducted as another study (Drzyzga et al., 2023) and supported by the Thinking Aloud technique, explored user interaction with the LD from a new perspective. The users eye movements captured by eye-tracking and the verbal feedback from the Thinking Aloud sessions provided insights into cognitive load and user guidance that contributed to the further development of the interaction concept. This study highlighted two key challenges: increased cognitive load due to complex navigation and unclear interaction elements, and overwhelming information density in certain LD areas. These findings led to targeted improvements in navigation simplicity, clarity of interaction elements, and optimized information presentation. In addition to the objectives of the design study (Drzyzga and Harder, 2023a) and the eye-tracking study (Drzyzga et al., 2023), this research aimed to identify specific challenges and cognitive efforts directly related to the interaction concept, such as analyzing eye movements in the context of navigation or understanding user expectations during the activation of an interaction element.

2.2 Design Elements and Interaction Flows

The systematic development of the interaction design within the LD focused on enhancing UUX and learning efficiency. During follow-up/iterative sessions, the interaction concept was considered separately to provide a specific focus within the LD, ensuring that each element aligns closely with user needs. The selection and design of interaction elements, as shown in Table 1, were driven by two main objectives: to enhance intuitiveness for seamless navigation and to foster user engagement through customization features. These elements are pivotal to the UUX of the LD, acting as primary interfaces for user interaction.

The expected outcomes of this design approach include improved usability, achieved through a more intuitive interface, and enhanced learning outcomes, facilitated by allowing students to interact with the LD in a better way.

The table 1 below shows an overview of the main interaction elements implemented in the LD, grouped by their functional category. This categorization helps to better understand and organize the different roles these elements play in the context of the interaction concept.

Table 1: Representation of the interaction elements and associated functions.

Fig.	Interaction elements	Functions
Navigation elements		
	Maximize / minimize icons	Navigation between Summary- and detailed view
	Zoom in / zoom out icons	Navigation between Summary- and detailed view
	Arrow icons	Navigation between Summary- and detailed view
Text	Text buttons	Used for triggering specific actions and navigation
Information and help elements		
	Information icon	Provides help or additional information on a specific topic
	Question mark icon	Provides help or additional information on a specific topic
Editing elements		
	Trash can icon	Used to delete specific entries or information
	Pencil Icon	Allows editing of entries or information

In accordance with established concepts, the design of the interaction elements was systematically developed to ensure an intuitive interaction concept (Ifenthaler et al., 2018). A particular focus was placed on the iterative sessions to continuously optimize the interaction concept and better meet the needs of online students.

3 RESULTS OF THE INTERACTION CONCEPT

The following sections present the central findings from the different evaluation phases of the developed interaction concept. The findings are divided into two main sections: The optimization of specific interaction elements and a deeper exploration of fundamental interaction principles. The analyses and adjustments based on both user feedback and the application of accepted design principles.

These optimizations of the interaction elements directly reflect RQ1 by demonstrating how iterative feedback cycles from user testing directly influence and improve the design and functionality of the interaction concept in the LD.

3.1 Evaluation and Optimization of the Interaction Elements

Optimization of the interaction elements played a critical role in increasing the efficiency and effectiveness of the LD. Through precise analysis and adjustments, the interaction elements were refined to better align with user expectations and facilitate smoother navigation, thereby significantly contributing to an improved user-centric environment within the LD.

3.1.1 Icon Adaptation and Visual Clarity

During the iteration process, it was evident that some icons in the original design caused confusion. In particular, the visual similarity between the cross and trash can icons and between the question mark icon and information icon created ambiguity among users. Users reported difficulty distinguishing content differences between these icons, presenting potential confusion (Drzyzga and Harder, 2023a). To address this, a careful selection process for the icons was implemented. The decision-making was based on user feedback and standard iconography practices. We sourced icons from Google Material, known for its intuitive and universally recognizable designs. This library was chosen for its adherence to industry standards in icon design, ensuring that the icons are easily recognizable and understood by a wide user base. In the redesign, we removed the information icon and trash can to enhance their uniqueness and recognizability. The chosen icons were designed to follow the Gestalt law of separability, enhancing their distinctiveness. This design principle was particularly important in ensuring that each icon clearly conveyed its intended function without ambiguity.

Regarding the pencil icon, participants were mostly positive. Participants expressed that this could be due to the Gestalt law of closedness, as the icon has a clear and closed outline that is easy to recognize and understand. Despite the positive feedback, there is still room for further investigation to optimize the UUX.

