Towards a next generation design-aware learning analytics integrated system: scaffolding assessment design and learning analytics literacy in smart learning environments

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Abstract

The potential for teachers to make meaningful and effective use of learning analytics (LA) depends on decisions they make right from the start of their learning design (LD) stage. For LA to provide feedback that is appropriate to for the specific pedagogical context (i.e., for the LA to be design-aware) the clarity of LD and the appropriateness of the assessment tasks matter. It is also important for the teachers concerned to be able to generate actionable LA questions (LAQs) and be able to ensure that their LD can generate the requisite data to address the LAQs. This study is design-based research that investigates how students in a master's course on Learning Design and technology navigates the process of developing a complete LD that includes design-aware learning analytics feedback to teachers and learners, scaffolded by a first iteration of a GenAI integrated SLE designed to support the entire LD to e-Learning implementation to LA generation system. Analysis of the evolution of the design artifacts identified challenges encountered by the students. The results show fine-grained challenges in students' understanding of learning outcomes, assessment design and the formulation of LAQs. These will be used to refine the existing SLE to provide more customized scaffolding.

Keywords

Design-aware learning analytics, Learning design, LD-LA integration, SLE

1. Introduction

The effective use of learning analytics (LA) requires a combination of pedagogical knowledge and supportive contextual conditions [1]. Assessment design, as an integral component of learning design (LD), influences the type of learning data collected and the extent to which it can generate meaningful insights through LA. Constructively aligned assessment design is essential for enabling feedback mechanisms and creating opportunities for reflection [2]. Thus, challenges in identifying and using LA begins at the LD stage, mediated by teacher inquiry [3], and revolve around how LA can support the continuous improvement of LD [4]. Law and Liang [5] put forward a multilevel integrated LD-LA framework that specifies a 7-step development process — from the identification of intended Learning Outcomes (iLOs) to the final

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presentation of design-aware LA visualizations. Building on this framework [5], IDEALS is developed as a smart learning environment (SLE), providing real time contextual feedback**Error! Reference source not found.**. It adopts a design pattern language [6] and provides structured process scaffolding to assist teachers in developing their LDs, formulating design-appropriate LA questions (LAQs), and specifying LA visualizations and feedback for implementation. Figure 1 shows the interfaces for two of the three interconnected components comprising IDEALS: the Learning Design Studio (LDS) and the Moodle-based interactive Learning and Assessment Platform (iLAP). LDs completed in LDS can be converted into a course room on iLAP. Students can consult the LDFacilitator in LDS during the entire design process. The LDFacilitator is a retrieval-augmented generation (RAG) chatbot powered by GPT-4o and grounded in a robust pedagogical knowledge base that underpins IDEALS. To reduce unsupported outputs, the LDFacilitator follows standard RAG guardrails: it is instructed to prioritize the retrieved evidence, to avoid guessing beyond the provided context, and to ask clarifying questions when the available evidence is insufficient.

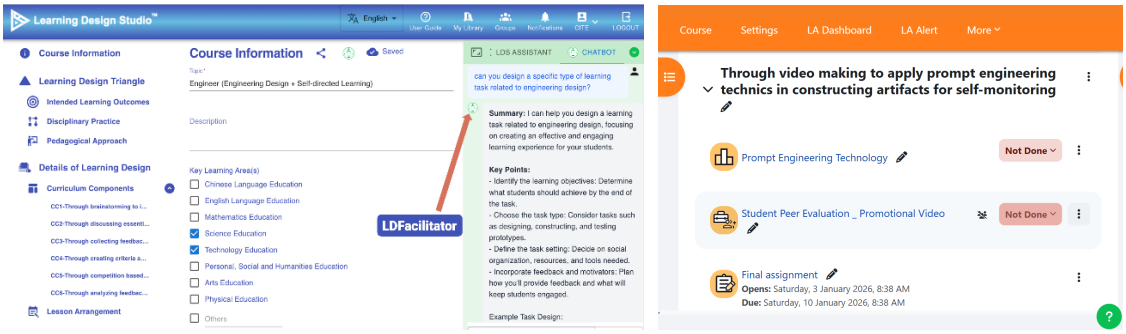

Figure 1: The two main interfaces in IDEALS—LDS (left) and iLAP (right)

The purpose of the present study is to examine the adequacy of IDEALS in scaffolding novice learning designers in the specification of design-aware LA for their LDs. In particular, the LDFacilitator does not have specialized knowledge about novice designers' understanding (or lack of) about LA and LAQs.

