

# Question-driven Learning Analytics: Designing a Teacher Dashboard for Online Breakout Rooms

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**Abstract**—One of the ultimate goals of several learning analytics (LA) initiatives is to close the loop and support students’ and teachers’ reflective practices. Although there has been a proliferation of *end-user* interfaces (often in the form of dashboards), various limitations have already been identified in the literature such as little account for sensemaking needs. This paper addresses these limitations by proposing a question-driven LA design approach to ensure that end-user LA interfaces *explicitly* address teachers’ questions. We illustrate this in the context of synchronous online activities orchestrated by pairs of teachers using audio-visual and text-based tools (Zoom and Google Docs). This led to the design of an open-source monitoring tool to be used in real-time by teachers when students work collaboratively in breakout rooms, and across learning spaces.

**Index Terms**—computer aided instruction, learning management systems

## I. INTRODUCTION

The field of Learning Analytics (LA) has emphasised the need for enabling teachers and learners to gain a deeper understanding of their own processes and progress, rendered in ways that until now have been accessible only to educational researchers [5]. This has led to the design of various “*end-user*” interfaces (EUIs) that have taken the form of prompts, alerts, recommendations, and dashboards [6]. Among them, dashboards have been particularly attractive since they follow the metaphor of car dashboards that provide only the most critical indicators needed to ensure the effective operation of a complex system. Yet, evidence is pointing at the multiple challenges that educators [7] and learners [8] are facing while trying to interpret LA interfaces to make sense of complex learning activities, as flagged by the recent review of learning analytic dashboards [8].

Since the interpretation of visual interface elements is central to the effectiveness of such dashboards, there has been a corresponding interest in the human factors of EUIs in LA [10]. Some authors (e.g. [4, 2]) have recently proposed ways to include educational stakeholders in the design process to create LA interfaces that are aligned to authentic needs that characterise the context in which they are intended to be deployed. However, whilst progress has been done in proposing design methods to engage teachers and learners in design practices, less attention has been paid to visual techniques facilitating the sensemaking.

The model introduced by Verbert et al. [11] is foundational in the LA community to explain the sensemaking process

that is expected to occur when people face a LA dashboard. This model suggests that teachers and learners are expected to formulate questions and assess how data is relevant for addressing those questions. The need for mapping teachers’ questions to educational concepts for data to be rendered, reported back, and be actionable, is also highlighted by other authors [12]. This emphasis on “*asking questions*” that data should address is critical because it latches on the inquiry cycle that teachers engage in to reflect on their practice [9]. However, it is not clear how the mapping between the teachers’ questions and educational constructs can be explicitly reflected in the visual design of LA interfaces.

This paper addresses this gap by proposing a question-driven LA design approach to ensure that EUIs *explicitly* address teachers’ questions about student progress and their own practice. We illustrate this approach in the context of synchronous online activities mediated by an ecology of communication and collaborative writing tools. We conducted interviews with 15 teaching assistants (TAs) to understand how they monitor groups of students in breakout rooms using video-conferencing software. An inductive process is proposed to extract teachers’ questions, identify the evidence that can be used to address them, and create prototype data representations that are explicitly mapped to such questions. The execution of this process resulted in the design of an open-source dashboard for teachers to monitor synchronous online activities across learning spaces (namely Zoom and Google Docs).

## II. BACKGROUND AND RELATED WORK

**Sensemaking of Learning Analytics Dashboards.** The *interpretation* of dashboards and other visual interface elements is central to their effectiveness in supporting *sensemaking* of teaching and learning activity. Several authors have followed Verbert et al.’s model [11] when designing their LA interfaces to support the sensemaking. The model consists of four steps that continue iteratively. The first step is i) *visualising and presenting* the data to the user (the only step that occurs at the side of the technological development). The second step expects that teachers and learners will ii) *formulate questions and assess* how data is useful for addressing those questions. The final two steps are concerned with the sensemaking process itself with the purpose of iii) *responding to those questions* (i.e. generation of new insights) in order to iv) *perform educationally meaningful actions* (e.g. for learners to change behaviours

and for teachers to perform interventions). However, according to this process, sensemaking is expected to spontaneously occur without any support from the technological side [3]. On the technological side, this process might be scaffolded by enhancing the visualisations of dashboards through the addition of visual elements that emphasise only the relevant data points and trends, and text that explains the data. Making sense of dashboards is a process we should fully understand and design for [12]. They proposed a sensemaking framework for teachers, in which the process starts by identifying the educational questions that the analytics can address.

In short, previous works have conceptually emphasised the importance of identifying the authentic teachers' questions to be answered [11, 9, 12]. However, it is still unclear how the mapping between a teacher's questions and educational constructs can be explicitly reflected in the design of the EUIs in LA. The user interface is commonly the only contact the teacher or learner would have with the analytics innovation, but not much work has focused on supporting the visual design of such interfaces. This requires careful consideration of human factors that shape the effective use of LA interfaces.

**Human-centred Learning Analytics.** The term human-centred learning analytics (HCLA) was recently coined in [10] to refer to the subcommunity of researchers interested in the human factors that can affect the effective use of LA innovations and in the adoption of concepts and methods from design communities to create effective LA innovations. The importance of human-centred design (HCD) in LA has been emphasised in [1] where it is suggested that it is critical to design LA interfaces that incorporate local needs and ensure productive adaptations between educational practices and the technology. Recent works emphasised how: the incorporation of co-design principles gives an active voice to teachers and learners [2]; participatory methods adoption resulted in understanding stakeholders' authentic needs and allowed them to define characteristics of the LA; how co-design approaches can lead to unexpected technological innovations and can increase the likelihood of technology adoption [4]. A different stream of HCLA research has focused on considering the principles of human perception and data literacy. More specifically, adoption of data visualisation principles from Information Visualisation theory – such as relying on goal-oriented chart types, de-cluttering the interfaces and employing narrative elements – to effectively convey insights in LA dashboards [3].