The optimization of icon arrangement and visual elements on the LD also adhered to the design principles of proximity and common region, enhancing intuitive UUX. To this effect, the positioning of icons was revised in both horizontal and vertical orientation to create visual balance and minimize potential confusion. The consistent layout promotes clear navigation of the LD, which helps to improve the UUX. Participants noted that the revised icon arrangement and clearly delineated dashboard areas facilitated interaction. Figure 2 visualizes this adaptation.

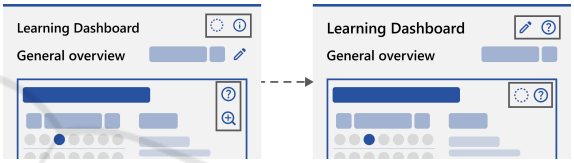

Figure 2: Repositioning of the interaction elements.

The left figure shows the LD in the second iteration step, in that the icons are still arranged in this way. The frames are again meant to represent the lack of coherence between the elements. The right figure shows the result after the students' feedback has been integrated into the interaction concept.

3.1.2 Adaptations for Intuitive Navigation

Another adaptation related to the navigation concept. In the first iteration step, a maximize and minimize icon were used. These icons were chosen because they symbolically allow to maximize/minimize the amount of information. Maximizing allows you to capture more information briefly, while minimizing allows for a clearer, less cluttered view. However, respondents incorrectly associated these icons with a move function, which interfered with the desired navigation function. Based on student feedback, these icons were replaced with a zoom in / zoom out icon to improve the clarity of the function for navigating between the summary and detailed views and to optimize the UUX (Fig. 3).

In the further process of the study, it turned out that the users had difficulties finding their way in the flat hierarchy with the help of the zoom in / zoom out between the views. The previously used zoom icons, which stood for the detailed view, were recognized as not sufficiently intuitive. Consequently, we

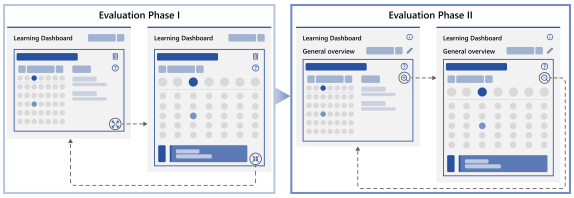

Figure 3: Detailed presentation of changes from the first evaluation phase to the second evaluation phase.

replaced these icons with a larger button to better signify view transitions. In the eye-tracking study conducted (Drzyzga et al., 2023), it became clear that, on the one hand, the combination between text and icon (arrow pointing to the right, thereby indicating the navigation direction) and, on the other hand, the enlarged button reinforced the interaction with the button and was more intuitive. Figure 4 illustrates the navigation concept's evolution from the second to the third iteration step.

These adaptations for intuitive navigation, like the zoom in/out icons and the enlarged button, also demonstrate RQ1. They highlight the incorporation and implementation of user feedback in iterative cycles to enhance the LD's usability and efficiency.

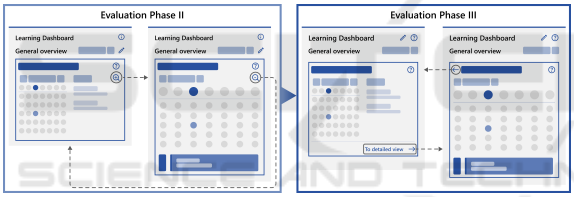

Figure 4: Detailed presentation of changes from the second evaluation phase to the third evaluation phase.

As a result, it showed that, in contrast to the previous evaluations, all participants reached the navigation to the detailed view.

Navigation was also supported by the introduction of text elements that always indicated to users which area or level of the LD they were currently in (Figure 5). This improvement made it possible to reduce the feeling of disorientation and further minimize cognitive load.

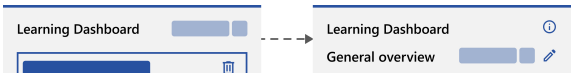

Figure 5: Adaptation of a text element for improved orientation in LD.

3.2 Focused Evaluation Based on Interaction Principles

In the previous section, the focus was on optimizing specific interaction elements. In this section, we aim to take a more in-depth look at interaction principles. By analyzing the principles of Self-descriptiveness, Conformity with User Expectations, Learnability, and Robustness to User Error, an understanding of how the interaction concept affects the UUX is gained.

These principles directly address RQ2, exploring how the refinement of the interaction concept through iterative development impacts UUX in LDs.

