Towards understanding the potential of teaching analytics within educational communities

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ABSTRACT
The use of learning analytics in ICT-rich learning environments assists teachers to (re)design their learning scenarios. Teacher inquiry is a process of intentional and systematic research of teachers into their students´ learning. When teachers work in small groups or communities and present results of their practice more interpretations are generated around the use and meaning of this data. In this workshop paper we present preliminary research about four dimensions of learning analytics (engagement, assessment, progression, satisfaction), and their visualization as teaching analytics, that are hypothesized to be relevant to help teachers in the (re)design of their learning scenarios. Moreover, we evaluate teachers' acceptance of exchanging these types of analytics within their teaching community. A workshop for blended MOOCs design (*N=20* participants) showed that although all the analytics dimensions were valuable, assessment data was the most useful dimension for (re)designing while data about the engagement of students was the less useful. Educational practitioners also showed interest in knowing a combination of specific data (e.g. achievements related with the satisfaction of students). Last, most participants expressed their willingness to share visual learning analytics related to their designs with their colleagues. The role of contextual information to interpret the learning analytics was recognized as important.

General Terms
Teaching analytics, Learning analytics, Communities of educators

Keywords
Teacher inquiry, professional learning communities, learning design

1. INTRODUCTION
There is a growing interest on the way teachers and learning designers prepare ICT-rich learning arrangements and how they use students´ data for the accountability and the (re)design of their learning scenarios. Teaching analytics have been proposed as the design, development and evaluation of visual analytics methods and tools for teachers to understand learning and teaching processes [28]. The current research has focused in different directions. This includes real-time learning analytics collected during the learning process and presented to teachers in order to intervene "on the fly" and orchestrate better their teaching [29], data gathering based on the affordances of specific learning analytics tools and presentation to the teacher after the learning sessions [13].

Although those approaches provide valuable information to the teachers, in this paper, we argue that a communicative approach of teacher inquiry within groups or professional communities can generate additional insights on the way teachers can improve learning scenarios and benefit from teaching analytics methods. We present our preliminary work on four dimensions of learning analytics data with the aim to generate discussions between teachers on how they plan their inquiry and reflect about their teaching plans with other practitioners. To extract requirements for the support of teachers within groups or professional learning communities, we evaluate perceived usefulness of learning analytics data for the improvement of learning designs. Moreover, we evaluate the acceptance of exchanging visualizations between educators. A case study took part within a workshop for blended learning scenarios that incorporate resources from Massive Open Online Courses (MOOCs) [1]. The remainder of the paper is organized as follow. In section 2 we describe teacher inquiry within professional learning communities, specifying the challenges addressed in the paper. In section 3 we explain our methodology and the four dimensions of students´ data which can be aligned with a learning design. Section 4 describes the evaluation study we conducted for extracting requirements from educational practitioners and results of the study. Last section 5 is devoted to a conclusion and implications for future work.

2. TEACHER INQUIRY WITHIN PROFESSIONAL LEARNING COMMUNITIES

There is evidence that data use is helpful in improving educator's attitudes towards teaching practice and their students [3, 21]. This is empowered when educational teams learn about the inquiry process and are engaged in collaborative informed decisions. Changes in teacher culture which has been often described as isolationist include the development of professional learning communities which encourages sharing, reflection and deprivatization of practice [12]. Research in professional learning communities acknowledges that active teacher's participation and collaborative activities has an impact in teaching practice [7] and students´ learning [9].

Teacher's groups or wider communities can be formulated within the same or different educational institutions with the aim to improve educational practices [8]. Currently a vast amount of networked technologies and investigation tools [23] provide many opportunities of knowledge sharing and reflection over teaching practice. The term teacher inquiry has been defined as "a systematic, intentional research by teachers" [10] which aims at improving instructions in four levels [14]:

1. By defining important instructional problems specific to the local context of the participating teachers
2. By planning and implementing instructional solutions-Connecting theory to action
3. By using evidence to drive reflection and analysis
4. By working towards detectable improvements and specific cause-effect findings about teaching and learning

As such, teacher inquiry consist of a cyclical approach which is connected with teacher´s planning and investigation and promotes changes in the way teacher´s design and rethink for their students´ learning. Moreover, currently the practice for the collection of data about teaching and learning has emerged. As Roshelle & Krumm [24] describe, evidence which can inform instructional improvement was previously infrequent and separated in time because it required an extensive time period and additional teams of people which could carry out for instance classroom observation and paperwork. However, with the integration of ICT in teaching and learning, data can be collected both from teachers and students more frequently and integrated into the everyday activities. The research field of learning analytics, defined as " the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs" [15], facilitates the practical application of extracting useful information from a learning environment.

