Semantically Annotated Lesson Observation Data in Learning Analytics Datasets: a Reference Model

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Abstract. Learning analytics (LA) and lesson observations are two approaches frequently used to study teaching and learning processes. In both cases, in order to extract meaningful data interpretations, there is a need for contextualization. Previous works propose to enrich LA datasets with observation data and to use the learning design as a framework to guide the data gathering and the later analysis. However, the majority of lesson observation tools collect data that is not compliant with LA datasets. Moreover, the connection between the learning design and the data gathered is not straightforward. This study reflects upon our research-based design towards an LA model for context-aware semantically annotated lesson observations that may be integrated in multimodal LA datasets. Six teachers (out of which 2 were also researchers) with previous experience in lesson observation were engaged in a focus group interview and participatory design session that helped us to evaluate the LA model through the conceptual design of Observata (a lesson observation tool that implements our model). The findings show the feasibility and usefulness of the proposal as well as the potential limitations in terms of adoption.

Keywords: learning design, learning analytics, lesson observations, multimodal learning analytics, semantic annotations

1. Introduction

It has been argued that Learning Analytics (LA) is lacking in understanding the pedagogical context of student activities [1][2][3]. To address this need, articulated learning design can contribute to the interpretation of LA data, creating an actionable feedback loop [4]. In addition, Learning Design (LD) and LA not only enrich each other, but also are important elements for improving teaching and learning: "Learning design provides a semantic structure for analytics, whereas teacher inquiry defines meaningful questions to analyse" [5]. In other words, synergies between LA and LD can be used to support teacher inquiry, reflection and pedagogically grounded learning analytics practice.

Learning Analytics is a field that studies learners and their contexts [6] mainly based on the data coming from digital realms to understand the computer-mediated

contexts. However, in order to analyse learning as a whole and understand the context, there is a need for combining data coming from both the physical and digital spaces [7]. Thus, multimodal data collection and analysis techniques –Multimodal Learning Analytics - that go beyond the digital environments can bring novel methods and evidence to understand the teaching and learning processes [8].

New data collection and sensing technologies make it possible to capture human activity (e.g., with wearable cameras, eye and position trackers, or biosensors). Nevertheless, human activity can be tracked not only by automatic digital means or sensors, but also by human labelling. In this article, we argue that lesson observation is a relevant data source that can be semantically described and integrated into LA datasets. However, to the best of our knowledge, lesson observation tools are not compliant with LA datasets [9].

To enable the integration of observations into LA datasets, we propose an LA model for semantically annotated lesson observations. Among the multiple purposes that lesson observation may have, this model focuses mainly on activity tracking. By means of predefined vocabularies extracted from the learning design, this model systematically contextualizes the observations. Besides, this model takes into consideration current LA practices to promote the data integration (i.e., using widely adopted specifications such as xAPI[1]).

This paper presents the research-based design process [10] followed towards the definition of our reference model for LA compliant lesson observations. The proposal is evaluated through the conceptual design of Observata, a lesson observation tool that implements our model. The design process took place in a scenario-based participatory design session using semi-structured, guided focus group interviews with 6 teachers (out of which 2 were also researchers) with previous experience in lesson observation. Such participatory design contributed to the refinement of our model and the identification of limitations to be overcome in our future work.

2. Background and related work

Educational practice, research and development require contextualised data and pedagogically grounded analysis to understand teaching and learning processes [1][2][9]. Indeed, a core challenge for the learning analytics community is to determine conceptual and practical frameworks that can link teachers' intentions with the data retrieved while teaching and learning [1]. Such contextualization may be driven by the learning design, since it reflects the pedagogical intentions in a particular learning context [2] [11] [12].

During recent years, it became obvious that collecting and analysing only digital traces is not enough [3] and that the inclusion of qualitative data into the equation might be beneficial [13]; alternative data gathering techniques could contribute to enriching the digital traces. For example, classroom observations are recommended for understanding an on-going process or situation [14]

Observation is a way of gathering data on individual behaviours, interactions, or the physical setting by watching behaviour, events, artefacts or noting physical

[1] https://experienceapi.com/overview

characteristics[14]. Methods of lesson observation may be quantitative or qualitative and the data can be collected with different degrees of flexibility (unstructured, semi-structured or structured). Such flexibility relates to the research paradigms and types of data one needs to collect [15][16]. Structured observations (also called systemic) are aimed at collecting quantitative, numeric and systematic data. Quantitative research has small focus, that can be aggregated into variables, while the qualitative focuses on phenomenological complexity of participants' worlds [16]. Researchers may prefer quantitative over qualitative depending on the aims of their research. Among the aforementioned types of observations, (semi)structured observations focused in the interactional setting could be the most similar ones to the digital traces.

