# Understanding the mediating role of teacher inquiry when connecting learning analytics with design for learning

Sakinah S. J. Alhadad[1], Kate Thompson[2]

[1] Learning Futures, Griffith University, Brisbane, QLD 4111, Australia
[2] School of Education and Professional Studies, Griffith University, Brisbane, QLD 4122, Australia
s.alhadad@griffith.edu.au

**Abstract.** Discussion amongst the learning analytics community is for the need to link learning analytics with learning design. However, learning design is a complex space, and not all approaches to design for learning are the same. With this proposed integrated practice comes unique challenges for the contemporary educator. In this paper, we focus on the underlying processes of teacher inquiry when connecting design for learning with learning analytics. We propose that valuable connection between learning analytics and design for learning is only realised through the mediation of effective teacher inquiry processes. Hence, we aim to better understand these processes in order to identify teachers' developmental needs. To this end, we propose a working model and examine educators' (as learners) inquiry process in a professional learning workshop. We conclude with implications for the proposed model and professional learning.

**Keywords.** Learning analytics, Design for learning, Teacher inquiry, Cognition, Design science, Professional learning.

## 1 Introduction

Teachers, at school and at the university, are expected to work in evidence-informed approaches. This often includes using data from assessments and surveys to support continuous enhancements for their specific learning and teaching contexts. Teacher inquiry, defined by a set of systematic, intentional, evaluative, and reflective research practices [1], is the practice through which data and evidence are used to inform educational design and decisions. The aim of this paper is to test a proposed model of inquiry-mediated design for learning. In so doing, we will also investigate the design of professional learning for academic staff to build their capacity to undertake such inquiry in a preliminary case study. We have adopted (and adapted) two frameworks to guide this research: Carvalho and Goodyear's [2] Activity Centred Analysis and Design (ACAD) framework, and Sandoval's [3] conjecture mapping, and ACAD suggests that learning design should account for (1) the designed elements, including tasks (epistemic), role and rules of interactions (social) and digital and physical learning environment and tools (set); (2) learner activity (observable learner behaviour); and (3) the learning outcomes (measurable changes over time). Conjecture mapping [3] then provides a method to identify (1) design conjectures that link designed elements of a learning environment to the desired activity of learners (conjectures about how the design will be enacted); and (2) theoretical conjectures that link the activity taking place in a learning environment with anticipated learning outcomes (conjectures about how people learn).

There are two advantages in using ACAD in combination with conjecture mapping to investigate the role of inquiry as the mediator between design for learning and learning analytics. Both approaches enable clear alignment between the situatedness of actions towards intended learning outcomes. As with other design for learning frameworks, the intended learning outcomes shape the design directions, however when using ACAD for deliberate inquiry for iteration, it is acknowledged that outcomes can encompass broader domains than the original intended design as a product of the emergent activity. According to ACAD, learning (as measured by outcomes or measurable changes over time) is mediated by activity, and as such, places activity – what the students do – at the centre of the design. Hence, we can consider activity as emergent, as influenced by the three designable elements that situates it: (1) set design (it is physically and digitally situated), (2) social design (situated in social structures: roles, group processes, interactions), and (3) epistemic design (the tasks). In both approaches, understanding the emergent activity needs to account for these elements in concert. This reinforces the idea of connecting the important contextual factors in sensemaking with learning analytics in complexity. Analysis of the designable elements and the relationships between them facilitates the assessment of the types of data and design knowledge (including the literature) towards the next round of design work, both pre- and post-teaching [4]. This reinforces the importance of connecting with the extant literature using the principles of scientific inquiry in sensemaking. Critically, this serves as an effective vehicle for analysing the relationships between the designed or designable elements in consideration of levels of cognitive inquiry processes.

The increasingly wide availability of data generated from the use of technological tools and applications creates new opportunities for educators at schools and at universities. The data generated enables teachers to engage in inquiry for learning and teaching with new methods and in time-scales that are more flexible and dynamic than traditional pre-post teaching period cycles. Learning analytics is often referred to as "the measurement, collection, analysis, and reporting of data about learners and their contexts, for the purpose of understanding and optimising learning and the environments in which it occurs" [5]. This emerging work denotes the new and changing nature of data in contemporary education, namely, data traces that are generated by technology and tools. As Reimann [6] argues, even though data has been routinely used in educational research, learning analytics introduces a step-change in that it enables longitudinal collection of data points on various levels of granularity from authentic learning environments. Similarly, we propose that this provides significant opportunities for transforming educational practice through combining learning analytics with established measures to support evidence-informed learning and teaching. Given teachers' motivation and aspiration to engage in this analytics-informed inquiry [7, 8], there is an increasing imperative to elucidate the new and existing challenges in teacher inquiry to facilitate the effective and ethical use of learning data and analytics. Fundamentally, complex factors such as data literacy, design literacy, methodological literacy, and learning literacy underlies ethical use of data and learning analytics [discussed further in 9, 10]. With the growing interest in design for learning innovation [11], increased work pressures for teachers [12], and rapid evolution of technology [4], building teachers' capacity to design for learning effectively, using data and evidence within their contemporary learning environments is both a developmental priority and strategic opportunity. In this paper, we examine ways in which learning analytics might change the conception and practice of teacher inquiry. In particular, we propose that this emerging challenge in the realm of capacity building of the contemporary teacher aligns well within the conception of teaching as a design science.

In what follows, we will provide further discussion of the links between learning analytics and design for learning, as well as the proposed role of inquiry in mediating these processes. We will then describe the study, including the development of the professional learning course, the identification of conjectures, as well as evidence to inform assessment of learning and design. The results of the analysis will be reported, with a revised model and discussions of future work.

## 2 Background

### 2.1 Discussion of Links Between Learning Analytics and Design for Learning

This imperative to bridge the gap between learning analytics and educational practice has led to an increasing call for linking learning analytics with design for learning in order to fully realise its potential in supporting learning and teaching inquiry and enhancements of student learning [13-18]. The advantages for connecting learning analytics with design for learning are clear. The practice of design for learning, particularly for digital learning environments, has seen significant recent adoption [4, 19, 20] in parallel with a substantial growth in the development of tools, models, and frameworks to support teachers [e.g., 21, 22]. Second, while the discipline perhaps lacks a shared common language [21], what design for learning practice does offer is an epistemology that enables the teacher to represent good pedagogy into designed artefacts, processes, and outputs. A product of this practice are design patterns, semi-structured representations of the teacher's method for solving a recurrent issue [23]. These design patterns can therefore serve as the structure and vocabulary when using learning analytics to support design enhancements for learning, and fundamentally act as a means to activate and enable deeper inquiry, introspection, and reflection.

