Student-centered Development of an Online Software Tool to Provide Learning Support Feedback: A Design-study Approach

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Abstract: Students in online degree programs have a higher risk of dropping out (Diaz, 2002; Beard and Harper, 2002; Baker et al., 2015). The use of learning support tools such as learner dashboards (LD) can promote self-regulated learning, which can have a positive impact on student learning (Jivet et al., 2018; Konert et al., 2016). This paper presents a three-stage design study and shows how the layout of the proposed LD was implemented from the initial digital design to a low-fidelity prototype. First, the developed wireframes were checked for consistency with respect to the Gestalt laws (Wertheimer, 1922). From the resulting wirefame design, a clickable low-fidelity prototype was developed. In the second step, this interactive prototype was reviewed by students (n=24) respect to the seven interaction principles (DIN EN ISO 9241-110, 2020). In the third step, the revised prototype was subjected to an eye-tracking procedure using the Thinking Aloud technique (n=10). The results so far show that the LD should be presented at a reduced information level during initial access, but that this level can be supplemented by additional elements if necessary. The navigation hierarchy should be kept flat and the information should be easy to understand.

1 INTRODUCTION

In order to be able to offer students of digital study programs support that promotes learning during their studies and to reduce dropout in this form of study overall, a research project of a university network for digital study programs with over 4,000 enrolled students is investigating how students could be supported in their learning process (Diaz, 2002; Beard and Harper, 2002; Baker et al., 2015). To this end, a learner dashboard (LD) is being developed to stimulate student self-regulation. The LD is to be integrated as a plug-in into the university network's Moodle learning management system (LMS) and, once completed, will be made available to the community as open source. Within the framework of a user-centered design (UCD) approach, it is to be investigated which indicators, representation, information and intervention possibilities could be useful in this process and in which way. To this end, a design-study was conducted that employed various usability methods in three steps to obtain qualitative feedback for the implementation of the user interface from experts (see Figure 1).

The design-study is based on findings from an initial literature review with the focus on self-regulated learning in digital learning environments and expert interviews (n=9). Based on these findings, a first wireframe was implemented in the winter semester 2021 / 2022 and subsequently evaluated (Figure 1, Level 1). During the summer semester of 2022, a low-fidelity prototype was implemented and is to be used in the Moodle LMS of the university network in the near future as the first development level of an LD (Figure 1, Level 2 and 3). This first technical deployment level provides descriptive evaluations for students. In this paper, we present the research questions based on qualitatively conducted studies presented in the current version of the LD as a work in progress. This approach has proven successful, as it has enabled successive optimization of the design of the user interface with the involvement of experts.

Research Questions (RQ):

- **RQ1:** How must the user interface elements of an online support tool be designed to effectively support learning?
- **RQ2:** How must the user interface and individual

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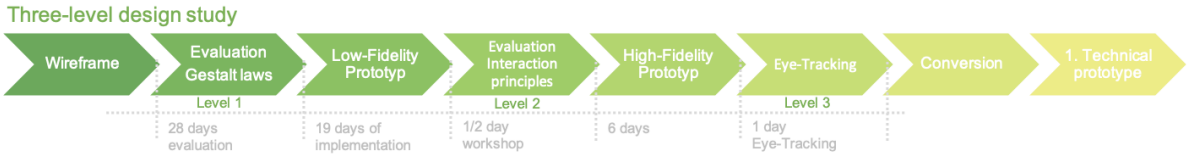

Figure 1: Representation of the three-level design study.

content elements of the online support tool be designed to promote usability and user experience?

2 METHODOLOGICAL APPROACH

The used investigations in the design-study were conducted on the basis of three usability tests with the focus group of students.

1. Evaluation of the wireframe by students (n=24) using the Gestalt laws
   (students of a module on human-computer interaction)
2. Evaluation of the low-fidelity prototype using seven interaction principles.
   (Students of a human-computer interaction module)
3. Student evaluation of the low-fidelity prototype, including examination of the user experience (UX) using the User Experience Questionnaire-Short (UEQ-S)
   (Students of a usability module)

3 DEVELOPMENT AND IMPLEMENTATION OF THE LD

The first graphic design in the form of a wireframe of the LD (Figure 2) formed the basis for the investigations. The wireframe was developed based on the literature review and expert interviews (n=9) as part of the UCD process following the paper prototype method.

3.1 Evaluation based on Gestalt Laws and Fact and Interaction Problems (Step 1)

The wireframe shown in Figure 2 was examined in two parts with an additional assignment over a period of four weeks as part of a module in the online course

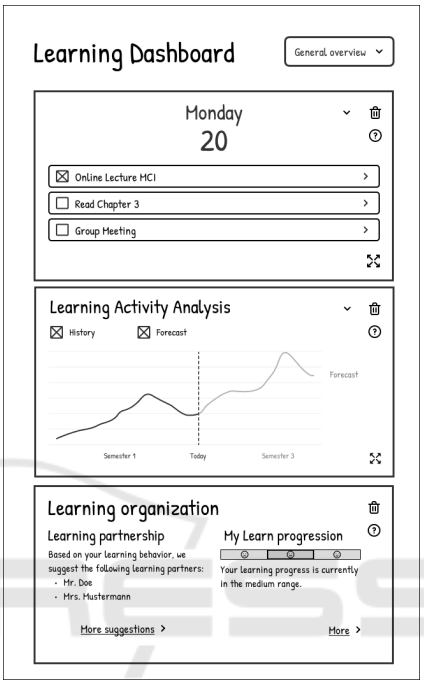

Figure 2: First version of the LD wireframe.