However, despite the positive factors of investigating teaching and learning to improve future students´ experiences we identify specific challenges addressed within a wider framework of professional communities for educators. There are currently few works on how to support collaborative teacher inquiry [27] within communities, which students´ information is relevant to extract in order to improve teaching and inform other colleagues and which extra factors influence a community of educators. For instance, the concept of equivocality [17] deals with possible multiple meanings and interpretations of the same data based on different contexts. Moreover, often educators may face the problem of information overload from the data deluge and the solution may be not to gather more data rather to better highlight the reasons to collect the data, understand the context from which it comes and locate better frames of reference [31]. It is also useful to differentiate between individual and collective sensemaking of data. The reason is that this process is considerably influenced from the context of the situation in which it takes place as well as the wider organization in which the individual is participating. Prior knowledge of the sense maker and routines of actions between individuals may also influence the way they interpret information. Thus, having more labels explanations and related experiences provides the ability to see and connect different data together and develop different narratives on what the data mean. However, developing a richer schema requires learning from the others and externalization of knowledge between educational practitioners.

3. LEARNING ANALYTICS DIMENSIONS FOR A COMMUNITY OF INQUIRY

Previously teaching analytics were proposed as the support of diagnostic-decision making by teachers with the use of learning analytics [28] and as the understanding of online teachers interactions when they search and create educational resources [32]. In both cases, educational practitioners are considered in small working groups with divergent backgrounds or larger communities which aim to reach common ground or learn from each other. However, little research addresses how communities of teachers could be supported for better collective performance and which analytics from students' activity are most useful to consider when reflecting about improvements to their practice. Schnellert et al [26] examined how teachers are engaged in collaborative cycles of inquiry within authentic communities of practice. Teachers were co-constructing and analyzing situated assessment based on formative assessment data. Avramides et al [4] describe and evaluate a collaborative approach of teacher inquiry into student learning and they emphasize in the need of defining what data to collect and what they tell us about the learning process.

3.1 Methodology: first LATUX steps

In this paper, our aim is to understand how to support teachers´ reflection on their teaching plan with the use of teaching analytics displayed within communities. Our research context leads as to follow a Design-Based-Research [6] approach as it provides flexibility and proposes analysis of requirements through the collaboration with educators and researchers in real-life settings in order to improve educational practices. More specifically, because we focus on visual analytics, after analyzing different frameworks for the design of visualizations, we decided to follow the iterative workflow LATUX (Learning Awareness Tools User eXperience) [20] for designing, validating and deploying learning analytics visualizations. LATUX propose a workflow for projects aiming to develop awareness tools for instructors regarding the learning activities of the students. The authors explain four steps which include problem identification, low-fidelity prototyping, higher-fidelity prototyping and pilot-studies. In the first steps of problem identification and low-fidelity prototyping the designers extract requirements, investigate stakeholder's needs, identify data sources aligned with intended pedagogies and develop possible visualizations. Our aim is to cover the first steps of problem identification and low-fidelity prototyping. For this

reason, we define our problem of supporting teacher inquiry within communities with visual learning analytics. We propose learning analytics data and visualizations which can drive reflections and we investigate stakeholders´ needs.

3.2 Description of the problem and low-fidelity prototyping

Examples of learning tools which can be integrated in face-to-face and online teaching sessions include Learning Management Systems (e.g., Moodle, Blackboard, Sakai), discussion forums for social learning or use of wikis and google docs for deploying activities of students´ writing. Those kind of tools store information about student to student interaction and student-content interaction. However, information provided by those tools with learning analytics visualizations often do not align with the pedagogical intentions expressed by teachers in a learning design and are not consistent with their aims of investigating their students [13, 22, 25]. Moreover, possible reasons of teacher's inquiry into students learning [22] and the sense-making of information about students may vary according to the specific educational context. In this paper, we focus on four learning analytics types which are relevant with the monitoring of students´ engagement, the assessment of student's work, their progression through the timeline of a learning design and the understanding of their overall satisfaction from the learning activities. Our aim is to connect common objectives of learning designs which promote active learning such as cognitive, behavioral, social and affective goals with the aims of learning analytics tools which has been stressed as assistance for educators that identify cognitive, social and behavioral aspects of students´ activities [2]. Moreover, we aim to address teacher information needs which can be extracted from three sources: the learning process, the learning outcomes and the teaching practice [13]. These learning analytics dimensions may be classified in different levels of granularity from higher order values to concrete metrics according to specific tools´ affordances and indicators of students learning. We propose four higher level categories which may be able to help teachers to plan the inquiry process and evaluate a learning design within communities. In each category we present examples of low-fidelity prototypes visualizations and explain the connection with the learning design as teaching representations.

