Evaluating the Design of a Learning Analytics Dashboard from a User Experience Approach

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Abstract: This study reported the process of developing and evaluating a student-facing learning analytics dashboard (LAD) for an online STEM skill practice system from a user experience approach. A usability survey was administered to 19 LAD users to gather information on what the learners believed were the most important features and what needed to be done to further improve the design of the LAD. Our findings showed that the most important LAD feature to students was showing the accuracy level of their practice and providing the option to redo the practice. These findings informed the revisions of the preliminary design of the LAD and provided insights into future development of student-facing LADs in online learning environments.

Introduction

A student-facing learning analytic dashboard (LAD) compiles important information that is necessary for students to understand their progress, quantify their academic standings, and make their own learning decisions. Research has suggested the benefits of student-facing LADs on providing feedback and facilitating decision-making during the learning process (Duan, Wang, & Rouamba, 2022; Sadallah & Gilliot, 2023). This study reported the evaluation process of a preliminary design of LAD created for STEM Fluency (https://stemfluency.org/), an online learning system that assists students in practicing and mastering their basic STEM skills via explicit practice. The LAD was to be created to provide students with information that allows them to track and visualize their progress and results and thus better monitor their own learning. We took a user-experience (UX) approach to evaluate whether the STEM Fluency student-facing LAD would potentially meet students' needs.

Literature Review

LADs and Its Benefits

A LAD is used within online learning programs to quickly provide important information at a glance to users (Duan, Wang, & Rouamba, 2022). The inclusion of a LAD may serve various goals and better assist student workflows such as "to provide all students with actionable feedback on their learning activities, motivate them to develop more effective learning activities, and help them perform better" (Duan et al., 2022, p.2). LADs automatically collect learners' behavioral data (Bodily, Ikahihifo, Mackley, & Graham, 2018) and visualize the data externally, which helps "amplify human cognition and support learning performance" (Park & Jo, 2015, p.112). In addition, incorporating visual and interactive features can activate learners' innate tendencies to detect patterns, establish connections and make inferences (Sadallah & Gilliot, 2023). As a result, Sadallah & Gilliot (2023) stated that "From a metacognitive perspective, LADs play a crucial role in supporting the process of sensemaking …, allowing individuals to construct meaning and derive insights that inform future actions and decisions" (p.3).

UX and LADs

UX and usability testing is a crucial part of the design process. In reference to LADs and evaluation, Sadallah and Gilliot (2023) noted that UX "provides an overview of the level of comfort to a person's satisfaction with a system and determines areas of improvement" (p.9). The benefits of adopting a UX approach in LAD design can be seen in a few different cases. In one study, researchers found that the information that they gained in LAD usability testing showed the important impacts of visualized information on students' understanding levels (Park & Jo, 2015). In another study, researchers highlighted that UX explained how users form experiences both in their first encounter with a product and as the product is used throughout a certain amount of time (Punchoojit & Hongwarittorrnan, 2017). Having this knowledge allows the designer to more accurately sculpt the design to fit the needs of users. The focus on UX within a student-facing dashboard allows new perspectives to be unveiled, granting access to differing pain points that the designer may not experience firsthand or conceive. In another study, Alvarez (2023) created their own LAD using insights from LAD literature as well as UX research. Perspectives gained from the two areas of research allowed designers to assess the users' needs in a more comprehensive way. UX testing can come in the form of focus groups (Bodily et al., 2018), interviews (Park & Jo, 2015), and surveys (Law, Roto, Hassenzahl, Vermeeren, & Kort, 2009). In this paper, a usability survey was conducted to collect the information needed to improve the preliminary design of the LAD.

To evaluate and improve the design and development of the STEM Fluency learning analytics dashboard, we pose the following research questions:

1. What types of performance data are perceived as most valuable to students?
2. What LAD functions are perceived as most important to students?
3. Based on students' feedback, what can be done to further improve the design of the learning analytics dashboard?

Method

Participants and Procedures

Participants were 19 engineering technology students who had used the STEM Fluency system without a student-facing dashboard for ten weeks to practice their basic math skills. Of those students, all are males. The average age of the participants was 22.61 with a SD of 9.27. To understand the dashboard from a typical user's perspective, a 15-question survey was developed and administered to these students to obtain their suggestions and feedback on (a) perceived value of different types of performance data, (b) perceived importance of different LAD functions, and (c) how well students understand dashboard functionalities when they were presented with the preliminary design mockup. The survey, consisting of four short answers, one long answer, five multiple choice, and five Likert scale questions, had four sections and was developed based on the usability surveys used by Park & Jo (2015) and Law et al. (2009). A summary of different sections of the survey is presented in Table 1.