Third, the granularity and temporal scale of learning analytics enables more flexible analysis of near real-time data over long, continuous periods of time. This fits well with the conception of the temporal dimension of design cycles in design for learning [24]. It is this third advantage of linking the two practices (learning analytics and design for learning) that arguably poses the greatest challenge in its integration. While making data more readily available to teachers over the course of the teaching period means that the true flexibility of design cycles may be realised, this in reality, only adds to the challenges in complexity with teaching as design, both in terms of cognitive challenge, but also of behavioural change. As Markauskaite and Goodyear [25] noted, "*The complexities of students' cognition, learning and conceptual change are well acknowledged; it is a mistake to underestimate the complexity of teacher* *thinking involved in design for such learning*". In the same vein, we argue that attempts to connect learning analytics *amplifies* the complexity of *thinking* for such design work. Conceptualising teaching as a design science [4, 26] places an additional emphasis on the deliberate and methodical element of design, one that demands a more rigorous and collaborative approach [26]. A key advantage of intentionally aligning and integrating teaching as a design science with learning analytics is the affirmation of the core identity and role of the educator in the process of inquiry. This enhances opportunities for genuinely evidence-informed practice and ameliorates the pressures of oversimplifying learning enhancement to a data-driven process.

### 2.2 Teaching As A Design Science In A World With Learning Analytics – The Changing Nature Of Teacher Inquiry

With new affordances that learning analytics brings, comes changes to evidence-informed approaches. While this is arguably a defining skill of a contemporary educator, there is increasing evidence that suggest that many teachers may not have the skills necessary to effectively engage in this practice [e.g., 28-30]. In a recent systematic review teachers' use of data [31], many teachers were found to not only lack the skills to effectively understand, interpret, and analyse data in order to develop learning and teaching strategies; they also generally have low efficacy in doing so. Importantly, while these findings point to key aspects of the skill gaps teachers may have when engaging in inquiry processes to enhance their practice, they do not address the current challenges teachers face when engaging with more contemporary methods and techniques such as learning analytics.

Such integrated practice may mitigate some of the challenges experienced in what really is a paradigm shift in contemporary education. Teachers are now faced with complex design and analytics challenges as contemporary educators. Taking the perspective of the developing contemporary teacher, this new opportunity importunes need for professional learning. For many teachers, navigating learning analytics is still a significant challenge [32, 33, 8]. What is required is a deeper examination of this integrated practice in order to bridge salient gaps in teachers' sensemaking. This is a critical step in designing professional learning to support teachers' capability and motivation.

Here, we focus on the process of sensemaking with learning analytics outside of the context of the orchestration or enactment of teaching. These are design instances where more deliberate, higher-order cognitive processes (i.e., System 2; [34]) can really result in productive designs for learning. The alternative, using data during orchestration of teaching, involves cognitive processes that are dependent on the real-time exposition of teaching activities, where cognitive load for thinking about data and design while teaching is high, and thereby, recruiting more of automatic, fast thinking processes (i.e., System 1; [34]). This is out of the scope of the current paper, and is examined elsewhere [e.g., 35, 36].

We argue that effective connection between learning analytics and design for learning can only truly be realised *through* critical teacher inquiry processes. Moreover, viewing the connection between learning analytics and design for learning as a direct relationship underscores the importance of the depth and quality of teacher inquiry processes engaged in when doing so. While these processes are often implicit, we stress the importance of explicating the underlying processes in order to enhance the quality and effectiveness of educational practice. Further, we suggest that the neglect of the teacher inquiry processes as a mediator may increase surface-level or reflexive (rather than reflective) approaches when enacting teaching as a design science in the world with learning analytics.

While there have been a number of calls to connect learning analytics with design for learning or pedagogical practice [13-16], there has been much less consideration of the developmental needs of educators to do so. We propose therefore, that these considerations of the teacher inquiry processes specific to connecting learning analytics and design for learning in its symbiotic mediated relationship, are critical in moving the field forward and effectively and authentically embedding learning analytics in educators practice.

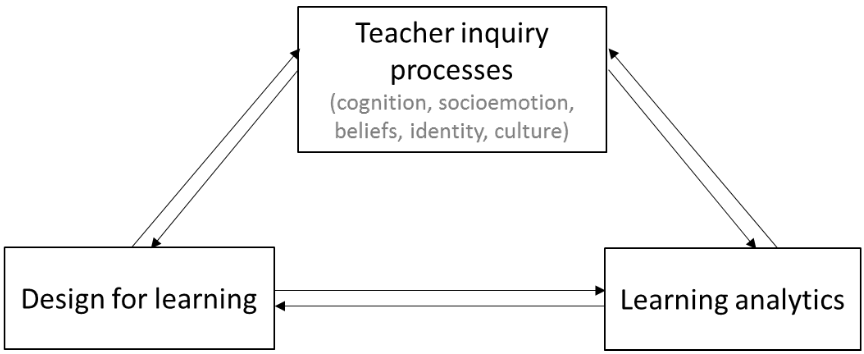


**Fig. 1.** Teacher inquiry as mediator to connecting learning analytics to design for learning.

Here, we aim to elucidate the underlying cognitive processes of teacher inquiry when connecting learning analytics (and other data) with design for learning. We recognise that there are key elements of teacher inquiry that would promote productive design for learning, such as epistemic fluency [37], scientific literacy [38], and data literacy [28]. As illustrated in Figure 1, teacher inquiry processes do not only involve cognition, but rather places importance on the significance of the emotional, social, identity, and cultural dimensions of teacher inquiry that fundamentally views the teacher as a whole being when approaching inquiry processes in their work. Teachers' beliefs about teaching and learning, their socioemotional values and principles, as well as the cultural context, the underpinning values of the teacher or academic identity, and the teacher's consequential beliefs about what is valued in their institutional context all influence the ways in which teachers approach inquiry, as well as their inferences from it. In this paper, we focus on the *cognitive* processes underlying teacher inquiry of the contemporary educator.

## 3 The Development Of Professional Learning For Teacher Inquiry Using Learning Analytics For Design For Learning

To investigate teachers' cognitive processes when sensemaking with learning analytics within a teaching as a design science framework, the first author designed and conducted a collaborative sensemaking workshop. This workshop consisted of a mini lecture exemplifying an approach to connecting learning analytics with a design for learning framework. This was linked to principles of scientific inquiry to further emphasise the utility of more rigorous, evidence-informed approaches to sensemaking, and was followed by a collaborative sensemaking session. In the remainder of this paper, we describe the design of the workshop, and the questions that guided our inquiry into the implications for the model of inquiry as a mediating factor between design for learning and learning analytics, as well as implications for the design of professional learning. Specifically, we explore the cognitive processes university teachers engage in when collaboratively making sense of learning analytics for design enhancements.

### 3.1 Study Context

This is a practice-based study conducted as part of a broader institutional project in which subject-level learning analytics was introduced with the strategic purpose of empowering subject-level educators' capacity to adopt more deliberate, evidence-informed design for learning. As the first university implementation of analytics for learning and teaching at the subject level, pilot participants (university educators) were given access to subject-level analytics in their course, and were concurrently enrolled in an informal online professional learning program. Participants were encouraged to use this as an opportunity to develop critical inquiry, to be critically reflective of their own design and practice, to better understand the impact of their design for learning work on student engagement and learning, before delving into more systematic analysis for future design work. The broader program comprised informal face-to-face workshops, as well as an online professional learning component, of which the present study comprised one of the face-to-face workshops.