2. Study Context and data collection

This study was conducted within a master's-level course on Learning Design and Technology in 2025. As shown in Table 1, the course comprised eight 3-hour face-to-face sessions. Sessions 1–4 focused on LD principles and pattern languages, while Sessions 5–8 addressed assessment design and LA. A group-based min-course design project formed the "backbone" around which students progressively applied the knowledge and skills introduced in the course. The design process began in Session 3. Each week, groups progressively developed their designs on LDS, used a Notion wiki for recording their work process, and reported the design work over the past week using slides. This was followed by breakout discussions, peer evaluations, teacher feedback, and an introduction to the focal design aspects to be completed for the next week, including key concepts, tools, and relevant resources. While the design process appears to be linear, the groups were free to backtrack and revise any design aspects they have done before. Table 1 presents the list of weekly course topics.

Table 1
The course outline of Learning Design and Technology during Session 1A, 2025

Session	Topic & key concepts
1	Introduction to learning design and Learning Design Studio component of IDEALS
2	Levels of pedagogical design, constructive alignment [7], curriculum components and design patterns
3	Designing an inquiry-oriented course using the Learning Design Triangle
4	Adopting and adapting learning design patterns
5	AI Literacy, assessment design and learning analytics
6	Learning analytics dashboards and feedback design
7	Designing design-aware learning analytics and teacher inquiry of student learning
8	Artificial intelligence, learning design, and learning analytics

To shed light on novice designers' difficulties in incorporating LAQs and LA solutions as part of the LD process, this paper reports on one specific research question: How do novice learning designers' understanding and competency in this integrated design process evolve over time as reflected by the learning design artefacts produced by the student groups?

There was a total of 23 students in the course. Each group determined a theme for their LD. To examine the evolution of each group's LD, we analyzed the quality of all six versions of the LD as represented on the Learning Design Studio (LDS) during the weekly presentations from Session 3 to Session 8, as well as their final assignment. The students' weekly presentation slides and their design logs on each group's Notion wiki were consulted to confirm the quality coding of the LDs. Institutional research ethics approval was obtained, and informed consent was obtained from all students for the study to use all their design artefacts and online learning data.

Due to time constraints, we have selected two of the 6 groups for in-depth analysis for the purpose of this paper. Group 3 and Group 6 were selected for this first round of analysis because they provided more details about their design thinking through their Notion wiki and slides. Group 3 comprised primarily of English language educators with experience in instructional design and business training contexts. Group 6 comprised of STEM teachers primarily from formal school settings with some involvement in adult training.

3. Data and data analysis

An assessment rubric (Table 2) was developed to guide the analysis of design quality, covering five design aspects: (1) intended learning outcomes; (2) assessment task design; (3) learning analytics questions; (4) learning analytics solution specifications; and (5) learning analytics visualizations, interpretations and feedback design. For each aspect, the rubric assessed four key elements that were introduced during the course. The assessment (or quality coding) used a simple scheme: the presence of an element was scored as 1, and its absence as 0, yielding a maximum score of 4 for each learning design aspect. Two raters independently coded the data, achieving a percent agreement of 96.43% (Cohen's Kappa = 0.928) for group 3 and 92.86% (Cohen's Kappa = 0.857) for group 6. The analysis was primarily qualitative, emphasizing patterns of progression across versions. Table 2 provides the details of the rubric.

