

# Involving teachers in learning analytics design: Lessons learned from two case studies

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## ABSTRACT

Involving teachers in the design of technology-enhanced learning environments is a useful method towards bridging the gap between research and practice. This is especially relevant for learning analytics tools, wherein the presentation of educational data to teachers or students requires meaningful sense-making to effectively support data-driven actions. In this paper, we present two case studies carried out in the context of two research projects in the USA and Spain which aimed to involve teachers in the co-design of learning analytics tools through professional development programs. The results of a cross-case analysis highlight lessons learned around challenges and principles regarding the meaningful involvement of teachers in learning analytics tooling design.

## CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in interaction design**.

## KEYWORDS

Learning Analytics; Teachers; Co-design; Case Studies; Teacher Professional Development

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## 1 INTRODUCTION

One challenging endeavor in Learning Analytics (LA) research is the intentional design of LA tools and their alignment with practitioner needs that emerge during teaching and learning. These

problems of practice have been addressed as a challenge in research and as a factor for practitioner adoption of data-driven tools [10]. One approach to understanding the impact of LA tools and their practical implementation in primary and secondary educational contexts is to involve stakeholders in the design of LA systems (e.g., teachers, students, technology-enhanced learning experts) [7, 8, 24]. In this paper, we focus on how to involve teachers (meaning also instructors) as learning designers in the design of LA systems and we highlight problems that surfaced through two separate strategies to achieve this goal.

Learning analytics design seeks to develop knowledge on the practical implementation of LA in educational settings [28]. From the perspective of teachers, many challenges have been documented, several relating to teacher action research [11, 12] or teacher-led inquiry [21]. Dyckhoff et al. [11] have identified the following key issues: a) LA implementation does not answer important questions for teachers (e.g., how students perceive learning activities), b) LA do not consider teacher data such as the design of learning tasks and teachers' interventions and c) LA systems do not evaluate impacts such as change of behaviors by teachers and learners. Additionally, Wise and Vytasek [29] highlight challenges such as the relation of LA to the context in which they occur, the challenge of developing authentic learning design and task design, and the heterogeneity of priorities defined by teachers during the learning process and the variety of possible actions after the feedback provided by LA tools. Moreover, Shibani, Knight and Shum conclude that LA design needs to be configurable and tailored to the needs of teachers that allows a level of teacher control and agency [25].

The use of LA by teachers can be broken into two types of actionable information [16, 29]: a.) information presented at design-time that allows learning design customization, such as task design and b.) information presented at run-time that allows orchestration actions such as the management of learners' groups. However, utilizing this information can be challenging due to several factors, including teachers' data literacy, teachers' beliefs, previous experiences with students and practical constraints such as available time, technology and resources [17]. Additionally, the alignment of student-generated data with pedagogically grounded actions and problems defined by teachers is still an open issue both for researchers and practitioners.

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## 1.1 Goals

In this paper, we focus on involving teachers in the meaningful design of LA systems that bridge teachers, as stakeholders and practitioner input, with research in LA design. We present two case studies that attempted to engage teachers in the design of teachers-facing LA that they could utilize in their practice. The aim of the paper is to present two different methodologies in sufficiently different cultural contexts and to derive similarities, differences and implications for the development of teacher-driven learning analytics.

## 2 METHODS

### 2.1 Data

Data were drawn from two research projects that involved teachers in the design of LA. Both focused on involving teachers in the design of LA. The first was located in Spain (Catalonia) and involved high school teachers (N=33) with ages ranging between 20-60 years and teaching experience between 1-25 years. Their main subjects covered science, math, languages, social sciences and arts/music. Teachers' involvement in the project lasted two years, participation in the project was voluntary and teachers received certificates after the end of each project year. Teacher certifications were granted according to the level of participation during the training workshops and the classroom implementations.