The online professional learning program was designed to promote and develop educators' learning analytics literacy for learning and teaching reflective practice or design for learning. This consisted of mini lecture videos, general introduction to terminology in the field, key readings, and voluntary semi-structured reflections as related to the topics. The topics covered included a general introduction to learning analytics, principles of scientific inquiry, and conceptualising design and reflective practice in the world with learning analytics. The program was conducted during the teaching period, beginning in Week 2, where a self-directed online professional learning program ran between then and Week 6. In this paper, we will focus on the emergent activity during the sensemaking workshop session conducted in Week 7 of the teaching period.

Participants were self-nominated, and from various academic disciplines. They comprised nine educators; seven were course convenors and lecturers, one educational designer, and one tutor. On average, the group of educators had 10.81 years ($SD$ = 4.81) of teaching experience. During the collaborative sensemaking session, participants self-organised into three groups. This research was approved by the University's Human Research Ethics committee.

### 3.2 Informing Design For Professional Learning With Learning Analytics: Workshop Design

The same learning analytics tools that were the focus of the professional development were available to the designer of the workshop, and this data was used to inform decision-making in relation to the design of face-to-face workshop in terms of the *needs of the learner* (informed by reflective tasks and questionnaire data) and the *structure* (informed by learner activity data). An example questionnaire measure was participants' ratings (on a scale of 0 to 100) of their level of perceived familiarity with a list of twelve terms related to statistics and analytics. The ratings to these individual terms were then categorised into three domains as a *proxy* for prior knowledge. Categories are defined as follows: Statistical concept familiarity level one (mean responses to *Mean, Median, Statistical Significance, Validity, Reliability*); Statistical concept familiarity level two (mean responses to *Variance, Measurement Error, Confidence Intervals, Clinical Significance*); and Analytics concept familiarity (mean responses to *Predictive LA, Descriptive LA, Data Mining*). While these ratings were not intended to be used as an indication of content-based prior knowledge, in the absence of a formal assessment, they were nonetheless useful in estimating prior exposures to, and potentially, learning of related material [39]. Figure 2 illustrates this questionnaire measure indicating the wide-ranging perceived familiarity (both intra-individual and inter-individual variability), as well as the relatively low levels of perceived familiarity with more complex statistical and analytics-related concepts. This finding resulted in scaffolding strategies for the subsequent workshop to accommodate the diverse range of familiarity in the statistical and analytics domains.

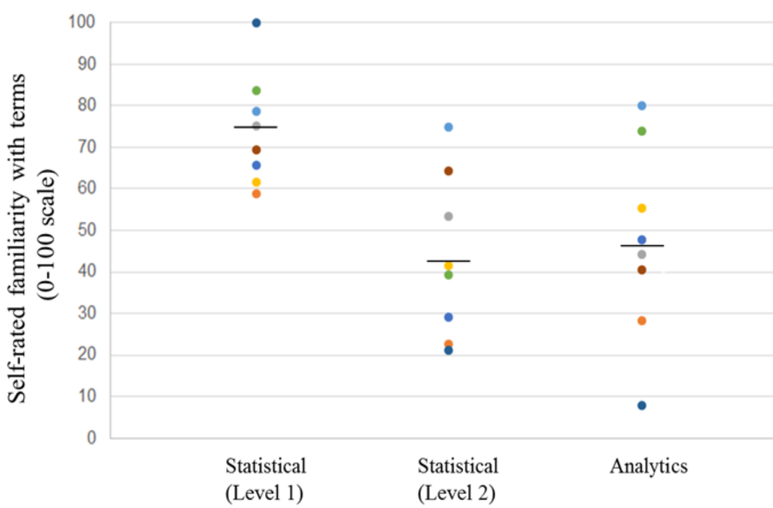


**Fig. 2**. Self-ratings of perceived familiarity of statistical and analytics terminology as a proxy for prior knowledge. Each data point indicates an individual with representative colours across construct categories (response n=8). The dark grey horizontal line indicates the mean familiarity level across participants for each category.

In addition, engagement data was used to inform changes to the design of the workshop based on learner participation during the first six weeks. Participants were informed that the online professional learning resources would form the basis of their preparation for the workshop. *The instructor inspected the video and resource engagement analytics before completing the design of the workshop.* Based on engagement analytics for the professional learning courses, two participants had completed the modules and reflections, five more had partial engagement with the resources and some completion of reflections about their experience using learning analytics in their subjects, and the remaining had at least viewed some of the first module, but not the second. Given the relatively low and sparse completion rates, the instructor started the workshop with a condensed version of the professional learning (mini-lecture) to ensure that participants had an equitable level of understanding and vocabulary to participate effectively in the workshop activities.

The workshop spanned three hours, beginning with a mini-lecture connecting learning analytics and design for learning, followed by semi-structured collaborative sensemaking activities, and a final debrief. The mini lecture focused on conceptualising subject-level analytics as situated actions, with the ACAD as the conversational framework for collaborative sensemaking. The mini-lecture concluded with considerations of principles of scientific inquiry for sensemaking as connected to the ACAD: (1) Inferential principle – that data is not the same as evidence; one has to make inferences from data in critical consideration of the context and theory; (2) Connectivity principle – to always link back to existing literature; new evidence must make connections with previously established empirical evidence and theory in sensemaking; (3) Convergence principle – that all methods have their strengths and limitations; converging evidence from different methods will better justify drawing a conclusion from.

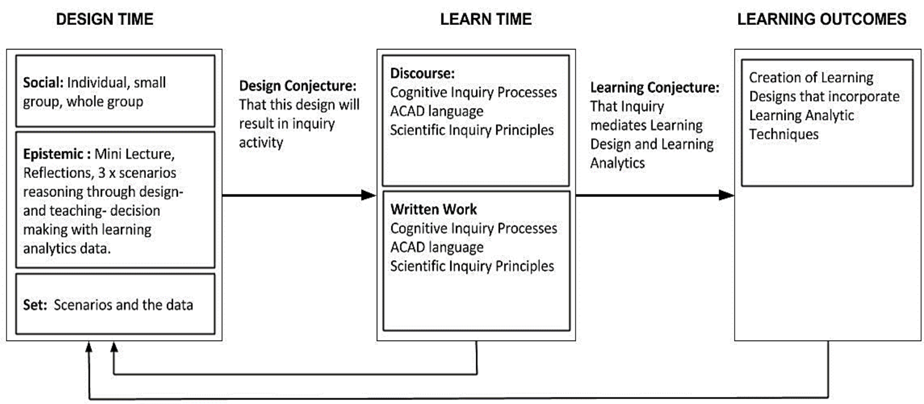


**Fig. 3** Design of the workshop mapped to the ACAD framework and used to identify design and learning conjectures that form the focus of our inquiry.

The designed elements of the workshop were mapped to the ACAD framework (Figure 3), with respect to the social, epistemic and set design. Given the model under exploration, and that it was the first time the workshop was run (and so, this research is exploratory), the identified design conjecture was that this design will result in inquiry activity by the learners. The observable evidence of this inquiry activity was identified in the discourse as well as the written work. The learning, or theoretical conjecture was that inquiry mediates design for learning and learning analytics, thus the intended learning outcomes were that learners should be able to create learning designs that incorporate learning analytic techniques.