Table 1. Survey Question Section Descriptions

SECTION	TYPE	DESCRIPTION	EXAMPLE QUESTION
Perceived Value of Performance Data	Five-point Likert scale questions	How important students think certain types of performance data are	"How important do you think it is to see the following data?"
Perceived Importance of LAD Functions	Five-point Likert scale questions	How important students think certain LAD functions are	"How important is the following function to you?"
Degrees of Understanding	Multiple choice questions	How well students understand dashboard functionalities when they were presented with the preliminary design mockup	"What feelings do you encounter as a result of your initial look at the dashboard?"
Additional suggestions	Long answer	Areas for improvement not covered in the survey questions	"What additional data would you like access to?"

Section one, Perceived Value of Performance Data, consists of five-point Likert scale questions broken down into four subcategories, one for each data type, with four to five questions in each. These questions sought to gain an understanding into users' perceptions of how valuable each of the provided types of performance data tracking are including accuracy, fluency, and others. Section two, Perceived Importance of LAD Functions, also consists of five-point Likert scale questions, but without subcategories. Section two contains nine questions, each denoting a potential LAD function with the purpose of gauging how important each function is to the survey participants. A breakdown of the Likert scale questions for section one and section two can be found in Table 2 and Table 3 respectively. Section three measures students' degrees of understanding of the LAD, i.e., how well students understand dashboard functionalities when they were presented the preliminary design mockup, mockup photos of two sections of LAD (see Figure 1 & Figure 2 in the Results section) were presented to the students and they were asked to spend a few minutes reviewing the images before selecting as many words as they feel accurately depict the emotions that arose during the review. The word list included: overwhelm, autonomy, confusion, helpful, stressed, knowledgeable, calm, understanding, and I don't feel anything. The same list was provided for both figures. Lastly, section four, Additional Suggestions, contains a final long answer question to gain insight into any additional information that was not revealed in the previous sections.

Data Collection and Analysis

First, student's responses to the survey questions were collected and analyzed. All students' responses to the five-point Likert scale questions on Perceived Value of Performance Data and Perceived Importance of LAD Functions were coded from -2 ("Very Unimportant") to 2 ("Very Important") with "Not Important or Unimportant" being 0. T-tests were conducted to see whether students' ratings on the items were significantly higher than 0. Second, the mean of students' responses to multiple-choice questions on Degrees of Understanding were calculated and presented in graphs. Finally, students' responses to open-ended questions were carefully analyzed to identify the common themes in relation to their responses to the previous questions.

Results

Perceived Value of Performance Data

Table 2 highlights students' answers about what types of performance data they wanted to see and how they preferred the data to be presented. In the table, accuracy refers to the percentage of questions answered correctly by a student. Fluency refers to the average time that a student takes to complete a question.

Table 2. Perceived Value of Performance Data Types Shown for LAD (n=19)

CATEGORY	ITEM	M	SD

ACCURACY	Show accuracy for a single assignment *in number*	1.16***	1.07
	Show accuracy for a single assignment *in graph*	0.68*	1.25
	Show accuracy changes over weeks *in number*	0.79**	1.13
	Show accuracy changes over weeks *in graph*	0.95***	0.97
FLUENCY	Show fluency for a single assignment *in number*	0.82***	1.07
	Show fluency for a single assignment *in graph*	0.32	1.16
	Show fluency changes over weeks *in number*	0.47	1.17
	Show fluency changes over weeks *in graph*	0.68**	0.95
OTHER	Show accuracy rank compared to other students	0.21	1.18
	Show fluency rank compared to other students	0.11	1.05
	Show change in accuracy, comparing current performance to with previous ones	0.53	1.12
	Show change in fluency, comparing current performance with previous ones	0.37	1.01
	Show frequency of access to the dashboard	0.21	1.03

*$p < .05$. **$p < .01$. ***$p < .001$

The data above reflects that the type of performance data with the highest perceived value is presenting accuracy for a single assignment in number [M = 1.16, SD = 1.07] in the LAD. Additionally, participants found the following types of performance data to be important, as indicated by mean scores that are significantly higher than zero: "accuracy changes over weeks in graph" [M = 0.95, SD = 0.97, t(18) = 4.26, p<.001], and "fluency for a single assignment in number" [M = 0.82, SD = 1.07, t(18) = 3.44, p<.001], "fluency changes over weeks in graph " [M = 0.68, SD = 0.95, t(18) = 3.15, p<.01], "accuracy changes over weeks in number" [M = 0.79, SD = 1.13, t(18) = 3.03, p<.01], and "accuracy for a single assignment in graph" [M = 0.68, SD = 1.25, t(18) = 2.39, p<.05].