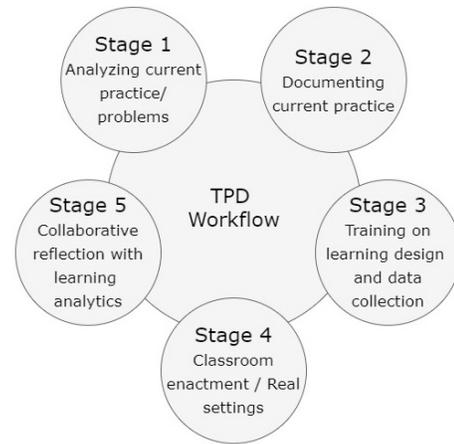
The second research project was based in the USA and involved primary and secondary school teachers (N=30). The study is a collaboration between researchers and 30 teachers across 20 New York City Public schools. 28 of the teachers were K-12 classroom teachers and two held positions in which they taught in specific capacities (library, literacy coach). Their ages ranged from 22-55 and their experience ranged from 3-18 years. Their instructional experience covered a wide range of academic subjects including English language, arts, mathematics, and science. All participating teachers volunteered to attend a workshop on data science in education that lasted two days.

Although these studies took place in different contexts, employed different methodology designs, and different analytical frameworks, we nonetheless believe a comparison is useful as a) there are so few examples of attempts to develop LA with K12 teacher input available that this is currently the most readily available comparison and 2) that the source contexts are so different that commonalities between the two studies may indicate generalizable findings.

### 2.2 Project Descriptions

**2.2.1 Project 1 (Spain):** The overall aim of the project was to study to what extent and in which form data analytics can support teachers (and schools as teacher communities) in the process of understanding and optimizing the design of learning activities [14]. To do so, the project proposed an experimental professional development program [18, 19] that trained teachers in learning design methodologies, with a special focus in the use of authoring tools to design (computer-supported) collaborative learning activities and in the systematic collection of student data during the implementation of the activities with their students. The project was a collaboration between a university research group and two High schools in Spain

(Catalonia) and took place from November 2016 until July 2018. During the project, a co-design methodology was embedded into the Teacher Professional Development (TPD) program (see Figure 1) and the classroom enactments.



**Figure 1: Teacher Professional Development program workflow in Project 1**

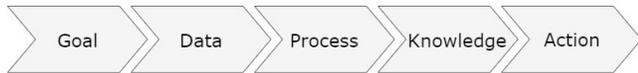
The co-design methodology involved teachers in the design of LA systems (namely a dashboard for community awareness related to learning design, a learning design feedback tool for teachers and students, and a teacher-inquiry tool). The overall methodology followed the structure described in Design-Based Research [2]. In this case, researchers collaborate with educational practitioners to understand their practical needs and related challenges addressed in the literature. Then, we followed solutions based on existing design principles and theories and the iterative evaluation of solutions in the workshops with teachers and their implementation in real settings. We involved teachers in teacher inquiry-cycles of design, implementation, and reflection on technology-integrated learning activities (see Figure 2). Lastly, lessons learned derived from the researcher-practitioner collaboration were communicated through case study descriptions and the development of design principles.



**Figure 2: Workshop in Project 1 (Left), Workshop in Project 2 (Right)**

**2.2.2 Project 2 (USA):** The overall aim of the project was to determine where friction points exist when teachers attempt to apply data science to their practice to inform daily decisions they make about teaching and learning [13, 22]. The aim was to map the points within teacher workflow where teachers believe data can be useful, where they believe their skills are lacking or where a technological solution is necessary. The strategy to map these friction points was to have teachers construct their own scripting language to describe

problems of practice that they have experienced. Teachers began with a problem of practice that they chose, then described aspects of that problem that could be counted, how they would process those counts (eg. take an average), how they would make meaning from the processed counts, and what action they would take in response to the meaning they have derived. We call this approach "Grounded Data Exploration" as it is a bottom-up approach that attempts not to impose a structure on the process of data exploration as occurs in other methods for promoting data use in education such as inquiry cycles [5]. The participants were given the framework represented in Figure 3 to support the development of semantic models.



**Figure 3: Teacher Professional Development program workflow in Project 2**

Teachers worked through hypothetical data scenarios to unearth and visualize a.) the data teachers currently engage with, b.) the data teachers want to engage with but do not have access to, and c.) the questions teachers use to interrogate this data and d.) make meaning from data. Teachers then engage in a process to develop the structure of these data problems of practice, otherwise known as semantic models (see Figure 2). Next, teachers take the semantic models and reduce them to abbreviations after being given examples of pseudo-code and instructed to create pseudo-code that represents their problem.