Table 2
Assessment rubric for evaluating learning design artefacts

Learning Design Aspect [Description]	Key Elements in Each Aspect
1. intended Learning Outcomes (iLOs) [Specific knowledge, skills, and attitudes learners are expected to acquire. Outcomes should be clear, measurable, and aligned with course goals]	1.1. Are iLOs clear, measurable, and aligned with course goals? 1.2. Do they start with active verbs aligned to Bloom's Taxonomy [8]? 1.3. Is the iLO appropriate for the outcome type (knowledge, skills, values)? 1.4. Are appropriate Gen-AI learning outcomes included?
2. Assessment Task Design [Assessment tasks should align with iLOs and enable achievement of targeted outcomes]	2.1. Are the assessments aligned with the iLOs? 2.2. Can the tasks realistically assess the iLOs? 2.3. Is the task nature suited to the cognitive level? 2.4. Are appropriate assessment resources (e.g., rubrics, success criteria) provided?
3. Learning Analytics Questions (LAQs) [Specify clear LAQs aligned with pedagogical intent and course design]	3.1 Are LAQs suited to the specific LD? 3.2 Are LAQs relevant to different levels of design granularity (course, curriculum component, task) and show connections across different components? 3.3 Do LAQs align with pedagogical intent? 3.4 Are the LAQs clear and answerable?
4. Learning Analytics Solution Specification [Define data to be collected, suitable e-learning tools, LA measures, and LA techniques for each LAQ]	4.1 Are appropriate data defined for collection? 4.2 Are suitable e-learning tools and analytic measures specified? 4.3 Are LA measures selected (performance, behaviour, engagement) relevant to the LAQs? 4.4 Are the LA techniques of analysis clear and appropriate?
5. Learning Analytics Visualizations, Interpretations and Feedback design [Provide visualizations and interpretations that address LAQs and offer actionable recommendations for teachers and learners to make the course design design-aware]	5.1 Are visualizations (charts, dashboards) specified? 5.2 Are interpretations meaningful and connected to LAQs? 5.3 Are actionable recommendations provided for teachers/learners? 5.4 Do the layout and annotations create a clear narrative that improves teachers' design or supports student self-regulation?

4. Findings

Results of the LD quality coding over the seven sets of LD artefacts from the two groups are represented as heatmaps (Figure 2). The heatmaps show that both groups demonstrated overall progress for all aspects overtime, roughly matching the curriculum session sequence (see Table 1). Also, Group 3 demonstrated higher quality design and greater progress over time. However, we see that the scores for some elements could revert from 1 to 0, indicating the progress could be shaky. In addition, some elements remained challenging from the start to the very end of the course. We will discuss the findings for each design aspect.

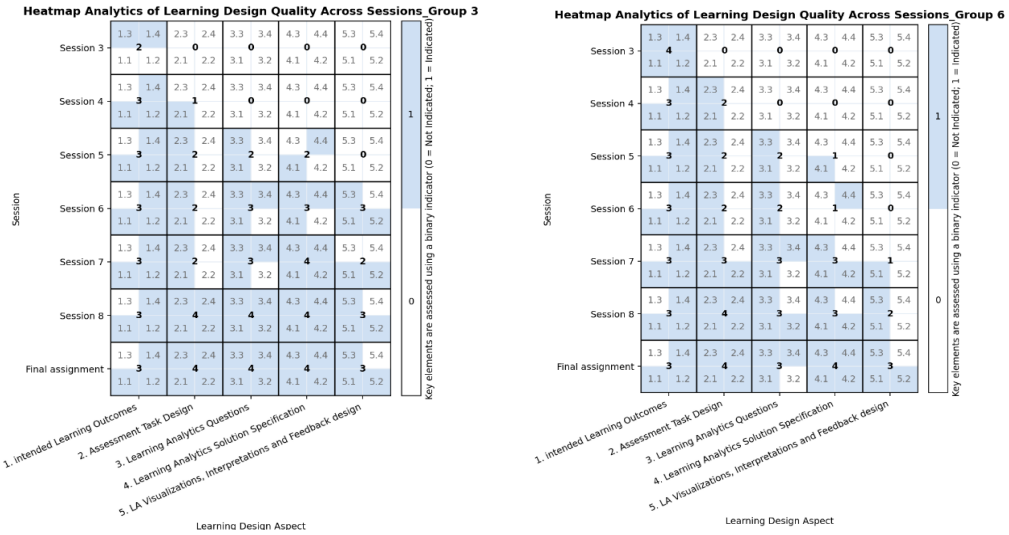

Figure 2: Heatmap showing analytic results of the LD quality according to the five quality aspects across sessions for Group 3 (left) and Group 6 (right). Each cell in the heatmap contains a 2×2 block structure representing the achievement or otherwise of the four assessed elements of the corresponding design aspect. The numeral in the middle of each block records the number of design elements achieved in the respective aspect.