However, less attention has been paid in the literature to design approaches and visual techniques that can facilitate the interpretation of dashboards for the purpose of supporting sensemaking. In this paper, we contribute to the growing body of HCLA literature by proposing a design approach to establish explicit connections between authentic teachers' questions and the visual design of LA interfaces.

### III. APPROACH

Inspired by the emphasis on “*question formulation*” as a key step in the LA sensemaking process [11, 9, 12], and the

need for HCD practices to address authentic needs in LA [4, 10, 12] we propose a question-driven LA design approach to ensure that the end-user LA interface explicitly addresses teachers' questions. We particularly focus on teachers to connect to the inquiry cycle that they commonly engage in to reflect on their practice. The design approach consists of the following 4 steps.

**1- Interviews with teachers** This step involves asking teachers about their current practices while monitoring groups of students. They can be explicitly asked about the kinds of evidence they commonly use to monitor both students' progress and their own teaching practice. Questions should be tailored to the educational context.

**2- Inductive analysis** Based on open answers from teachers, an inductive analysis can be performed to map the critical challenges they face with the evidence that can be used to address them. Codes emerging through this analysis can be thematically grouped to enable the identification of salient questions that participants commonly have. These themes are then ranked by frequency of appearance.

**3- Questions formulation** Each theme is labelled by formulating the challenges faced by teachers in the form of a question. These questions should be formulated using at least some of the words that participants used to express their actual concerns and the sources of evidence they would require. Semantically similar questions might be grouped together forming overarching questions.

**4- End-user interface prototyping** Based on the teachers' questions identified in the previous steps, the most highly ranked questions (i.e., those that address the concerns of the majority of the participants) are explicitly added to the dashboard or LA user interface. Inspired by the notion of data storytelling [3], each question needs to be associated with a particular data story. A data story is a combination of charts and text narrative that is focused on communicating a particular insight. Each component should be aimed at emphasising certain data points that are only relevant to one question at a time to minimise visual complexity.

### IV. EDUCATIONAL CONTEXT AND PARTICIPANTS

The proposed design approach is illustrated in the context of the authentic challenges that TAs face while monitoring synchronous online activities conducted as a part of the graduate course, where students engage in weekly 3-hour online workshops facilitated by two TAs. Students commonly perform a range of collaborative activities in small groups of 4-6 members, using audio-visual and text-based tools (Zoom and Google Docs). When students go to breakout rooms to work on group tasks, TAs cannot commonly see what happens in each room unless they join a particular one and spend some time listening to the conversations or checking the documents generated by the group, which is a critical monitoring challenge.

In our research, an open-source classroom analytics system for Zoom (ZoomSense) was used to capture data traces of students working collaboratively via Zoom. The system works

by creating headless agents that are distributed across the breakout rooms. Once in there, the agents capture who is speaking at each moment, text messages sent, and the actions performed by each student. If configured by the TA, ZoomSense can also automatically create a Google Document for each breakout room, providing the link to students to work on their particular document. All the actions and major revisions performed on the document are also logged. In its original version, ZoomSense only had very basic monitoring functionalities in the form of a simple pie chart summarising verbal participation during breakout discussions. This is the limitation of the system we set to address by following the approach introduced in Section III.

## V. STUDY

This section illustrates how the proposed approach can be operationalised in an authentic learning analytics project. A total of 15 teaching assistants (TAs) participated in this study. Most of them had more than a year of teaching experience.

**Interviews, Inductive Analysis and Question Elicitation (steps 1, 2 and 3)** Each TA was interviewed via the Zoom online communication system following the current government guidelines for physical distancing. A typical interview lasted around one hour, where questions aimed at capturing the general monitoring challenges that TAs face and identifying the evidence TAs use to monitor progress<sup>1</sup>. Then, based on the original capabilities of ZoomSense, some examples of evidence that could be captured were communicated to the participants. Interview transcripts were coded by a researcher and similar emerging code were grouped. Per each group of codes, an overarching question is formulated based on the words used by the TAs. For example, one of the questions “Q1. Are students inactive in Zoom?” corresponds to TAs wanting to know if there are disengaged students in a breakout room, the code for which occurred a total of 16 times by 12 TAs.

**End-user Interface Prototyping (step 4)** Based on the questions elicited from the TAs, a dashboard prototype was designed to explicitly address some of these questions. The prototype consists of five main components each addressing one of the questions which participants highlighted. All the components in the LA interface are dynamic and are updated in real-time. Following data storytelling principles [3], the charts are de-cluttered, showing only the data that can enable rapid comparisons between groups. Only two contrasting colours are consistently used to emphasise elements and also to create a user interface that is colour-blind friendly. Orange colour is used to emphasise cases that may need closer attention. Gray and navy blue are used for the rest of the visual elements. The ZoomSense is currently being used in authentic learning scenarios in different institutions. Each visual component is explicitly labelled with one of the questions.

<sup>1</sup>Full interview guide, elicited questions, a description and code for the prototype are available from: <https://bit.ly/3bnZV4S>

## VI. DISCUSSION AND CONCLUSION

The approach to designing LA dashboards proposed in the paper was illustrated through an ongoing authentic design case of synchronous online group activities in which teachers, in pairs, need to orchestrate group tasks using Zoom and Google Docs. This case may be representative of online classes that are currently relying on the use of similar online tools to conduct small group activities, especially during the COVID-19 pandemic. The ZoomSense system and the resulting dashboard prototype presented in the paper, are currently being deployed and evaluated in three universities.

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