Media Informatics in the summer semester of 2022: In the first part, the online students (n=24) were asked to evaluate the wireframe for the five Gestalt laws: ”Law of Proximity”, ”Law of Similarity”, ”Law of Proximity”, ”Law of (Good) Continuation”, ”Law of Good Gestalt” (Wertheimer, 1922) with at least one positive or one negative example each. The findings of Gestalt psychology are intended to reduce the cognitive effort required to assimilate information in LD in the first place (Wagemans et al., 2012). The second part was to investigate whether factual and interactional problems are present in the design. Both were justified with examples in the elaboration. In the section ”Created alternative solutions of the wireframe by students” the additional task is considered separately with an example. The result of the investigation was a total of 75 DIN A4 pages of student findings. Figure 3 shows an example of an identified problem on the ”Law of Proximity”.

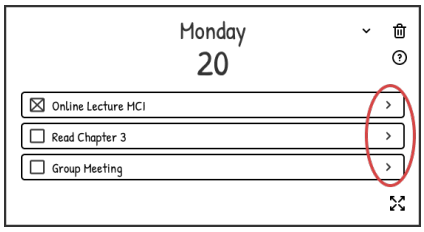

Figure 3: Example from a student of an identified problem with the Gestalt "Law of Proximity".

Alternative Solution of the Wireframe Created by Students

Those students were given the additional task of creating an alternative solution for a map of their choice based on the "Law of Proximity". 11 of the 24 students solved this task. An example of such a design can be seen in Figure 4, which illustrates how students perceive such functionalities and which aspects are important to them. Moreover, this demonstrates the benefits of the approach taken in this design-study, where the involvement of students results in high-quality, student-centered outcomes.

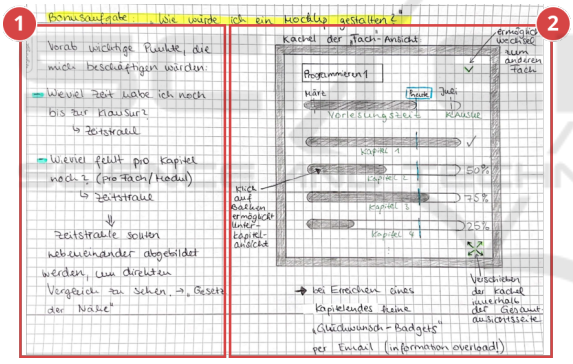

Figure 4: Example of a wireframe of a card developed by a student.

The following text describes the German text shown in Figure 4 in English.

Bonus Task "How would I design a mockup?" The area outlined in red with the number one describes the issues that would concern the student when viewing the card:

- *How much time do I have until the exam? → timeline*
- *How much is still missing per chapter? (per subject / module of study) → timeline*
- *Timelines should be displayed side by side to see direct comparison → "Law of proximity"*

The area outlined with the number two represents the card of the "Course" view. The course "Programming 1" is displayed as the heading. Next to the heading, there is a possibility to go to another course using the downward arrow. Below that, bars for different information are displayed. The top one shows the complete lecture period, including the start of the exam period. The following four progress bars indicate chapters to be completed within the course. Progress bars show a subchapter view when clicked. Click on the icon in the lower right corner to move the card anywhere within the overall view page. A "congratulations-badge" should not be emailed to the student as this could result in information overload.

The navigation concept was revised because it was described as contra-intuitive by those students. In order to take the aspect of individualizability into account, an editing functionality was also integrated. For the calendar, the interaction options were revised (marker element deleted, information expanded or summarized, navigation elements for changing the days of the week). For the learning progress, the graphical representation was adapted by popular request of the students. Due to the variety of information within the LD, an additional information element in the form of a question mark was inserted in a prominent position (in the first line of the grid, right-aligned). This can be used to quickly obtain information about dashboard elements from any view. Figure 5 shows the revision in detail.

3.2 Evaluation based on the Seven Interaction Principles (Step 2)

The revised wireframe served as the basis for creating a low-fidelity prototype. There were 14 different views with different modal dialog boxes in the final version of the LD prototype. The individual interaction elements of the LD (question mark icon, zoom icon, pencil icon, and menu) were designed to be clickable.

The prototype was made available to students of a human-computer interaction module (n=24) for evaluation during a four-hour online workshop via an Internet browser. The experts tested and evaluated the seven interaction principles using a two-part task (DIN EN ISO 9241-110, 2020). The workshop was accompanied by 3 persons from the university sector. The result of the study was a total of 54 DIN A4 pages with the students' findings.