4.1 Intended Learning Outcomes

Across both heatmaps, there is a clear trend toward improving clarity and measurability of iLOs, particularly in mid-to-late sessions. Initially, Group 3 struggled to formulate outcomes aligned with Bloom's Taxonomy [8], while Group 6 demonstrated early proficiency. Students consulted the LDFacilitator on what are the properties of well-defined iLOs throughout the different weeks, indicating that "presence" in the coding may not indicate robust understanding. Moreover, the heatmaps show the element 1.3 remain elusive for both groups even in their final submitted LD. It is not that students' understanding did not progress, but that as they were not able to clearly understand the implications of different types of iLOs (knowledge, skills, or values) in connection with assessment design and LA.

4.2 Assessment Task Design

From session 4, students were required to design assessments aligned with intended learning outcomes. While both groups demonstrated a basic understanding of the need to align assessments with iLOs, their designs lacked detailed e-learning tools and clear grading guidance, making effective assessment difficult. The heatmaps show elements 2.2 (whether the assessment tasks could realistically assess the iLOs) and 2.4 (provision of appropriate assessment resources such as rubrics and success criteria) were absent until Session 7. Fine-grained analysis also shows that students find it difficult to select assessment methods matched to the cognitive level targeted based on Bloom's taxonomy [8] (element 2.3).

4.3 Learning Analytics Questions (LAQs) [1]

The concept of LAQs was only introduced from Session 5. The heatmaps show that 3.1 (connection between LAQ and LD) and 3.3 (LAQ alignment with pedagogical intent) were easier to grasp. However, 3.2 (setting LAQs that connect different levels of design granularity) and 3.4 (clarity and answerability) remained weak. These suggest a strong need for scaffolds to support teachers in formulating LAQs and how to operate them in the form of measurable metrics that yield actionable interpretations.

4.4 Learning Analytics Specification

As the course progressed, students began to include some aspects of LA specifications in their LDs from Session 5: 4.1 (defining the data to be collected) and 4.4 (suggesting appropriate LA techniques). In Session 7, Students were introduced to the iLAP component in IDEALS Students could initiate an automatic conversion of the LD constructed in LDS to be implemented on iLAP, which provides some LA dashboard features. This encouraged students to develop design-aware analytics solutions. However, it also appeared that Group 6 struggled with understanding LA techniques (4.4) even though some evidence of understanding emerged briefly in Session 6. The selection of suitable e-learning tools and analytic measures (4.2) and alignment of LA measures with the LAQs (4.3) were also challenging though some awareness of these elements appeared in Session 5. The heatmaps also show that element 4.4 remained inconsistent across sessions, suggesting that students struggled to articulate their justification for the choice of analytic techniques.

4.5 Learning Analytics Visualizations, Interpretations and Feedback design

Visualization and feedback design were only in focus later in the course. Some elements of this design aspect emerged in Session 6 for Group 3 and Session 7 for Group 6. By the final assignment, both groups showed abilities to incorporate elements 5.1, 5.2, and 5.3 by including dashboards, interpretations, and actionable recommendations. Group 3 used Poe, a chatbot service providing access to several popular LLMs, to design a student-facing Learning Analytics Dashboard (LAD) demo, providing real-time visualizations of learner progress and engagement to support reflection and self-regulation. However, both groups had difficulties in designing feedback layouts and annotations to create a clear narrative and actionable insights (5.4).

5. Discussions

These preliminary findings show that the IDEALS SLE effectively supports novice learning designers in navigating the process of designing LA-incorporated LDs in their design practice. Additionally, students' ability to design appropriate LA is inextricably tied to their understanding of LD. We anticipate that such SLEs will help to bring the benefits of LA to a wide population of teachers and learning designers, while at the same time enhancing their pedagogical design competence. The findings also offer fine-grained insight into the challenges that novices face in designing LDs with appropriate LAQs, LA visualizations and actionable recommendations. Building on these findings, we will further enhance IDEALS by further embedding customized GenAI bots beyond LDFacilitator to address the identified design challenges, serving as human-centred partners in the LD and LA workflow. The conversational agents could also be extended beyond the scope of our current study to include support for the interpretation of LA results and recommendations.

Declaration on Generative AI

The authors hereby declare that Co-Pilot has been used for the copyediting of this manuscript.

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