If these are necessary mediating conditions for inquiry, how do we evidence these, and how does it manifest in connecting learning analytics and design for learning? Having discussed the design of the workshop, we refined the conjectures and identified three questions that guided the analysis of learner activity and the results of this analysis.

(1) What cognitive processes are elicited by scenario-based tasks requiring increasing depth of cognitive engagement?
(2) To what extent do teachers relate to and employ the design for learning framework and terminology in making sense of the learning analytics?
(3) To what extent do teachers apply the scientific principles of inquiry for sensemaking and design thinking?

### 3.3 Collaborative Inquiry: Using Scenario-based Learning To Scaffold Sensemaking In Connecting Learning Analytics And Design for Learning.

The tasks were designed within a collaborative learning framework [26] to facilitate the collective knowledge through shared reflections, deliberate diversity of multiple perspectives, and design knowledge. The instructor developed three scenarios using historical data from a real course in order to simulate sensemaking in authentic educational complexity. The scenarios were designed to sequentially reveal increasing amount of context information about the subject, and complexity of analysis to examine how cognitive inquiry processes might mediate the connection between learning analytics and design for learning. The cognitive process categories for coding were based on the revised Bloom's taxonomy [40] for the group responses (lower-order cognitive to higher-order cognitive processes: *Describe, Explain, Interpret, Integrate, Critique, Infer, Inquire, Hypothesise, Plan*). Groups had dashboards pre-loaded on a computer for the collaborative task. These dashboards comprised visualisations (e.g., bar graphs, line graphs, heatmaps) of engagement analytics at various levels of measurement (i.e., cohort-level, individual level) and source (i.e., tools used in LMS, resource items, etc) from the LMS of a particular subject.

Scenario 1 was designed to enhance participants' self-efficacy in using the four main subject-level analytics dashboards such that they are able to tackle (and think about) more complex questions in subsequent scenarios. Hence, the first collaborative task was largely *descriptive* – participants were asked to *describe* what they saw in the analytics dashboards, and to *explain* what they had noticed to each other. Here, contextual information included the subject, number of students enrolled, and teaching mode. For each dashboard, participants collaboratively discussed, then wrote key points that emerged in the discussion, and discussed as a group before moving to the next dashboard.

Scenario 2 revealed additional design information about the subject, including the overall structure of the subject delivery (i.e., weekly tutorials, laboratory activities, and lectures), as well as the assessment design information. Participants were encouraged to flexibly use all the dashboards, and to consider any other sources of data to answer the questions in this collaborative task (*integrate, critique*). Participants were asked to identify *one* design problem to focus on for the purpose of informing design enhancement(s) for learning, and subsequently consider learning behaviours or situated actions in informing their future inquiry towards informing design enhancements for learning. In order to effectively do so, participants were expected to engage in higher-order cognitive process of inquiry (e.g., *critique, infer, hypothesise, plan*). Following their small group discussion, they noted key points on a word document, then discussed as a larger group.

Scenario 3 was delivered as an instructor-led presentation and discussion. This ran shorter than anticipated due to time constraints. This meant that there was no collaborative task nor collective discourse as planned, and hence is excluded from further analysis in this paper.

## 4 The Results of our Inquiry into the Professional Learning

As per Figure 3, all data sources – the written responses by groups for each scenario, the recording of the dialogue in class, and individual post-session reflections – were collated, analysed, and reported here as a whole. Analysis of the qualitative responses were also coded using key cognitive processes as assessed by the scenarios. The individual reflections were additionally analysed for evidence of metacognitive reflections and consequential thinking [32]. Figure 4 summarises the levels of cognitive processes engaged in as per the revised Bloom's taxonomy, the references to design for learning framework (ACAD), and scientific inquiry principles during the collaborative sensemaking for both case scenarios for each group.

| | | Scenario 1 | | | Scenario 2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Group Deep 1 | Blooms' | Describe | Explain | Interpret | Integrate | Critique | Infer | Inquire | Hypothesise | Plan |
| | ACAD | Lay reference | | | Lay reference | | | | | |
| | Scientific inquiry | Inferential | Convergence | Connectivity | Inferential | Convergence | Connectivity | | | |
| Group Deep 2 | Blooms' | Describe | Explain | Interpret | Integrate | Critique | Infer | Inquire | Hypothesise | Plan |
| | ACAD | Lay reference | | | Terminology reference | | | | | |
| | Scientific inquiry | Inferential | Convergence | Connectivity | Inferential | Convergence | Connectivity | | | |
| Group Surface 3 | Blooms' | Describe | Explain | Interpret | Integrate | Critique | Infer | Inquire | Hypothesise | Plan |
| | ACAD | Lay reference | | | Lay reference | | | | | |
| | Scientific inquiry | Inferential | Convergence | Connectivity | Inferential | Convergence | Connectivity | | | |

*Surface approach* — *Deep approach*

**Fig. 4.** Summary of the grouped collated responses during the collaborative sensemaking activity for Scenario 1 & Scenario 2 as aligned to different levels of cognitive inquiry processes (Blooms'), design for learning framework (ACAD), and principles of scientific inquiry. Darker colours indicate deeper engagement in underlying process.

The naming convention of the groups was based on their collective depth of approach in engagement with features of the levels of analysis as shown in Figure 4 under the conditions of the workshop. We would like to emphasise that both "Surface" and "Deep" approaches here are valuable and important, and the analysis is focused on the alignment of these with the task requirements during this session. Overall, all groups met the task expectations for Scenario 1 (*describe, explain, and interpret*), but only partially for Scenario 2 (*"integrate"* onwards). Scenario 2 revealed some gaps in cognitive processes engaged in during the collaborative sensemaking activity. These findings are reported and discussed in detail below, as per the design conjectures (Figure 3).

### 4.1 Collaborative Sensemaking: Scenario 1.

In Scenario 1, participants were asked to *describe* and *explain* what they saw on each dashboard to each other. To answer our first research question of the levels of cognitive processes teachers engage in based on sequentially complex scenario-based tasks, we explored the discourse during the collaborative sensemaking session for evidence of lower- to higher-order cognitive processes based on the revised Bloom's taxonomy.

All three groups could describe, explain, and interpret the data across all dashboards as per the task. Interestingly, while the minimal contextual information in the scenario risked data driving the discourse, participants still sought to understand the design for learning better. This behavioural evidence is consistent with the contention that teachers are fundamentally interested in connecting learning analytics with design for learning and pedagogy [7, 8]. This consideration of the contextual factors in making sense of the data, evidence of applied inferential principle, was evident with all groups. Both *Deep* Groups (1 & 2) made connections to the other dashboards (applied convergence principle) when describing them to seek convergence or divergence in understanding the data (*e.g., "multiple attempts allowed for some tests* [reference to third dashboard; *Group Deep 2*], *which helps us understand the count of clicks on submit* [reference to first and second dashboards; *Group Deep 1*]*"*). An individual in *Group Deep 1* further posed a potential connection to the literature in considering students' perceived task value on engagement patterns.