3.2.1 Engagement

Engagement of students with the learning content and their peers constitutes prerequisite for their learning. Lockyer et al [18] explain two types of engagement data which can inform the (re) design of learning scenarios. First, checkpoint analytics which are relevant with the engagement of students with the course resources and can show how students prepare to learn. Examples can be metrics for submission of learning assignments, online access to resources and downloads of course content. Second, process analytics like participation in activities per group and interaction analysis can show how students are engaged in specific tasks (see figure 1).

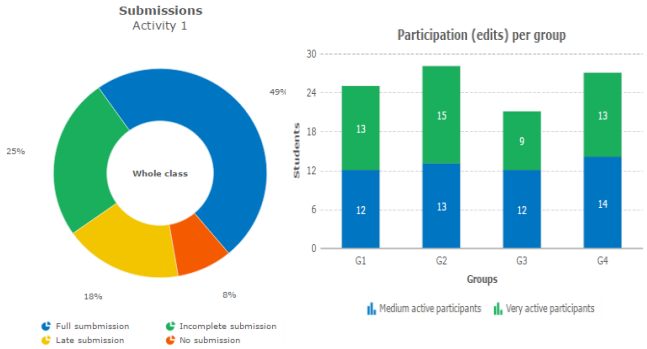

Figure 1. Examples of checkpoints and process analytics visualizations

For instance, regarding checkpoints the left graph shows the percentage of students who submitted a learning assignment in different levels of completeness. Regarding the process, the right graph shows the level of participation in the assignment from different groups of students. A teacher may estimate if students fulfilled requirements to proceed in an upcoming activity.

3.2.2 Achievements and assessment

Achievement of students may be assessed through the evaluation of student's products and artifacts. Thus, access to e-portfolios can generate valuable insights on how to (re)design future learning activities [19]. However, since this requires time, qualitative information for the students´ works through the use of rubrics may be able to inform educators about how to improve their design. Moreover, automatic analysis from tests can also show where the students struggle and cognitive impacts of the learning design [16].

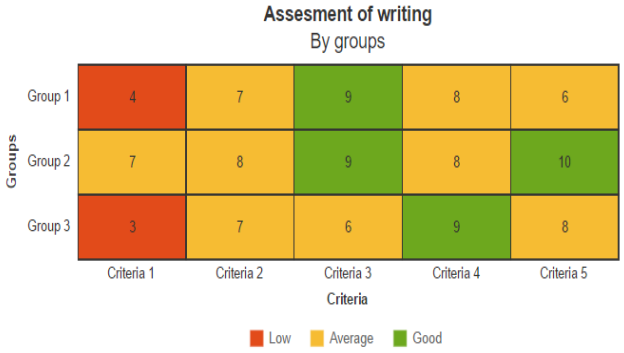

Figure 2. Sample visualization of assessment rubrics per group based on different criteria.

Figure 2 shows a visualization of assessment rubrics based on different criteria of evaluation which can be contrasted with the goals of a writing assignment. Values correspond to the grades given by the teacher and show comparisons between different groups of students.

3.2.3 Progression through the time

Learning progression can help guide teachers in designing their objectives and choices in the classroom [11]. Bakharia et al [5] describe a framework for the alignment of learning analytics with learning design and one dimension deals with temporal analytics relevant with course, content and tool access during the timeline of the course. Tracking the progression of students through the time may help teachers to better orient their decisions based on temporal planning (see figure 3).

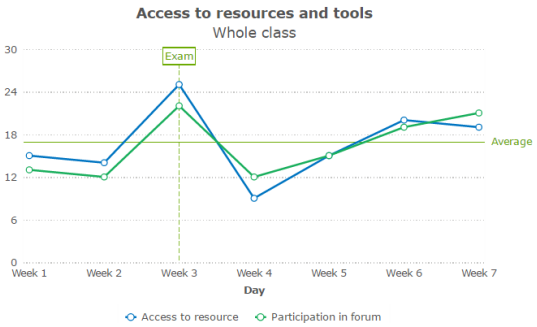

Figure 3. Example of progression through the time of a learning design

Figure 3 shows the progression of a whole class regarding access to resources and participation in a forum during the timetable of a learning design. Low participation in specific weeks may orient the design of future activities.