Different to what may happen in an interview or in a questionnaire targeting the participants, observations rely on what people do rather than on what people say they did. However, observations have also some limitations such as the susceptibility to the observer bias and the impact that the presence of the observer may have on the context. Besides, observations are time-consuming compared to other data collection methods. If we look at the classroom life, it is so busy that makes it difficult to obtain the detailed account of it [15]. It may contain around 1000 thousand exchanges (or activities) in a single day [17]. For this reason, most of the teaching goes unobserved, even if it is informative to look at such practice for teaching inquiry and research purposes [18]. Aware of the need of combining evidence from the physical and the digital context, the research done in the area of multimodal learning analytics (MMLA) is currently addressing this gap, especially by introducing different kinds of sensors in the learning environment [5], and aggregating into multimodal dataset (e.g., using xAPI [7] [19][20]).

Enriching the datasets with observational data could contribute to obtaining a more realistic view of the educational scenario as it brings the user perspective into LA datasets [7]. However, although there are multiple tools that support the observation process (like Kobo Toolbox[2], FieldNotes[3], Ethos[4], Followthehashtag[5] ,Storify[6], VideoAnt[7], or LessonNote[8]), to the best of our knowledge, there is no one that enables the integration of the observations with other LA data sources for later analysis. Indeed, a number of difficulties hinder the generation of LA compliant lesson observation data at data gathering, integration and analysis levels [5]:

- Data gathering: the lack of guidance in classroom observation applications leads to unstructured and pedagogically neutral data that has no consistent format [8].
- Data integration: the problem of limited number of data sources in the LA solutions [3][21][22] mainly due to the heterogeneity of data models, formats and granularity [4].
- Data analysis: it is mostly time consuming and ineffective process to

[2] http://www.kobotoolbox.org
[3] http://fieldnotesapp.info
[4] https://beta2.ethosapp.com
[5] http://www.followthehashtag.com
[6] https://storify.com
[7] https://ant.umn.edu
[8] http://lessonnote.com

manually code the data [8].

Thus, in order to enhance teacher inquiry and research, we propose to enrich existing LA datasets with observational data, and to analyse such datasets within the framework provided by the learning design. The following sections present the research process towards that aim.

3. Methodology

To connect our research goals with the reality of the observers' practice, we are following a design-based research process [23] which entails a tight relationship between researchers and stakeholders. More concretely, our research is inspired by Leinonen version of design-based research: research-based design. Research-based design is an iterative approach that spans through four phases, namely contextual inquiry, participatory design, product design, and production of software as hypothesis [10]. In this paper, we reflect on the contextual inquiry and the first participatory-design session.

The overall research question addressed in this paper is: *How can we integrate lesson observations to generate semantically annotated, context-aware data in multimodal data sets?* To better understand this question, the contextual inquiry and the participatory design sessions tackle the following aspects:

- RQ1: How can we computationally represent observation data to enable the integration in LA datasets?
- RQ2: What are the process, elements, and motivation of different stakeholders and unit of analysis for observational data collection?

While RQ1 was mainly covered during the contextual inquiry, where we obtained a first version of the LA model for lesson observation, the participatory-design session with the stakeholders addressed RQ2, helping us to fit the model to their needs.

The contextual inquiry phase lasted for 3 years and consisted of literature review and a preliminary study about the how to transform observations into LA data from the semantic point of view [7], partly answering RQ1 at the unit of analysis level (see Section 4.2). Later on, the proof-of-concept study on the lesson observation data aggregation into LA datasets allowed us to shape a preliminary reference model [5]. An extended version of this model is presented in Section 4.

Starting from contextual inquiry, all the stages of the research are iterative and, therefore, the phases of research are not distinctly separated [22]. Thus, the contextual inquiry -through the literature review, the proof-of-concept and the first study- has informed the scenario-based participatory research by providing the initial conceptual design of the lesson observation application and the reference model. Then, the conceptual design - through the participatory design session described in Section 5 - informed the contextual inquiry, helping us to revisit initial ideas about the design concept and evaluate the reference model. In future phases, the updated reference model will inform the product design and vice versa.

4. Learning Analytics Model for Lesson Observations

The overall goal of this research is to introduce observational data into LA datasets in order to provide with more holistic view of teaching and learning processes. In this paper, we offer a reference model for learning analytics that includes lesson observations. This model builds on three main approaches: context-aware, pedagogically grounded, and multimodal LA. Figure 1 provides an overview of our model, showing how the relations among these approaches intersect.