3.2.1 Self-Descriptiveness and Conformity with User Expectations

A consideration of the principles of Self-descriptiveness and Conformity with User Expectations led to findings regarding user expectations and further results of intuitive navigation. It was determined that the introduction of a "back button" was identified as a necessary addition to provide users with a familiar navigation option. Participants expressed that they are used to finding a back button in the upper left margin from other applications, which was missing in our concept (Fig. 1).

Furthermore, the importance of feedback mechanisms became clear from the user feedback. Here, it was highlighted that visual feedback after interaction can provide confirmation to users whether their action was successful or whether an error occurred.

Likewise, the need for an accessible and easy-to-understand help section, signaled by a question mark icon, became clear. Users emphasized that such a feature is of great importance to them, especially when ambiguities or difficulties arise. In addition, participants stressed the importance of consistent placement of elements, especially icons, to avoid confusion.

3.2.2 Learnability and Robustness Against User Error

The primary aim of these principles was to make the interaction concept easy to learn and use. During the evaluation, it was found that users were unsure how to edit and add dashboard elements. To address this issue, clear instructions and guidance were added to guide the user through the process, Drzyzga and Harder (2023b) have already fully executed this approach in their work. Additionally, mouse hover support was introduced, providing extra information or instructions when hovering over an element.

A central consideration was the robustness of the interaction concept against common user errors. The evaluation showed that accidental deletion of cards was a recurring problem. Participants appeared overwhelmed after an accidental deletion, with reactions such as *"Did I just press somewhere?"* or *"How did that happen?"*. To counteract this problem, additional

confirmation prompts were introduced before deleting a card.

The eye-tracking study showed, regarding the interaction concept, that one participant had difficulty deactivating the edit mode again.

4 CONCLUSION

After thorough evaluation and iterative optimization, this chapter presents the last version of the interaction concept for the LD in the evaluation process. The findings collected in the previous chapters and the feedback from the users provided the basis for the elaboration of this last concept. The goal was to create a user-centered and intuitive interaction concept that significantly improves the UUX (Fig. 6).

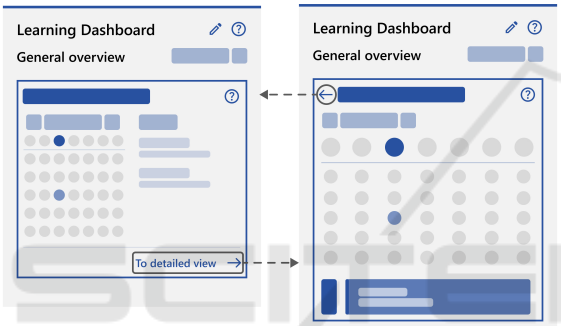

Figure 6: Presentation of the last interaction concept in the evaluation process

This version features evaluated icons that were refined during an extensive iterative process. In addition, navigation that was identified as intuitive in the tests was integrated into the LD, but its technical effectiveness has yet to be validated. Based on this, it must be considered whether the developed interaction concept also proves itself in technical reality.

In the following, the core components of the latest interaction concept of the evaluation process as well as the underlying design principles are presented in detail.

4.1 Navigation and User Guidance

In the latest iteration of the interaction concept, the navigation structure takes a central role. Although the hierarchy is inherently flat, a clear and defined navigation path was established through iterative evaluation cycles. This ensures that users can navigate between the summary and detailed views seamlessly despite the clarity of the user interface. Sahin and Ifenthaler (2021) note this approach helps prevent disorientation in online students.

The specific positioning of navigation icons follows established design conventions that have been established through empirical research in the field of user interaction. In alignment with the findings of Molich et al. (2004), the specific positioning of navigation icons supports users to better understand the structure of the application and to navigate efficiently through the user interface. The integration of text buttons with arrow icons, found helpful in feedback rounds, clarifies navigation paths and enhances user guidance (Molich et al., 2004). Here, the arrow icons act as signifiers that signal the direction of navigation and thus reinforce the affordance of the text buttons (Pucillo and Cascini, 2014; Norman, 1999). The visual and semantic support of the arrow icons makes it clear to users in which direction the navigation paths lead. This allows for intuitive user guidance. It should be noted that this consideration took place exclusively in a simulated environment. A test of the interaction concept under real conditions is still pending.