3.2.4 Satisfactions rates

Student interest and satisfaction is referred to as another factor to evaluate the effectiveness of learning environments [33]. The term student satisfaction can refer to whether students liked to participate in the learning environment, if it was enjoyable to work in groups and their overall experience in each learning activity (see figure 4).

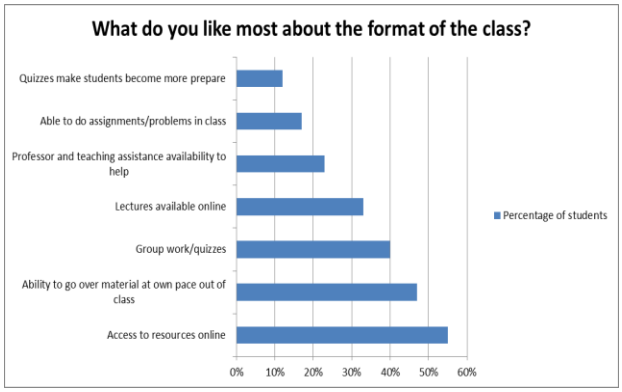

Figure 4. Satisfaction of students in different elements of the learning design

Figure 4 shows percentage of students´ satisfaction regarding different elements of a blended learning scenario. Each element can be estimated in the design of an upcoming learning scenario.

The alignment of those learning analytics dimensions with a learning design may require from a teacher to be involved in the inquiry process. This presumes to plan in advance how to collect this data, which learning objectives to evaluate and in which instance of the design to focus. Although different types of data may be needed to be collected during the learning activities, teachers often are overloaded with multiple tasks and thus need to focus in a specific dimension in each case. These multiple types of learning analytics collected during the learning process may be able to evaluate a learning design and serve as support to intentionally collect data when designing for students' learning.

3.3 Research focus

In this paper we provide low-fidelity prototypical examples of analytics for teachers but our aim is not to evaluate the design of the visualizations rather to understand which of those learning analytics dimensions are relevant for educational practitioners. More specifically, we explore which information is useful in a community of educators´ to drive the improvement and customization of their learning designs. To address these issues, educators´ usage beliefs (usefulness) of learning analytics dimensions for the (re)design of learning scenarios may provide insights on the adoption of this approach in teacher´s practice. Moreover, to evaluate those dimensions together, rather than separately, we discover relations between the usage beliefs of different learning analytics data and between their contexts. Last, since our framework is within teachers´ groups or communities we evaluate the acceptance to exchange with other colleagues teaching analytics and additional useful information for them.

The research question explored in this paper is:

RQ: Which learning analytics are useful to (re)design or to re-use a learning design?

This research question is investigated though the following more specific questions:

RQ1: Are the above learning analytics dimensions (engagement, assessment, progress, satisfaction) or other information perceived as valuable by educational practitioners?

RQ2: Is there any relation between the four dimensions and between the dimensions and the contexts of the students?

RQ3: In a collective level, do educators will to share learning analytics visualizations or to look at the results of their colleagues?

4. EVALUATION

A case study was used to evaluate how educational practitioners perceive the use of learning analytics for the improvement and reuse of learning designs. The setting was a teacher-training workshop about designing blended MOOCs held in conjunction with a MOOC platform conference. 24 participants, including 8 professors, 12 university assistants devoted to the design of courses and 4 educational researchers took part in the workshop. The use of technology in blended learning approaches allows the collection of data about students representing a feasible case where teachers can have access to learning analytics data. The aim of the workshop was to introduce to a group of educational practitioners a framework for the design of blended MOOCs and to evaluate which different levels of analytics or additional information from colleagues can drive decisions for learning design improvement.

Regarding the profile and interest of the participants, 60% of them were conceptualizing an idea of a blended MOOC course to be implemented in the future while 35% were preparing or running a blended MOOC course at the time of the workshop and only 5% were not intended to implement a MOOC course. Their interest to participate in the workshop was primarily to learn how to blend MOOC resources in face-to-face classrooms and apply it into their practice.