### 2.3 Analytic Strategy for Cross-Country Comparison

In this paper, we present two case studies [26] that investigated how K-12 educators could inform the design of LA for the daily teaching (see Table 1 for the context of the two cases). Inherent to case studies is the premise that they are situated representations of phenomenon that provide depth to the problems of practice teachers encountered in both studies while exploring their nuances. Our methodology was based on established methods for theory-building inductive research using cases [23, 26, 27]. We worked recursively between our two cases and the theory we were developing [1], evaluating field notes in two dimensions: 1) problems of practice and 2) solutions. We first focused on constructing detailed descriptions of the problems that teachers were tackling in their analytic work, identifying new problems or opportunities that they uncovered. We then examined these data comparatively, developing a series of matrices in which we coded the problems/opportunities according to themes that emerged during the process [20]. The second level involved the same process but instead looking at the solutions that the teachers developed, desired or co-designed with researchers. Finally, we filled out concurrent themes that both cases experienced, for example, issues teachers had with problem decomposition.

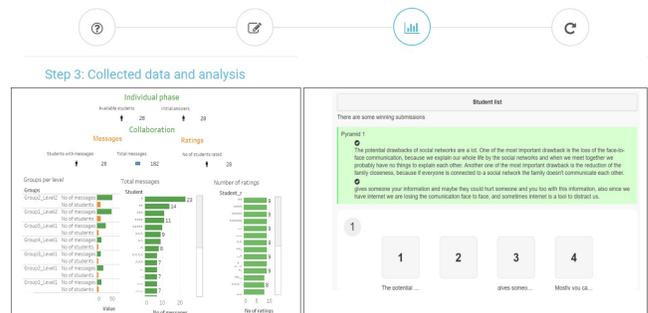
## 3 RESULTS

While both cases include case-specific findings, in this section we provide highlights of cross-case findings. We begin with teacher-identified problems and then share teacher-identified solutions.

### 3.1 Teacher-identified problems

Regarding the teacher-identified problems, we analyzed the different data sources (questionnaires, interviews, focus groups transcripts, teacher artifacts) and focused on the common and emergent topics/problems which appeared in both cases (Project 1 and 2). Table 2 presents the identified topics and the main data sources.

One of the common problems regards teacher scaffolding in problem decomposition and question identification. In Project 1, teachers faced difficulties related to problem and question definition before the collection of student data in classroom activities' implementations (see Figure 4). In Project 2, this problem was relevant to teachers' classroom practice and its relation to the collection of student data. The Project's 2 study data revealed that teachers experienced difficulty when attempting to quantitatively define problems. The participants required substantial scaffolding with identifying problem definition at the beginning of the workshop, but were able to follow along and successfully complete the task by the end of the workshop as part of collaborative teams. Another noted issue was that participants had a tendency to replicate similar problems as those provided by the researchers facilitating the workshop instead of using the process to identify problems of practice that LA could support related to their teaching. A second common problem in both cases was the concentration of teachers concerned with classroom and time management. In Project 1, all teachers who implemented classroom activities reflected on the difficulty to manage the duration of technology-integrated activities. In Project 2, the problem was related to disciplinary data and classroom management.



**Figure 4: Learning analytic artifact shown to teachers in Project 1 and embedded in a teacher-inquiry tool [19]**

We also identified emergent topics which were not common in both cases. In Project 2, the most significant challenge the participants had during the workshop was breaking a problem down into component parts. For example, they frequently focused on metrics that were easy to count or on metrics they were incentivized to count such as test scores and displayed a lack of creativity in the latent constructs. The participants concentrated on disciplinary data as well as psychological models and methods (i.e. proving human level traits) rather than applied problems of practice. As Table 2 shows, in Project 1, teachers explained that time constraints do not allow for systematic and everyday data collection. Their reflection on classroom implementations was mainly based on their previous experiences with students, or with informal discussions.