During the large group discussions, the instructor made deliberate connections back to the ACAD model using learning terminology to encourage more use of the relevant vocabulary in communicating their observations. Despite the range of previous experience in formal design for learning, participants were able to communicate pedagogical intentions and design in the language they were comfortable with. This did highlight the need for more formalised professional learning to support the ability of participants to make, and communicate, connections between design for learning and learning analytics.

Individual reflections post Scenario 1 discussions revealed that participants were critically aware and appreciative of the role of contextual and design knowledge in making sense of the data. The reflections indicated that participants were engaged in the continuous refinement loop in connecting design for learning with learning analytics. For instance, participants stated that in knowing about the learning design, they were then able to explore whether students' engagement was as they hoped or predicted (design for learning preceding learning analytics). While some people viewed this as a closed confirmatory loop between learning design and learning analytics (e.g. "*The data is plentiful and detailed – I'm still trying to find some real meaning in the data beyond the obvious*"), some saw this as an opportunity to design more deliberately using analytics (learning analytics as informing design for learning):

"*I agree with colleague X that the data is confirming what we already knew. However, I see this as an opportunity to share our course in future to improve engagement. For my course, while there are announcements made each week, and materials posted for each week's lecture, we find most activity occurs at assignment time. We had considered putting in a discussion board to encourage engagement …..so we will aim to do this next trimester….be interesting to compare engagement from this trimester and next semester to see what difference the addition of a discussion board makes.*"

A unique feature of teacher inquiry process when connecting learning analytics with design for learning is the conception of time. As learning analytics affords longitudinal, flexible, near real-time data collection, we observed whether there was evidence of this flexibility or longitudinal design thinking when sensemaking here. While teachers here reflected on ways to design better measures to understand better what was important to enhance design for learning, the inquiry cognitions related to timeline in the reflections varied from that of a single subject in one point in time (e.g., subject X, semester 1), single subject iteration (i.e., subject X, semester 1 & semester 2, etc) to progressive vertical alignment during the student lifecycle (i.e., subject X in the context of year 1, year 2, etc of a degree program). Interestingly, reflections or discussions of the design cycle *in medias res* as covered in the pre-collaborative sensemaking mini-lecture was not yet evident, as were the absence of consequential thinking when proposing actions (e.g., if we did this, then it might impact on students this way). This may reflect the relatively new nature of design thinking within shorter temporal cycles in this sample of teachers.

### 4.2 Collaborative Sensemaking: Scenario 2.

The second scenario task required participants to engage in deeper cognitive inquiry processes (*integrate, infer, inquire, hypothesise, and plan*) to answer the collaborative scenario-based questions. This task distinguished two groups from the third, where the third group appeared to engage with the task on a surface level, hence not eliciting deeper levels of inquiry for effective connection of learning analytics and design for learning. The other two groups, whilst eliciting deeper levels of cognitive processes in approaching the questions, approached the questions from different perspectives, but converging to a similar design plan for future iteration. Both *Deep* groups focused deeper on analysis (*Groups 1 & 2*) focused on the weekly assessments – the online quiz, and the laboratory workbooks.

Group *Deep 1* continued their line of inquiry regarding students' perceived task value (this was not measured, but hypothesised), with reference to the online quiz activity. When considering ways to enhance the design, they communicated plans that integrated the designable elements and identified some of the relationships. They further considered how they could redesign the task (e.g., online but completed in class) or to facilitate the set and epistemic design via increasing the perceived task value by offering a higher percentage of the final grade to this task. They discussed the conversion of the lab workbook task into an online activity, explored possible tools, and considered the implications of student engagement as well as capacity of the instructor to mark and access "deep data" about students' learning given the large cohort (social design). These were expressed in lay reference to the design for learning framework.

As with Group *Deep 1*, Group *Deep 2* considered administering the lab workbook online in order to gain deeper insights into student learning. However, this was expressed within the context of the convergence principle, whereby convergence of this data with other sources of engagement analytics (access of subject content and assessment materials) was thought to enhance understanding of student learning when analysed at key points in time as relevant within the assessment plan. They further planned to additionally focus on students who have previously failed this subject, and proactively provide support in relation to the timeline of the assessments. This group's plan for future design also included an evaluation strategy for the assessment task design itself, by examining assessment analytics (e.g., item analysis) to identify questions that large groups of students are not getting correct, and to offer new or modified learning materials addressing the misconceptions or difficulties to assist learning. This plan was met with a strategy to evaluate the efficacy of a new design addition – formulating feedback during quizzes for student learning – through consideration of tools available to enable this task delivery and evaluation. These were expressed using the terminology of the ACAD framework.

Group *Surface* 3 did not appear to identify a design problem and instead offered suggestions for potential enhancements of the subject design for learning. These suggestions were broad and ranged across the assessments (e.g., "Short, well-timed announcements can help direct students to complete their workbook", and "encourage students to go in and check course materials at certain times"). These were not specifically related to the designable elements, nor the integration of them.

Taken together, the responses to Scenario 2 revealed more depth in analysis of design problem when connecting learning analytics with design for learning. Participants moved from describing and understanding the data to trying to understand the design elements and how they may influence activities through which students learn, in planning towards reconfiguration of these elements to enhance design for learning. One group approached the task with less depth, though it is unclear as to whether this was a function of a misunderstanding of the task, or depth of understanding of the connection.

Further, the differential levels of cognitive processes engaged in the collaborative sensemaking tasks resulted in different outcomes for design iteration. Consistent with the theorised mediated model of inquiry processes mediating the connection between learning analytics and design for learning, the hypotheses and plans that resulted from deeper cognitive engagement were developed in such a way that enabled better understanding of the intended learning outcomes or of a related underlying process for learning (e.g., students' perceived task value). In contrast, surface-level cognitive processes of inquiry led to simpler hypotheses that remained on a student engagement rather than deeper learning processes or performance.

Finally, the sequential scaffolding of the contextual information to aid sensemaking appeared to help educators reflect on the importance of the contextual factors in making sense of the data with increasing evidence of metacognitive awareness of the importance of these cues and structures as the session progressed.

### 4.3 Post-workshop Reflections.

At the end of the workshop, participants were encouraged to critically reflect on what they thought they had learnt during the workshop in relation to their own teaching context. Participants generally rated the workshop as being beneficial in moving towards their goals for using learning analytics for learning and teaching (5-point Likert scale of 'poor' =1 to 'excellent' = 5; $M = 4.80$, $SD = 0.45$). Participants were then probed about which aspect of the workshop was most beneficial for them (open comment response). Three participants identified the collaborative aspect of the sensemaking activities was beneficial for them as they offered multiple perspectives. Most of the participants reported that they liked going through the sensemaking activity with real data, though the reasons why were not articulated. Four participants communicated plans of approaching the design for the next trimester, in particular, in relation to considerations of the tools used to fit both the pedagogical purposes of the task, as well as the opportunities for data to enhance their insights towards understanding the impact of their design configurations on various aspects of student engagement and/or learning.