For the facilitation of the workshop, participants were provided with different example cases of blended MOOCs design (e.g. flipped classroom case) which were analogous to their own ideas about course design. Each case was enriched with low-fidelity prototypes of learning analytics data in each of the above categories (engagement, assessment, progress, satisfaction). The examples included the figures shown in the previous section and among others, histograms, bar charts and line-graphs of temporal analysis for student´s access to resources of the course, satisfaction rates of face-to-face and online activities, students´ pass rates and group participation in wiki assignments. Both the example cases and the visual analytics were provided as paper material.

To generate discussions within the workshop´s groups, after an initial introduction to the topic, the participants were asked to look at the example cases and the learning analytics dimensions and to think which information help them to re-design or reuse these cases. Moreover, they were asked to discuss which information after the implementation of their course they were willing to share within their educational community.

Figure 5. Working groups discussing about the use of learning analytics in different cases.

Figure 5 shows low fidelity prototypes of four learning analytics dimensions as paper material. Groups of participants were provided with example cases of blended MOOCs designs and the four learning analytics dimensions.

For the evaluation of this approach, we used two data sources, a questionnaire and observations carried out by one individual researcher. We constructed a questionnaire based on the Learning Analytics Acceptance Model described in [2] for the perceived usefulness of learning analytics dimensions to improve learning designs. The questionnaire included four questions, one for each of the learning analytics dimensions and one question regarding the usefulness of knowing about the context and student´s profile. Additional open questions aimed to extract which additional information could be useful from the perspective of the participants to support reflection for the improvement of a learning design. Finally, to evaluate acceptance of collective practices when teachers present results of their inquiry in the form of visualizations, two additional questions were referring to the acceptance of sharing learning analytics visualizations with other colleagues and the acceptance of having access into results of other educator's results.

Descriptive statistics and correlation analysis between the constructs were used to explore the results of the questionnaire. A total N=20 participants responded in the questionnaire with an acceptable reliability a = .76. The results regarding the **perceived usefulness of learning analytics dimensions** (RQ1) showed that these categories receive high value from the participants with means ranging between 3.6 and 3.95 within a Likert scale 1-5 (See table 1). An interesting result was the fact that the assessment category had the higher mean (M = 3.95) whereas the engagement of students had the lowest mean (M = 3.6), while progression and satisfaction were in similar levels. One interpretation could be that participants perceived high value in past students´ achievements when designing a blended MOOC whereas engagement with course material and online interactions is a secondary priority.

The question concerning **perceived usefulness of knowing the context** (RQ2) of the course (e.g. the profile of the students, level of education, and the domain of knowledge) for the understanding and analysis of learning analytics visualizations received high value with a mean M = 4.4 (SD = .68) within a Likert Scale 1-5. This may shows high relevance of providing information about the students and the overall context of a learning design in order to interpret visualizations given by others.

Correlation analysis between those dimensions (see Table 1) showed that perceived usefulness of engagement analytics was correlated with progression and assessment with satisfaction. Moreover, interest in knowing the educational context was correlated with interest about engagement and assessment. The relation between the value of engagement and progression awareness may show how participants anticipate and combine the efforts of the students with their progress. The relation between assessment and satisfaction can be interpreted from the perspective that achievements of students are perceived consistent with their overall satisfaction. Finally since we found a correlation only between usefulness of context information and assessment and engagement analytics, we can interpret that those types of data are especially relevant within the context in which they are collected.

Table 1. Descriptive statistics and correlation matrix. Usefulness of each learning analytics dimension and the context

	Mean(SD)	1	2	3	4
1.Engagement	3.6(1.04)				
2.Assessment	3.95(.82)	.402			
3. Progression	3.8(.89)	.585**	.271		
4. Satisfaction	3.85(.81)	.297	.616**	.391	
5. Context	4.44(.68)	.532*	.506*	-.035	.304

n = 20, *p<0.05, **p <0.01

Table 1 provides descriptive statistics regarding the usefulness of each learning analytics dimension (1-4) and the usefulness of knowing the context and student´s profile in the example cases (5). Moreover, columns 1-4 show the correlations between the five items of the questionnaire.

The qualitative responses of the participants regarding **additional information** which could help them to redesign their course or re-use an implemented design showed the importance of having descriptive qualitative information about face to face sessions such as teacher reports and observations about the levels of students´ interactions. Some other interesting responses were the idea that online connection time does not necessarily indicates useful work, but that actual time used in each activity is useful to redesign a course (see figure 6). In general, learning designers may often need a combination of data regarding face to face and online interactions and qualitative feedback from their colleagues.