Perceived Value of LAD Functions

Table 3. Perceived Importance of LAD Functions (n=19)

FUNCTION	*M*	*SD*
Having the option to retake an assignment	1.37***	1.02
Instantly viewing your performance after completing an assignment	1.26***	1.10
Customizing your assignments by selecting the skills you want to practice	0.63*	1.01
Having a recommender that suggests what you need to practice next	0.58	1.22
Setting up your own learning goals (e.g., The level of accuracy that you want to reach when you practice a skill again)	0.52	1.35
Having points that recognizes your progress and efforts	0.37	1.02
Having badges that recognizes your significant progress	-0.11	1.24

*$p < .05$. **$p < .01$. ***$p < .001$

Table 3 provides the means and standard deviations of students' responses to the perceived importance of different LAD functions. From the above table, we can see that the functions with the highest levels of perceived importance are (a) "the ability to retake an assignment" [M = 1.37, SD = 1.02, t(18) = 5.90, p<.001] and (b) "the ability to instantly view your performance after completing an assignment" [M = 1.26, SD = 1.10), t(18) = 5.01, p<.001]. Another function with statistically significant perceived importance is "customizing your assignments by selecting the skills you want to practice" [M = 1.63, SD = 1.01), t(18) = 2.72, p<.05]. Additionally, we can see that the function with the lowest perceived importance is "having badges that recognize your significant process" [M = -0.11, SD = 1.24, t(18) = 0.37].

Degrees of Understanding

Figure 3 shows the results of participants' perception of the Single Assignment LAD (Fig. 1). Figure 4 shows the results of participants' perception of Over-Time Performance LAD (Fig. 2). The findings suggested that most of the students believed they understood the LAD functions well, as indicated by the number of students who chose "understanding", and the LAD would be helpful, as indicated by the number of students who chose "helpful". However, a good number of students (42.1%) felt the LAD presented in Figure 1 was overwhelming. As three students mentioned later in their survey responses, the addition of a guide or tutorial might help minimize the amount of time spent initially understanding the LAD. Students' responses to Figure 2, in contrast, showed a lower percentage of Overwhelm (5.3% versus Figure 1's 42.1%) as well as a higher percentage of both Knowledgeable (42.1% versus Figure 1's 31.6%) and Calm (42.1% versus Figure 1's 21.1%).