The interaction concept also features a strategically placed ”back button” in the upper-left corner (Fig. 6), aligning with common application interface standards (Sahin and Ifenthaler, 2021). In addition, based on the findings from the observation of the factual and interaction problems, a text element was introduced that always indicates to the user in which area or on which level of the dashboard the user is currently located (Fig. 5). This adjustment assists the user in reducing feelings of disorientation and further minimizing cognitive load (Sweller, 1988).

Ongoing refinement of these navigation features aims to meet user needs and align with latest research in user guidance and interaction (Susnjak et al., 2022).

4.2 Interaction Elements

A precise and thoughtful design of elements was key in the latest iteration of the interaction concept. These elements serve as crucial intermediaries between online students and the system’s functions. The iterative design process of the icons was fundamental to the improvement of the UUX, supported by the continuous collection and analysis of user feedback (Sahin and Ifenthaler, 2021). Each iteration involved testing the icons against criteria such as clarity, recognisability and user expectations. User feedback, obtained through usability testing, was instrumental in this evaluation. The success of each iteration was measured by improvements in user interaction metrics, including task completion time, icon usage accuracy, and user satisfaction. These measures were related to the research questions. For RQ1, the impact of iterative feedback cycles on design and function-

ality improvements was evident through the progressive refinement of icon clarity and utility. For RQ2, improved learner motivation and effectiveness in the Moodle LD was observed through increased usability and positive user feedback in subsequent iterations.

The question mark icon, which was integrated into the LD from the beginning, deserves special attention. It was not just a design decision but was intended to anticipate and address the potential uncertainty and questions of online students. In doing so, it represents a proactive tool that not only helps users with existing questions, but also helps prevent future uncertainties from arising in the first place.

In addition, the pencil icon was integrated into the interaction concept as an interaction element. In this way, online students are enabled to customize content in the LD according to their needs (Nguyen et al., 2021). The integration of the pencil icon signals that users are actively involved in designing and customizing their learning environment. Overall, the design and interaction elements embody a scientific and methodological approach, aligning with online students' cognitive and emotional needs and narrowing the gap between user and technology.

4.3 Adaptive Interaction Mechanisms

The developed interaction mechanisms within the interaction concept are characterized by their adaptability into the LD. The results show that this adaptability not only increases user satisfaction, but also increases the efficiency and effectiveness of the interactions. Han et al. (2021) underscore the importance of adaptability in LDs, demonstrating how adaptive feedback mechanisms promote interaction efficiency and user satisfaction in university settings.

A key finding is the intuitive editing and customization of the LD, corroborating Drzyzga and Harder's (2023) research on the significance of such features. However, during the interaction approach, it becomes clear that customization of the learning environment corrects with the results of a reduction in cognitive load and increased user engagement. The immediate feedback from the system to the user is another aspect of the interaction concept. Continuous feedback, whether through visual signals, has been shown to be crucial in minimizing user uncertainty and providing a sense of reassurance (Chen et al., 2021).

Proactive system support is another critical aspect. The integration of alerts and confirmation prompts significantly reduced the number of user errors in various user tests, demonstrating a tangible benefit of predictive support mechanisms (Nielsen and Molich, 1990). These proactive strategies, designed to anticipate and prevent user errors, align with Han et al.'s (2021) findings on their importance in LDs. By reducing user errors, these mechanisms enhance UUX and effective navigation in practical learning contexts.

5 OUTLOOK

The presented interaction concept for the LD represents an important step towards a user-centered and intuitive learning environment. By applying an iterative methodology based on UCD, this concept clearly stands out from existing approaches. It is specifically tailored to the needs of online students and offers a customized solution to improve the UUX.

This research offers multidimensional insights: it contributes to LD research by demonstrating how a user-centered approach can improve the UUX. In contrast to many existing LDs, which are often based on standardized interaction models, our concept focuses specifically on the specific requirements of online students.

Future pilot projects in various learning environments will evaluate both the technical practicability and user acceptance of the developed concept. These projects will serve to identify the strengths and weaknesses of the current design and further optimize usability. An important focus of future research will be to investigate how the iterative design process influences user engagement and effectiveness in the context of LDs.

In summary, this work provides a solid basis for the further development and empirical testing of the interaction concept in real-life scenarios. The ongoing research project opens up promising opportunities for a targeted refinement of the concept in order to further improve the learning experience of online students.

Furthermore, it is crucial to test the interaction concept in terms of its applicability and effectiveness in different learning contexts. This includes analyzing the usability, intuitive navigation and adaptability of the concept to different user profiles. Particular attention should be paid to how the concept responds to the individual interaction patterns and preferences of online students and how it helps to simplify and personalize interaction with the learning material.

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