Figure 6. Word cloud of participants´ responses

Figure 6 shows key words of participant's responses regarding information that help them to re-use or re-design their course or anothers' implemented design. Interaction of students, time duration of activities and face-to-face observations were among the key information.

Regarding the **willingness to share learning analytics (RQ3)** results in the form of visualizations with other colleagues, the results showed high acceptance as 75% of the participants gave positive responses. 2 of the participants indicated that they would be willing to share specific data and on demand information if they were asked from other colleagues and 2 were not willing to exchange aggregated analytics from their scenarios. The participants were also asked which type of information would be useful to help other colleagues to design a similar experience. Although this question received low responses, useful information was related to the details of the teaching strategy (similar to the representation of a learning design or a teaching notation), explanations of faced difficulties and positive experiences from other educators and aspects of their four dimensions we proposed. This highlights the need to inform other educators about the way they design their courses and their experiences after their implementation as statistics and visualization may be not enough for the interpretation of learning analytics results.

The willingness to see the results of the implementation of other learning designs also received high acceptance (75%). However, this time 4 participants indicated that they would not like to have access to these kinds of visualizations. This opens up questions in the way data can be presented to educators and which additional information would help them to re-design their course. The limited responses concerning useful information from other colleagues do not allow us to make conclusions. However, many participants inquired information about concrete related learning design examples and students´ satisfaction levels for each specific part of the course.

Last, the observations carried out by the individual researcher showed that participants were particularly interested to have analytics results for each specific case. The discussions of the groups were varying according to the participant´s beliefs about the different analytics dimensions and often participants were having different understanding of the same results and possible learning design improvements.

4. CONCLUSION

Data-driven reflections on the teaching practice can impact the way in which educators design for learning and deliver their teaching. Educational teams or communities can be formed around situated activities such as teacher planning, analysis of student's data and improvement of learning designs. In this paper we analyzed which learning analytics data or additional information is useful to help educational practitioners to redesign their learning scenarios. We considered our analysis within teacher's inquiry teams or wider communities and thus we proposed four learning analytics data which can be aligned with teacher's pedagogical intentions expressed in a learning design and can drive discussions.

Our case study within a workshop for the design of blended MOOC courses showed that the dimensions of engagement, achievement, progression and satisfaction were perceived as of high value by the participants. This proposes that in this context these learning analytics dimensions are considered as relevant to drive reflections. The assessment of students was the most useful information to develop decisions on how to improve future courses. However, the limitation of our case in blended MOOCs and the fact that the participants were provided with the learning design of high granularity (representing the whole course rather the design of partial phases of the course) may influence the value of having this data. For instance, teaching representations for a collaborative learning activity may require more data about the learning process and the engagement of students to show interesting information to the teacher.

Second, the experience of the participants with the implementation of blended courses with MOOCs, positive or negative, may influence the interpretations of our results. The largest amount of them were preparing the content of a blended course but had limited experience in implementing it. Further studies should consider interviewing educational practitioners during or after the implementation of their own learning scenarios as accessibility and effort to interpret data will provide better insights for the usefulness of this approach.

In a collective level, educational practitioners were interested to view learning analytics visualizations from other colleagues or to share their own results to inform educational teams. However, the context of the learning design was valuable information to

interpret this data. This proposes that educators are interested to collaborate with others on issues such as the use of student´s data to improve their practice, data collection, data visualization and learning design. However, we need to consider that there is an amount of practitioners that are not willing to open their practice about data-driven reflections in open educational teams and thus prefer to share practice on demand if they are asked from others.

Regarding the four dimensions we proposed, we can conclude that educators may need to search relations between their data according to their actual meaning. For instance, in our case the value of assessment data was correlated with information about student´s satisfaction and engagement with their progression. Moreover, in our workshops participants asked for teacher´s reports regarding the student´s discussion in the classroom, and exchange of positive or negative experiences from other colleagues. This proposes that additional work is needed on how teachers connect different sources of visual learning analytics and qualitative data to decide how to improve their scenarios. Studies that evaluate practitioners during their design, the use of learning analytics data and their collaboration with other educators can identify patterns of data-driven reflections.

Last, design implications of our evaluation propose that educators´ teams can be supported with learning analytics visualizations when they have access to the specific learning design of a course and additional teacher´s reports or exchange of teaching experiences. Educational communities need to concentrate in specific learning analytics data that show impacts of learning designs in order to formulate collaboratively important meanings for the teaching practice.

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