One participant went further to reflect on what they thought was important to measure in their classes to help them design for learning better, but was either not measured, or not measurable, and reflected on ways this impacted on their interpretation of existing data, as well as its influence on future designs. Of note is also this participant's close engagement with the program and incorporating of the analytics in his own teaching. Inspecting this participant's depth of reflections over time, this participant showed a consistent increase in insight and metacognitive awareness of systemic influences in connecting design for learning with learning analytics over time. While this may not be generalisable, this provides some indication of the possible learning trajectory a teacher may take if one is able to engage with the professional learning at this level of commitment and consistency.

## 5 General Discussion and Conclusions

### 5.1 General Discussion

The analysis presented above combines evidence from a variety of sources, at the individual, small group and whole group level. By relating this to specific design and learning conjectures, we are able to connect the results forward to learning outcomes (and address the assumption we made and tested related to inquiry processes) and back to specific designable elements. One group (*Group Deep 2*) demonstrated higher-order cognitive processes of inquiry, such as inquire, hypothesise and plan. This group also demonstrated a development of ACAD language as well as scientific inquiry. A second group (*Group Deep 1*) demonstrated higher-order cognitive processes of inquiry as well as scientific inquiry, without the ACAD language. *Group Surface 3* engaged with the task with a more surface level approach in cognitive and scientific inquiry, and limited ACAD language. The analysis of *Group Deep 2* showed that by engaging in an inquiry approach, the data (and the learning analytics techniques used to generate this data) were identified for a specific, design-related purpose. The learning analytics community has focused on the generation of this actionable knowledge, where analytics are to be meaningful and useful for teachers [41]. Decisions are able to be made in three areas: related to the design, teaching and orchestration, and assessment. In situating inquiry as a mediator, between design for learning and learning analytics, the purpose for the generation of actionable knowledge is clear. The remainder of this discussion will focus on the implications of the finding for the model, and for the design of professional learning.

It is important to note that the present study was a preliminary means of testing the mediational model of teacher inquiry in the context of connecting learning analytics when designing for learning. Critically, the present study was contextualised in an informal professional learning workshop with higher education educators. In so doing, the context limits the generalisability to other contexts in various ways. For instance, the informal professional learning setting attracts attendance from self-selected educators. This self-selection bias often comes with increased motivations, of various origins, towards enhancing one's practice, and is therefore still somewhat representative of informal professional settings. The ways in which the findings are generalisable to more formal or top-down professional settings is unclear as yet, and not the purpose of this paper. In addition, the ways in which sensemaking with data is approached here within a higher education context is not completely generalizable to that of the K-12 context given the many nuanced differences in data-informed practices in schools. These initial considerations of the preliminary, informal, higher education context suggest that any extension of the testing of the proposed model warrant deeper insights into the complex teacher inquiry processes in varied learning and teaching settings.

### 5.2 Research Implications For The Model: Towards Understanding Teacher Inquiry Processes For Teaching As A Design Science In A World With Learning Analytics

The results demonstrated that participants were able to engage in inquiry-mediated learning design. Identifying appropriate learning analytic generated data, and discussing this in the context of a design framework resulted in the generation of actionable knowledge. Examining the evidence collected in the three groups aided in the further development and refinement of the role of cognitive process of inquiry in the ACAD framework. In what follows, we provide a worked example of how the elements can connect and prompt inquiry leading to actionable knowledge. In Figure 2, we demonstrate how the ACAD framework can be used to guide the investigation and discussion of an inquiry into user-interface design. In Figure 5, ACAD is overlaid with a structured, research-informed inquiry into user-interface design. According to

ACAD, this can be discussed in terms of the relation between set design and activity. We use this structure to identify Inquiry question 1: *is the set design accessible and easy to use?* This level of analysis is necessary in considering whether the set design elements may hinder students from participating or achieving their goals through activity. Good applications of human-computer interaction principles here, for instance, should enable students to complete the task effectively and efficiently. An analysis of set design can then be used to identify connections with learning analytics or any other forms of data. Questions for evaluation that emerge from this analysis, are likely to centre around ease of use and perceived satisfaction of use of a particular tool for the activity, even if the intent is to relate to learning outcomes. Using ACAD encourages the designer to consider all elements of the design, and how they relate.

Extending set design analysis to that of its relations between epistemic and set design element may also focus on user-interface design or human-computer interaction. An example of this is the design of the instructions (epistemic design) and their connection to the set design, leading to the development of Inquiry Question 2: *are instructions needed?* In order to answer this question, we need to identify our assumptions about learning, and then ask how best to design the instructions in order to support our assumptions about the relationship between activity and learning.

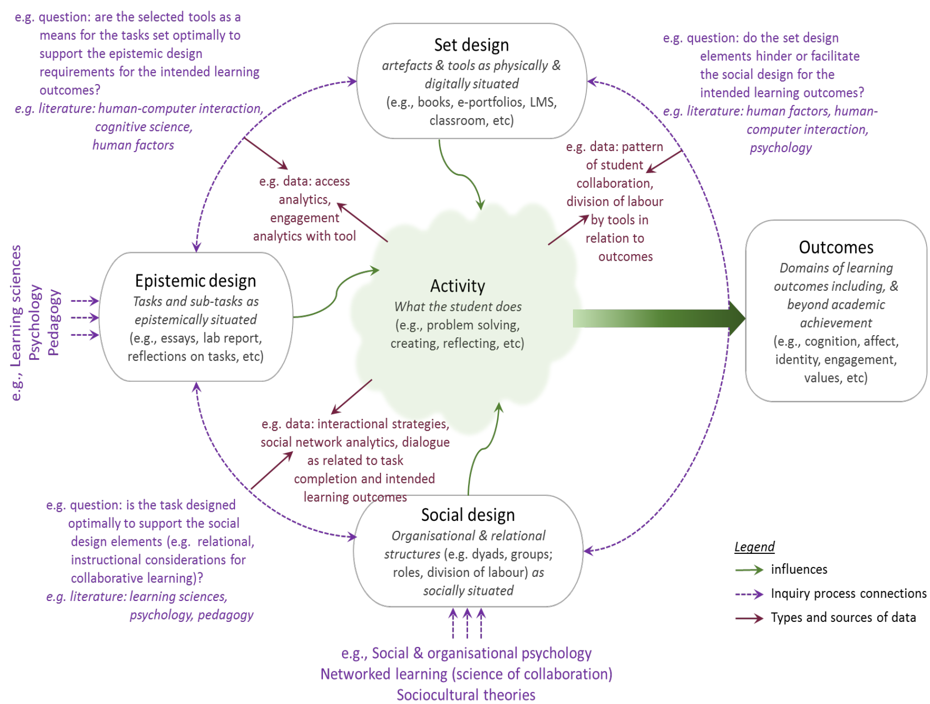


**Fig. 5**. Example cognitive inquiry processes overlaid on the ACAD framework model (adapted from Goodyear, 2015). The inquiry processes indicated are example ways in which cognitive inquiry mediates the synergistic relationship between learning analytics and design for learning. Links to the extant literature indicated are intended to illustrate structure inquiry processes for design, understanding, and data identification.