Figure 1. Single Assignment LAD

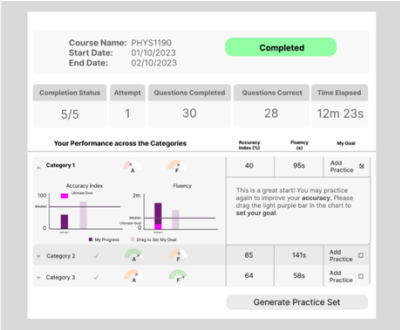


Figure 2. Over-Time Performance LAD

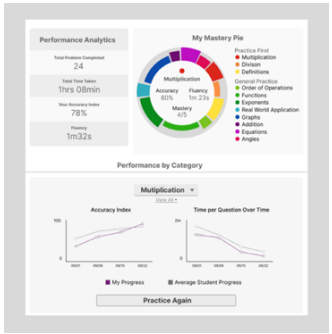


Figure 3. Participants' Degree of Understanding for the Single Assignment LAD

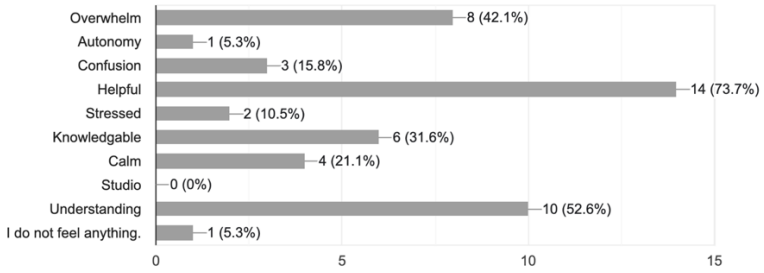
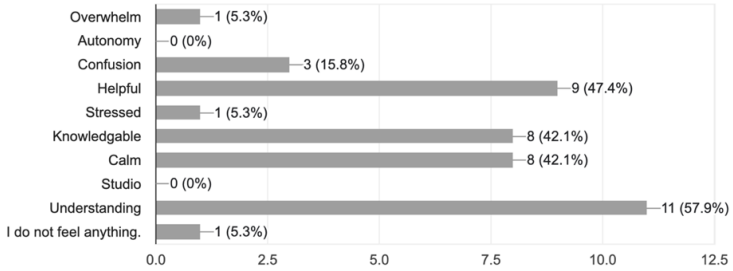


Figure 4. Participants' Degree of Understanding for the Over-Time Performance LAD



Student's Comments

Out of 19 participants, two participants spoke completely negatively, eight participants spoke completely positively, and the remaining nine spoke mostly positively with some constructive criticisms. Those who spoke negatively about the LAD mentioned that "It felt like I'd have to scour the page to access my information" and that the LAD, "needs a better layout and description of graph and stat elements. Too much info being crammed in a small

space and dull colors." Participants that spoke positively about the LAD note on the data being "well organized and easy to read" as well as the LAD being "very simple and helpful". Other criticisms that emerged were that the LAD is too cluttered, some elements need additional labels, and colors need to be more vibrant. In addition, some students provided specific suggestions to improve the LADs, including, "the ability to choose what's displayed on the pie would be helpful" and "an addition of a secondary color may help with engagement and organization".

Scholarly Significance

The user experience study of the dashboard design holds significant importance in enhancing the Learning Analytics Dashboard (LAD) for students. By adopting a User Experience (UX) approach, the survey results offer valuable insights into the features and functions of the LAD that are deemed important by students. This approach allowed for a thorough examination of the students' perceptions, leading to revisions and refinements in the early design of the LAD. The adjustments made were substantial, incorporating elements such as presenting performance data with high perceived value, enabling students to retake assignments, and providing instant access to their performance data. Furthermore, the creation of a comprehensive tutorial aimed to improve the overall navigation experience for students within the LAD.

The significance of this UX study lies in its departure from an exclusively internal perspective-driven design approach. Acknowledging the limitations identified by Sadallah and Gilliot (2023) in literature-only driven design approaches, where human factors related to intended dashboard use and decision-making were not explicitly integrated, the present study incorporates user experiences as a pivotal element in shaping the future iterations of the STEM Fluency LAD. Aligning with Sadallah and Gilliot's concerns, the current study addresses human factors concerning decision-making and dashboard use. It ensures that specific features perceived as important by users are integrated into the dashboard's future iterations. Beyond the immediate improvements to the current LAD, the findings from this study hold broader implications. They serve as a foundation to inform the design of future similar Learning Analytics Dashboards, guiding decisions on crucial aspects such as the types of performance data deemed most important and the functions that contribute significantly to student learning. In essence, the user experience study not only refines the current dashboard but also contributes valuable insights to the broader field of Learning Analytics Dashboard design, promoting a user-centric and effective approach to enhance student learning experiences.

References

Alvarez, N. E. (2023). Designing a Learning Analytics Dashboard: A case study inside the Novare Potential Boot camps. *Master's Programme in Media Management*.

Bodily, R., Ikahihifo, T. K., Mackley, B., Graham, C. R. (2018). The design, development, and implementation of student-facing learning analytics dashboards. *Journal of Computing in Higher Education*, 572-598.

Duan, X., Wang, C., & Rouamba, G. (2022). Designing a Learning Analytics Dashboard to Provide Students with Actionable Feedback and Evaluating Its Impacts. *Proceedings of International Conference on Computer Supported Education*.

Law, E., Roto, V., Hassenzahl, M., Vermeeren, A., Kort, J. (2009). Understanding, Scoping and Defining User eXperience: A Survey Approach. 719-728.

Park, Y., & Jo, I. (2015). Development of the Learning Analytics Dashboard to Support Students' Learning Performance. *Journal of Universal Computer Science*, *21*(1), 110-133.

Punchoojit, L., & Hongwarittorrn, N. (2017). Usability Studies on Mobile User Interface Design Patterns: A Systematic Literature Review. *Advances in Human-Computer Interaction*.

Sadallah, M., & Gilliot, J. (2023). Generating LADs that Make Sense. *HAL Open Science*.

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