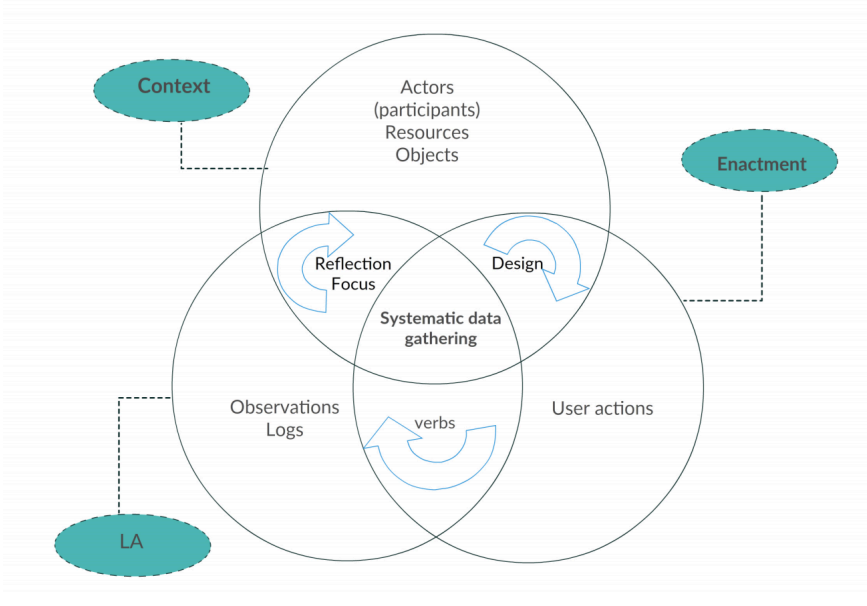

Fig. 1. Learning Analytics Model for Lesson observation

4.1. Theoretical basis

Context awareness. From the perspective of the observation practice, the observer must be aware of the elements of the learning context, i.e., there is a need for context awareness [7]. Similarly, LA researchers state that in order to make sense of the data analysis, there must be a contextualization effort [24]. Thus, in our model we adopt this view of context-awareness, which is aligned with both observation practice and learning analytics.

Pedagogical underpinning. Learning design could be considered a part of the learning context and it also reflects the pedagogical background. Some authors [24] propose the usage of pedagogically grounded LA in order to provide pedagogical meaning to the data analysis. Moreover, others [11] illustrate the benefits of gathering and analysing data, taking into consideration the learning design (e.g., providing more comprehensible and actionable data connected to the teacher concerns). Therefore, in those cases where the design is available, we propose to use this information to guide

the observations and the analysis. Following this approach, we expect to: first, bring more evidence to the LA field; and second, create an actionable feedback loop that will help to refine the design and analysis, as well as teaching and learning practice.

Multimodal datasets. The blended nature of technology-enhanced learning and teaching requires gathering evidence from both the digital and the real world [3]. While action logs and the content produced by the participants provide traces of the digital activity, sensors and observations can capture evidence of the real world [25]. Although multimodal datasets normally rely on digital traces and data gathered from sensors [21], our model includes observations in order to incorporate the perceptions and the evidence collected by teachers and observers about the activity of the participants. Thus, in order to enable the data integration with other data sources and the compatibility with different data analysis tools, our model has been designed to be xAPI compliant.

Observation process. Among the different purposes and kinds of observations, our target is to gather evidence about the interactions happening during the teaching and learning processes. Therefore, the envisioned observations will describe participant (inter)actions with other participants or with the context, considering as participants not only teachers and students but also the observers.

From the point of view of the flexibility of making observations, there is a continuum from highly structured to unstructured [16]. On the one hand, highly structured observations restrict the expressiveness in favour of reducing the pre-processing effort. Since, purely quantitative data is criticized for being taken out of context and failing to show the "story of the classroom life" [14], our model answers to this challenge using vocabularies extracted from the context i.e., including all the agents, resources, tools and media involved. These observations are then time-stamped and contextualized on individual, group or community level. On the other hand, unstructured approaches enable observers describe freely an event or interaction, requiring, however, pre-processing (e.g., tagging the observations for their aggregation) before carrying out the analysis. Indeed, some authors argue that classroom observations benefit from qualitative and unstructured approaches [14]. Despite the fact that our model is mainly directed at structured observations (where participant action is registered as a xAPI statement), it also supports unstructured observations (where observations are considered actions carried out by the observer) that later on may be used for better understanding the interactions during the analysis.