While these are important elements of design for learning, they operate at lower-order cognitive processes for learning (and teacher inquiry). A higher-order cognitive level of teacher inquiry might include connecting set and epistemic design in considering how that interaction fosters higher-order cognitive processes during learner activity. One might then consider the strategies that the cognitive science literature suggests to connect these elements of design, as well as the types of data to consider or measure to inform a future iteration. For example, the lower-order cognitive inquiry may seek to evaluate student perceived satisfaction and ease of use of tools along with engagement proxies from learning analytics. This may inform the teacher of tool engagement and student experience of the activity; however, it will not inform the teacher of the effectiveness for learning. Effort alone (inferred via tool engagement analytics) does not necessarily lead to learning [42], and students' perceptions of their learning is often misjudged through the illusion of fluency [43]. Similarly, only looking at measures of learning from products of the activity alone is arguably insufficient for effective teacher inquiry in connecting data with design for learning. In converging the various sources of data, the teacher is then able to engage in more higher-order cognitive processes of inquiry by critiquing and evaluating the data in recognition of the various design elements and of their relationships for learning more holistically. Moreover, no matter how effective an element of design is for learning, if students are not engaging in them, or worse, refuse to engage with them, then the evaluation based on learning performance alone defeats the purpose of effective teacher inquiry. Hence, there is a fundamental need to ensure and assess that the design is constructed in ways that facilitates engagement, rather than rejection of the task is fundamental [44], and increases the likelihood of student learning. Taken together, these form important considerations for planning for future studies to test the mediation model presented in this paper.

### 5.2 Research and Practice Implications For Professional Learning

The focus on the underlying processes of teacher inquiry in the development of professional learning for the integrated practice of design for learning and learning analytics underscores the importance of understanding these processes to effectively scaffold and orchestrate design for professional learning. For instance, understanding and designing within the university's culture for professional learning impacts on the effectiveness of the design for professional learning. In the present study's university's culture, the face-to-face workshop was preferable to the self-directed online medium for professional learning. As an example of this, only one of the participants in the broader program (of which the present study's workshop was only one part thereof) was able to fully commit to the online professional learning program, the reflection tasks, as well as the workshop. Granted, complete 100% engagement in large, long duration programs are unrealistic and unlikely, however, following the learning trajectory of this individual suggests that if teachers *were* able to participate in the professional learning program and to incorporate the professional learning with application in their practice concurrently, the benefits of doing so may be fully realised. This supposition, however, needs to be empirically tested in future. Also notably, many participants experienced significant challenges with being able to engage with the program as much as they wanted to given their workload, that despite best intentions and aspirations, some were unable to participate to their desired levels. This is a critical point in relation to academic workload – while being expected to engage in new methods and technology that requires a reasonable amount of professional learning and opportunity to apply to their practice, often this expectation is not corresponded with some respective allocation in their workload [12].

The exploration of the cognitive processes of teacher inquiry in the present context revealed some insights for design of professional learning and resources. The sequential scaffolding of scenarios appeared to be effective in developing teachers' metacognitive insight into the importance of contextual factors in their sensemaking, if we examine their reflections and discourse over the course of the workshop. What could not be examined in this study is whether this increase in metacognitive insight had any impact on their consequential thinking or attribution biases in sensemaking, issues both deemed to be important when sensemaking with learning analytics [9, 33]. During the session, elements of the design that were particularly effective was the collaborative sensemaking task, the activity of which led to increase in collaborative discourse and sequential use of design terminology. With a lower-level task (descriptive task - scenario 1), lower-order cognitive process as required were elicited by all teachers. However, the more complex task (scenario 2) which required higher-order cognitive processes to approach more effectively instead revealed some gaps in capacity to elicit these deeper inquiry processes in the present context. These gaps suggest that the scaffolding for learning for this level of inquiry may not be sufficient if the gaps are too far, and may require intermediary sequential steps to bridge the gap. This gap *may* be bridged through more of these exercises (deliberate inquiry practice), a supposition that could be empirically investigated.

Another finding through the use of this design inquiry approach framework was the explication of the way in which time is conceptualised for the design process. Where some models for learning design appear linear or cyclical, arguably, all models are at least implicit in the requirement for multiple feedback loops. Goodyear and Dimitriadis [45] suggest that the phases of ACAD, the framework are non-linear, nor are they explicitly cyclical with a clear start and end loop. Rather, design as a process could be understood within a more flexible timeline, where feedback loops can begin anywhere in the timeline or lifecycle. For the purpose of this collaborative workshop, this conceptualisation of a flexible timeline aligns well with the affordances that learning analytics offer. As such, conceptualising the many ways these elements can be deconstructed for analysis in a systemic relationship with each other and the emergent activity as it unfolds over time may facilitate the connection between design for learning and learning analytics towards enhancing one's design for learning and understanding, and may encourage forward-oriented design. This reinforces the methodical, rigorous analysis of deconstructed and connected elements when connecting learning analytics with design for learning as a science. ACAD was useful in establishing a common language and in structuring discussion towards appropriate use of data. In particular, having the whole group discussion where the language and the connections could be modelled was important to the adoption of this in the reasoning during the scenarios.

As indicated in the teacher inquiry mediated model, we indicated other underlying factors that manifests as teacher inquiry - the teacher identity, beliefs, socioemotional, and cultural factors. These factors allude to the educator's values, principles and identity within the educational culture. More research is needed to elucidate the effects of these mechanisms in inquiry for learning. Identified factors such as experience in design for learning [11], subject area, data literacy [28] are among some of the factors that when researched at the process level, may reveal different aspects of judgement and decision making in relation to their effects on the academic identity. At the systemic level, it is worthwhile developing approaches to facilitate the transition to contemporary evidence-informed learning and teaching practice in ways that respects both the teachers' past and their future, that promises the continuity of the educators' identity (with adaptive changes in their practice), such that they can more firmly and effectively engage in the data- and evidence-informed educational narrative, whilst keeping the importance of educational values and judgement.

## References


1. Clark, W., Luckin, R. & Jewitt, C.: NEXT-TELL research report D5.1: methods and specifications for TISL components V1. NEXT-TELL Consortium, European Commission IST-285114 (2011).
2. Carvalho, L., & Goodyear, P.: The architecture of productive networks. Routledge: NY (2014)
3. Sandoval, W.: Conjecture mapping: An approach to systematic educational design research. Journal of the Learning Sciences, 23(1), 18-36 (2014).
4. Goodyear, P.: Teaching as design. HERSDA Review of Higher Education, 2, 27-50(2015).
5. Siemens, G., & Gašević, D.: Guest editorial: Learning and knowledge analytics. Educational Technology & Society, 15(3),1-163 (2012).
6. Reimann, P.: Connecting learning analytics with learning research: the role of design-based research. Learning: Research & Practice, 2 (2), 130-142 (2016).
7. Corrin, L., Kennedy, G., & Mulder, R.: Enhancing learning analytics by understanding the needs of teachers. Proceedings ascilite 2013 Sydney. pp. 201-205 (2013).
8. West, D., Huijser, H., Heath, D., Lizzio, A., Toohey, D., Miles, C. … et al.: Higher education teachers' experiences with learning analytics in relation to student retention. Australasian Journal of Educational Technology, 32(5), 48-60 (2016).
9. Lodge, J. M., Alhadad, S. S. J., Lewis, M. J., & Gašević, D.: Inferring learning from big data: The importance of a transdisciplinary approach, Technology, Knowledge and Learning, 22(3), 385-400, doi: 10.1007/s10758-017-9330-3 (2017).
10. Mandinach, E.B., Parton, B.M., Gummer, E.S., & Anderson, R.: Ethical and appropriate data use requires data literacy. Phi Delta Kappan, 96(5), 25-28 (2015).
11. Bennett S., Agostinho S., & Lockyer L.: Investigating university educators' design thinking and the implications for design support tools. Journal of Interactive Media in Education, 9(1), 1-10. (2016)
12. Gregory, M. S., & Lodge, J. M.: Academic workload: The silent barrier to the implementation of technology-enhanced learning strategies in higher education. Distance Education, 36(2), 210-230 (2015).
13. Lockyer, L., Heathcote, E. & Dawson, S.: Informing pedagogical action: Aligning Learning Analytics with Learning Design. American Behavioral Scientist, 57(10), 1439-1459 (2013).