**Table 1: Comparison of Study Context/Design**

Characteristic	Project 1	Project 2
Location	Spain (Catalonia)	USA (New York City)
<i>n</i> -teachers	33	30
<i>n</i> -schools	2	20
Teaching experience (years)	1-25	3-18
Volunteer	Yes	Yes
Number of educational settings	1	3
Participation incentive	Certification	None
Study timescale	2 years	2 days
Methodology	Design-Based Research	Grounded Data Exploration
Combination of software	Yes	No
Research data sources	Questionnaires, Interviews, Focus group, Teacher artifacts	Interviews, Focus group

**Table 2: Main identified problems for learning analytics design: cross-case analysis**

Problems	Project 1	Evidence	Project 2	Evidence
Substantial scaffolding in problem/question definition initially	✓	Questionnaire, Interviews	✓	Interviews, Focus group
Concentration on classroom and time management	✓	Teacher artifacts, Interviews	✓	Interviews, Focus group
Reflection is based on experience and informal discussion with students	✓	Questionnaire, Focus groups	x	
Time constraints hinder systematic/everyday data collection	✓	Questionnaire, Interviews	x	
Breaking a problem down into component parts	x		✓	Interviews, Focus group
Concentration on easy to count metrics	x		✓	Interviews, Focus group

### 3.2 Teacher-identified solutions

Regarding the teacher-identified solutions, three common topics appeared in both cases (see Table 3). Teacher collaboration on problem definition and the sharing of teacher inquiries (problem, student data, solutions) was positively received in both cases. In Project 1, teachers' collaborative reflections about student-generated data showed evidence of knowledge building (pedagogical and practical drawn from experiences). In Project 2, peer collaboration successfully promoted problem decomposition. The second common topic was related to the connection of the collected data with learning design improvements and differentiated instruction. In Project 1, teachers expressed the need to simplify data collection to inform the learning design decisions. In Project 2, teachers explained the utility of student data in informing differentiated instruction for specific student cohorts. Lastly, one main concern in both cases was student privacy and the long term consequences of data collection and analysis.

Data from Project's 2 study suggested several interconnected teacher-identified solutions for incorporating LA into their practice. Teachers believed LA could improve their workflow and efficiency by generating reminder, autograding, identifying areas of student success on tasks as well as predicting instances of difficulty, keeping track of behavior problems, and sending updates to parents and students related to attendance or homework. Although the participants were hopeful about the role of LA to increase their efficiency

at teaching related tasks, they were reluctant to give up control over communication. Teachers were also hopeful that by participating in the design of LA for their classroom that they would be able to better differentiate instruction and allocate resources in their school. The discussions and workshop learning experiences provided additional insight into the participants limited understanding of the role LA can have in educational contexts, while proficient understanding in other contexts such as gaming and app design. A consistent theme from the participants was interest in the possibilities as long as safeguards are implemented to protect student privacy.

In Project 1, two emergent topics were related to student qualitative feedback and the need to complement it with quantitative LA data [19]. This was identified as one way to connect student data with learning design decisions. Moreover, teachers expressed the need for easy-to-understand and explore data visualizations which could provide access to student artifacts (student comments, student work). Teachers appreciated having aggregated data summarizing the impact of the designed activities but they also found it useful to have more detailed (qualitative) data available for disclosure (e.g. chat discussions) to understand specific aspects of the resulting activities. Teachers liked the approach of documenting their learning designs together with the analytics following a teacher-led inquiry cycle and structure, where they formulate questions inquiring into their students' learning and select and associate the analytics that

**Table 3: Main identified solutions for learning analytics design: cross-case analysis**

Solutions	Project 1	Evidence	Project 2	Evidence
Teacher collaboration successfully promotes problem definition/interpretation of learning analytics	✓	Questionnaire, Interviews	✓	Interviews, Focus group
Simplifying the data collection process towards improvements in learning design and instructions	✓	Questionnaire, Interviews	✓	Interviews, Focus group
Concerns over student privacy and long term consequences	✓	Questionnaire, Focus groups	✓	Interviews, Focus group
Teachers need qualitative feedback to align learning analytics with their learning designs	✓	Questionnaire, Interviews	x	
Teachers need easy-to-understand and explore data visualizations	✓	Questionnaire	x	
Reminders for teachers	x		✓	Interviews, Focus group
Auto-grading	x		✓	Interviews, Focus group

can answer those questions. Moreover, teachers were hopeful that by documenting and sharing their inquiries within their schools, they could create communities of inquiry, leading to school-level reflective practices informed by evidence. Project 1 also researched about ethics from a perspective of capacity building regarding data privacy [3].

#### 4 DISCUSSION

This paper describes a comparison of two projects to engage teachers in LA design. The overall conclusion that we advance here is that, despite clear differences in the experimental professional development programs, cultural context, and the population studied, there are substantial shared similarities in both the problems teachers identify and the solutions they propose. With respect to LA as a research endeavor this might demonstrate that indeed there are traits and processes that are common across countries and learning contexts, there still may be some generalizable, substantial findings to uncover that may be leveraged to change education positively at scale, rather than every context requiring bespoke research projects with individualized, contextual findings.