As mentioned before, multiple efforts have been done so far in terms of context-aware, pedagogically grounded, and multimodal LA. However, when the existing works have tried to integrate observations in their LA, they have accomplished it through ad-hoc solutions lacking of a methodological framework/model. To our view, the observation process in this context consists of the following steps [7]:

- *Step 1.- Be aware of the elements that belong to the learning context*. To facilitate a systematic observation process, all the actors and objects will be extracted in advance from the learning design, so that the observer links the events to the corresponding actors and objects. It should be noted, that in order to support unstructured observations, observers should be considered as potential actors.
- *Step 2.- Define the areas of focus, the indicators to be obtained in order to illuminate such areas and the specific events to be observed* – the application

is loaded with vocabulary to describe the events to be observed, including actions carried out by the actors involved in learning activity and the observers.

- *Step 3.- Collect observable events*. This is done by subject-verb-object structure and xAPI complex format, time stamped and sent to a learning record storage together with the rest of the MMLA dataset.
- *Step 4.- Analyse and interpret the results*. Observations are analysed together with the rest of the complementary data sources according to the focus defined in step 2.

4.2. Model description

Figure 1 shows not only the relations between context-aware, pedagogically grounded, and multimodal LA, it also specifies how they are aligned with the observation process. In order to connect the observations with the learning design (taking into account the actors, resources, activities, objects), we need to define the events to be observed and the specific verbs to be used, and finally, store it in a computational format that enables the integration with other data sources (xAPI).

Contextualizing and connecting observations with LD. The learning scenario is created in advance or directly imported from the learning design. Meta-data is stored (class, grade, teacher etc), observation protocol is defined, and all the actors, resources, learning activities are registered. Also, the classroom layout may be set, registered and is modifiable as the layout changes. Then, the coding happens on the basis of the chosen pedagogical scenario and framework.

Observable events and verbs. In order to observe the events, we define the foci of interest and we make annotations of events. This is done by coding the events in the classroom and producing real-time semantic annotations. *User actions* are coded and recorded by predefined code-sets [verbs] (in some cases, open coding can be used). Different types of taxonomies and levels of taxonomies (for instance, Bloom's) can be applied by defining the level in the annotated event. The events/notes are placed on the timeline. The levels can involve individual, group, whole-class activities.

Storage. It is important to store the data in a computational format that enables the integration with other data sources (xAPI). Semantically annotated lesson observations are integrated in the MMLA data set for the later analysis and visualization.

Unit of analysis. The central concept of our discourse is the unit of analysis. By definition, the unit of analysis answers to the question "who" and "what" and is the entity we want to describe and analyse [26]. This is the *unit* based on what the analysis is made. In the context of learning analytics, we are interested in tracking the interactions and making inferences on those interactions in a context, so the unit of analysis is the whole *activity*. Units of observation can be different from units of analysis and to obtain information on the unit of analysis, we may use different units of observation (also, in case of our data collection, units of observation can be different) [27].

Lesson observations that are aimed at observing and capturing LA compliant learning activities, need a definition of a universal *unit of analysis*, that can capture

activities that were planned and implemented by a teacher. This can be done through annotating observable events; it has been suggested that such unit of analysis is an *event* [7]. *Events* create *stories* that are based on enacted learning scenarios. Previous study on the use of eTextbooks in the classrooms was able to annotate lesson observations with the help of LessonNote[9] app and event-like structured xAPI statements [1].

We conceptualize xAPI statements as *unit of analysis* that in the context of lesson observations are [observable] events. This structure can capture events with any given pedagogical scenario/pedagogical intentions and can be later analysed with other sources of data, since they are structured and semantically annotated xAPI statements. To our view, this unit of analysis is suitable because it is neutral to pedagogical scenarios and intentions, it can express any activity through the verb (the verbs are predefined, so are the pedagogical intentions and indicators), it can be analysed with different methods and pedagogical frameworks and it is LA compliant.

Figure 2 shows different dimensions that influence the unit of analysis within the context of our model: educational theory (context), research approach (observations), technology (semantic annotations in xAPI format).