14. Mor, Y., Ferguson, R. & Wasson, B.: Editorial: Learning design, teacher inquiry into student learning and learning analytics: A call for action. doi:10.1111/bjet.12273 (2015).
15. Persico, D. & Pozzi, F.: Informing learning design with learning analytics to improve teacher inquiry. British Journal of Educational Technology,46(2), 230–248 (2014).
16. Tan, J. P. & Koh, E.: Situating learning analytics pedagogically: Towards an ecological lens, Learning: Research and Practice, 3(1), 1-11 (2017).
17. Bakharia, A., Corrin, L., de Barba, P., Kennedy, G., Gašević, D., Mulder, R., Williams, D., Dawson, S. & Lockyer, L.,.: A conceptual framework linking learning design with learning analytics. In Proc. LAK. pp. 329-338. (2016).
18. Nguyen, Q., Rienties, B., & Toetenel, L.: Unravelling the dynamics of instructional practice: A longitudinal study on learning design and VLE activities. In Proc. LAK (2017).
19. Laurillard, D.: The teacher as action researcher: Using technology to capture pedagogic form. Studies in Higher Education, 33(2), 139-154 (2008).
20. Elliott, K. & Lodge, J. M: Engaging university teachers in design thinking. In R. James, S. French, & P. Kelly (Eds.), Visions for Australian Tertiary Education, pp. 55-66 (2017).
21. Celik D., Magoulas G.D.: A Review, Timeline, and Categorization of Learning Design Tools. In: Chiu D., Marenzi I., Nanni U., Spaniol M., Temperini M. (eds) Advances in Web-Based Learning – ICWL 2016. vol 10013. Springer, Cham (2016)
22. Dalziel, J et al.: The Larnaca Declaration on Learning Design. Journal of Interactive Media in Education, 2016(1): 7, 1–24 (2016).
23. Mor, Y. & Winters, N.: Design approaches in technology-enhanced learning. Interactive Learning Environments, 15(1), 61-75 (2007).
24. Dimitriadis, Y. & Goodyear, P.: Forward-oriented design for learning: illustrating the approach, Research in Learning Technology, 21(1), doi:10.3402/rlt.v21i3.20290 (2013).
25. Markauskaite, L. & Goodyear, P.: Designing for complex ICT-based learning: Understanding teacher thinking to help improve educational design. In Proc. ascilite. pp. 614-624 (2009).
26. Laurillard, D.: Teaching as a Design Science: Building Pedagogical Patterns for Learning and Technology, Routledge: Abingdon (2013).
27. Datnow, A. Park, V., & Kennedy-Lewis, B.: High school teachers' use of data to inform instruction. Journal of Educational for Students Placed at Risk, 17(4), 247-265 (2012).
28. Dunlap, K., & Piro, J. S.: Diving into data: Developing the capacity for data literacy in teacher education. Cogent Education, 3(1), 1-13 (2016).
29. Little, J.W.: Understanding data use practice among teachers: The contribution of micro-process studies. American Journal of Education, 118(2), 143-166 (2012).
30. Mandinach, E. B. A perfect time for data use: Using data-driven decision making to inform practice. Educational Psychologist, 42 (2), 71-85 (2012).
31. Sun, J., Przybylski, R., & Johnson, B. J.: A review of research on teachers' use of student data: From the perspective of school leadership. Educational Assessment, Evaluation, & Accountability, 28(1), 5-33 (2016).
32. Alhadad, S. S. J.: Attentional and cognitive processing of analytics visualisations: Can design features affect interpretations and decisions about learning and teaching? In Proc. ascilite, pp. 20-32 (2016).
33. van Leeuwen A., van Wermeskerken M., Erkens G., & Rummel N.: Measuring teacher sense making strategies of learning analytics: A case study. Learning: Research & Practice, 3(1), 42-58. (2017).
34. Evans J.S.B.T, & Stanovich K.E.: Dual-process theories of higher cognition. Perspectives on Psychological Science, 8(3), 223-241 (2013).
35. Martinez-Maldonado, R., Clayphan, A., Yacef, K., & Kay, J.: Towards Providing Notifications to Enhance Teacher's Awareness in the Classroom. In S. Trausan-Matu, K. E. Boyer, M. Crosby, & K. Panourgia (Eds.), Intelligent Tutoring Systems: Lecture Notes in Computer Science, Volume 8474 (pp. 510-515) (2014).

36. van Leeuwen, A., Janssen, J., Erkens, G. & Brekelmans, M.: Teacher regulation of cognitive activities during student collaboration: Effects of learning analytics. Computers & Education, 90, 80-94. (2015).
37. Markauskaite, L., & Goodyear, P.: Epistemic Fluency and Professional Education: Innovation, Knowledgeable Action And Actionable Knowledge, Springer: Dordrecht. (2017).
38. Bingle W.H., & Gaskell, P.J. Scientific literacy for decision making and the social construction of scientific knowledge. Science Education, 78(2), 185-201 (1994).
39. Serra, M.J., & Metcalfe, J.: Effective implementation of metacognition. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), Handbook of metacognition in education (pp. 278–298). (2009).
40. Krathwohl, D. R.: A revision of Bloom's Taxonomy: An overview. Theory Into Practice, 41 (4), 212-218 (2002).
41. Wise, A.: Designing pedagogical interventions to support student use of learning analytics. In Proc. LAK, pp. 203-211 (2014).
42. Dunlosky, J, Rawson, KA, Marsh, EJ, Nathan, MJ, Willingham, DT.: Improving students' learning with effective learning techniques: promising directions from cognitive and educational psychology. Psychol Sci Public Interest, 14(1), 4-58 (2013).
43. Kirschner P.A., & van Merriënboer J.J.G.: Do learners really know best? Urban legends in education. Educational Psychologist, 48(3), 169-183. (2013).
44. Boud D., Cohen R., & Sampson R.: Peer learning and assessment. Assessment & Evaluation in Higher Education, 24(4), 413-426 (1999).
45. Goodyear, P., & Dimitriadis, Y.: In medias res: reframing design for learning, Research in Learning Technology, 21(1), doi:10.3402/rlt.v21i0.19909 (2013).