Alternately, although the level of similarity is remarkable, it may demonstrate that the introduction of data-informed practices into K12 classrooms is at a similar level of infancy globally. Reflecting that education systems are currently in a stage of attempting to map new data practices onto old pedagogical and administrative conventions with similar hurdles relating to the introduction of any new process into a complex system. Subsequently, we are not currently at a point where teachers or schools are differentiating themselves based on the kinds of analytics that they develop. Rather, they are highly influenced by ideas generated by government and the private sector. This is clear from the preponderance of concerns among teachers with quantitatively analyzing test scores and student disciplinary data. This mirrors the approaches to analytics that have been driven by government agencies and products that have been successful on the market [6, 9].

Regardless whether the commonality between these two contexts demonstrates the level of generalizable findings that might be uncovered by the broader LA enterprise, we are confident that

there is one area that is very common across countries and contexts - the need for a substantial professional development of the teaching workforce around technology, data, its processing and uses. Both cases under study here uncovered a need for substantial time to be devoted to basic data and technology literacy. To some extent whether or not resources are devoted to developing teacher capacity depends on what one’s view of how the teacher’s role should evolve in response to education technology and the data stream it generates. If we assume that the teacher is integral to the educational enterprise then LA is as much a teacher-education endeavor as it is a matter of developing and applying metrics and reaching broad research goals to better understand student learning. What follows from this is that involving the teaching workforce in the LA enterprise will necessarily have to tackle how teachers can creatively apply metrics and automated processes to their work - a teacher-driven LA. A hurdle that has been uncovered by the current study is the extent to which historical attempts to adapt quantitative analyses to educational contexts influence current attempts to involve data within education. Part of the the legacy of previous data debates in education has been the lack of teacher involvement in the creative work of developing and testing metrics and their applications. As such, when teachers are given the space to do this, they are hesitant to stray away from traditional data sources or ways of processing data. Part of any program of professional development that endeavors to involve teachers in LA development will likely have to tackle both learning about data and methods of data analysis, but also involving them in the creative-side of how analytics are designed and developed.

#### 5 CONCLUSIONS:LESSONS LEARNED

Given the disparities between the two studies the remarkable conclusion in how similar the problems teachers identified were and the solutions that they proposed. This cross-case analysis between the two different contextual uses of LA (and countries) led us to some lessons about the meaningful involvement of teachers in LA design. We formulated the following principles according to the commonalities between the two cases:

- (1) **Focus on problems of teacher practice and consider teachers' priorities in the interpretation of LA** (e.g., classroom and time management). The design of LA tools for teachers should target teacher-identified problems of practice with the aim to easily integrate them into their learning interventions.
- (2) **Scaffolding in linking teachers-identified problems with LA.** The two analyzed cases propose that scaffolding is required to facilitate the connection between LA and teachers-identified problems. Scaffolding might be part of a TPD program (through researcher-practitioner collaboration) but also a build-in tool of a LA dashboard. Such tools can integrate the generation of questions and solutions to problems relevant to teacher practice that are linked with the LA. A teacher inquiry process will allow the mapping between teachers' conjectures and data-driven pedagogical actions.
- (3) **Teacher collaboration and sharing of data use learning scenarios.** Teacher collaboration promotes discussion and knowledge building related to problem identification which is grounded in the interpretation of LA. The sharing of data use learning scenarios promotes knowledge exchange for the practical use of LA by teachers. An example for the sharing of data use learning scenarios is shown in the TILE tool [19].
- (4) **Linking LA with actions related to the real-time management or re-design of learning activities.** Teachers require time and experimentation to use the design knowledge generated after reflective, inquiry cycles with learning analytics.
- (5) **Ethical considerations on student-generated data.** Learning analytics tools should integrate the ethical use of LA which is informed by teachers concerns and contextual knowledge of their students [3].

The above principles are in line with recent related research which seeks to develop human-centered LA [4, 15, 28]. Future research needs to consider these principles when involving teachers in LA design and could be implemented in TPD programs about LA use by teachers or embedded in technological scaffolds for teachers.

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