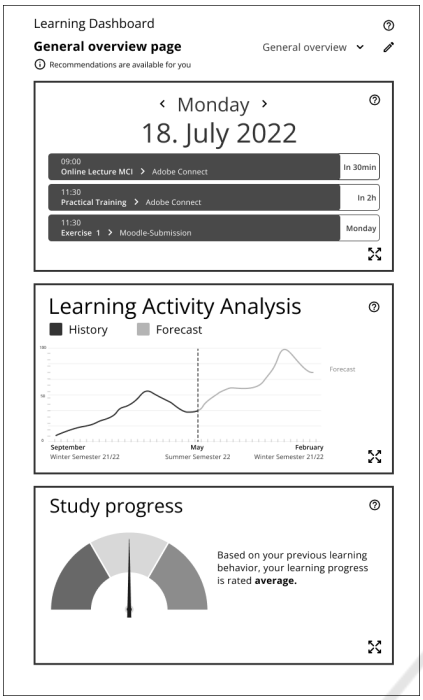

Figure 5: Revised variant of the LD's wireframe.

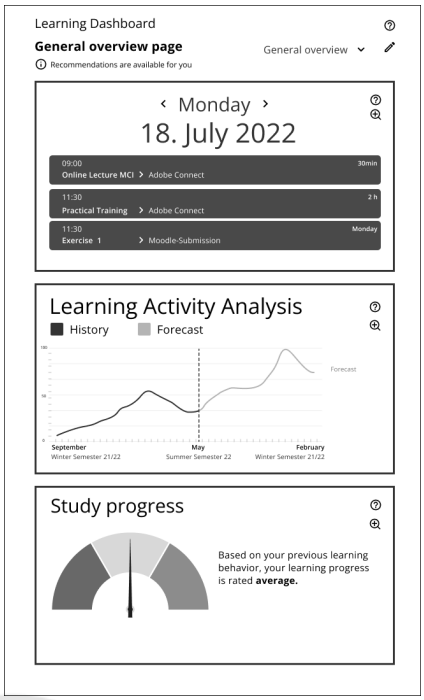

Figure 6: Low-fidelity prototype of the LD.

3.3 Performing the Eye-tracking Procedure with Thinking Aloud (Step 3)

The entire low-fidelity prototype was revised with the new findings (Figure 5 shows part of the revised LD). Afterwards, it was evaluated by a group of students from a usability module (n=10). The entire study was conducted in one day. Each session lasted a total of 30 minutes (including a welcome, introduction of the project, and explanation of the procedure). Students were presented with several subtasks to complete during the 20-minute testing period and were guided by moderators. After the eye-tracking study, students performed a rating of the LD using the short version of the User Experience Questionnaire (UEQ-S) (Schrepp et al., 2017). This was used to evaluate the overall usability of the prototype. Since eye-tracking study was conducted only recently, only the already available results are presented below.

First Results of the Third Step of the Design Study

The students confirmed the implementation of the navigation concept and the general structure of the LD. Specifically, they stated that the descriptions should be precise and brief and can be expanded by clicking on further or more detailed information as needed. This applies, for example, to the recommendations on learning progress, which should initially be presented only in condensed form when the detailed view is called up. The reason for this is that the LD is accepted as an additional element to support learning, but this should not interfere too much with the actual learning time of the students. It should be possible to add additional user-defined information to the assessments (e.g., current exam grades or progress in reading the learning content). However, this needs further research as students expressed that the functionality might be too complicated or time-consuming. For the top-level help page, students would like to see a walkthrough or short slideshow for the LD instead of textual information (also time-consuming). In the usability test, it was found that the navigation structure is not always intuitive: for example, the icon for more information about the displayed content was not always recognized as such. One solution would be to make the entire map clickable. The individual views (overall view, semester view and module view) could not be distinguished in some cases. Here, the way the content is displayed should be reconsidered in order to better distinguish between the different views.

3.4 Student Opinions from the Evaluations

The evaluations clearly showed that the students got a good idea of the future purpose and benefit that the shown wireframes depicted. For example, the students commented in particular on the interaction principle "User Engagement" that the interest was aroused "[...] whether the learning behavior has improved (or worsened) after a few days - the ambition is aroused, game character". Further feedback showed that the students were pleased with the LD in their studies and could imagine "[...] that the available information would lead to structuring my studies further or better and thus increase the chances of success. Which in turn leads to using the system permanently."

4 OUTLOOK & DISCUSSION

The next steps include the evaluation of the eye-tracking study, the revision of the LD and subsequent transfer as a plug-in into the LMS. The results so far show that the direct exchange with the students is crucial in order to be able to offer a LD that is used and accepted. Important aspects and impulses for the information transfer, the design as well as the structure and conception of a learning-supporting LD could be gained. It is important that no additional (time and cognitive) effort is required when using the LD, e.g. for familiarization and understanding of its use, as it bears the risk of not being used by online students. The design study brought substantial results for further research and implementation of the LD in the LMS.

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