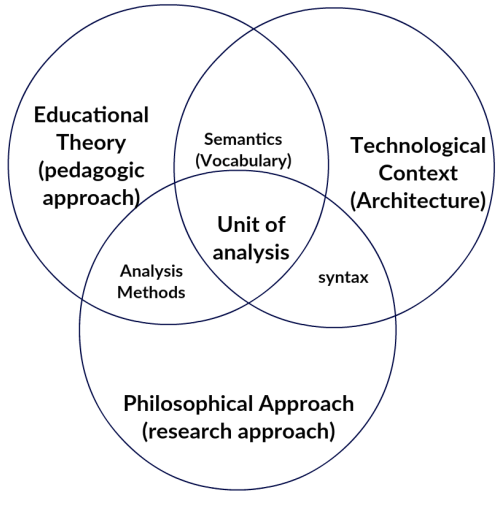

Fig. 2. Different Dimensions of Unit of Analysis

We hypothesize that there can be one neutral *unit of analysis* that can be used to record data with pre-defined teacher intentions, indicators and objectives, define the foci of interest and through semantically annotated observations link it to classroom practice for analysis with MMLA datasets.

[9] http://lessonnote.com/

5. Participatory design

5.1. Description of the study

The overall aim of the participatory study was to evaluate the reference model through the conceptual design of the application. For the design session, we have followed a scenario-based research method, modelling five personas[10] [28] based on the stakeholder profiles representing primary and secondary users of the application (see Table 1). A supervisor teacher represents a primary persona. Secondary personas are: an intern teacher (teacher in training), a head of an educational technology start-up, a teacher-researcher (in-service teacher partnering with the university), and university researcher. The persona models were data-driven [29] and their modelling followed by scenario-development was also iterative and comparative – repeatedly going back and forth from personas to scenarios. Since the final goal of the design session was to validate the model, the scenarios (see Table 2) described hypothetical uses and detailed functionalities of Observata, an application envisioned to implement the proposed LA model for lesson observation. For the study, we chose 6 participants familiarised with the personas described above and with previous expertise in classroom observations. All of them were in-service teachers (4 from secondary and 2 from higher education). Besides, 2 of them had a dual profile being not only teachers but also researchers.

Table 1 Description of personas

Type	Name	Goal	Requirements
Primary	Supervisor teacher	Observe and share observations	Efficiency and easiness of use
Secondary	Intern teacher	Compare the teaching execution vs intentions	Quick and effective annotations
Secondary	Edu Tech start-up head	Track the technology usage in the classroom	Ability to record activities that are using a certain tool
Secondary	Researcher teacher	Understand how pedagogical intentions are implemented (for regulation and reflection	Register, analyse, and visualize activities compare with the intentions
Secondary	TEL researcher	Automatically collect and code data with different semantics	Connect structured and consistent data with other sources

The scenarios introduced in Table 2 describe the hypothetical uses of the lesson observation application, together with specific functionalities that enable collection of LA compliant lesson observation data. While the first scenario represents a simple lesson observation case (independent of the learning design), the second one illustrates the added value of connecting the observations with a specific learning design and context. Then, third and fourth scenarios aim to exploit the benefits of a

[10] Modelled personas http://bit.ly/2skvTd2

context where other LA traces can be gathered for later integration and analysis. The former is shaped to the interests of a head of a TEL start-up, and the later to a teacher with research background.

Table 2 Overview of the scenarios discussed during the participatory design.

Scenario	Personas involved	Process
1. Simple lesson observation case (without lePlanner)	Teacher in training [Supervisor]	1. Manual context description and protocol definition 2. Classroom observation and evidence gathering 3. Observation sharing 4. Discussion
2. Observation based on LePlanner scenario	Supervisor [Teacher in training]	1. Reusing context description 2. Load existing design 3. Protocol definition 4. Classroom observation and evidence gathering 5. Comparison visualization 6. Discussion
3. Observation of a technology-rich lesson	Edu Tech start-up head [Researcher teacher]	1. Manual context description 2. Protocol definition 3. Classroom observations and evidence gathering with several foci of interest (several codesets) 4. Combining two data sources 5. Research
4. Curriculum research based on data observation	Researcher teacher [Edu Tech start-up head]	1. Reusing context 2. Discussion and comparison of semi-automated observation transcript with hand-written annotations using video-recording 3. Data export for analysis 4. Research

For the research based-design, where the researcher is not an objective observer but also a participant, we have used semi-structured, guided interviews and had the session recorded on the audio. Participants were handed-out 4 typical use cases (scenarios)[11], which are summarised in Table 2. The participants, after reading the scenario (each scenario was reviewed by all the participants at the same time), were asked to reflect on it based on specific questions listed in the scenarios. During the guided interviews, where needed, clarifications on the tool functionalities or the model were given. The questions explored during the session were related to our research questions but were semi-structured in order to obtain: general feedback on the feasibility and usefulness, recommendations/modifications suggested from, the usual process and use cases of observations (scenarios with questions are given in the detailed scenarios link in the footnotes).

[11] Detailed scenarios http://bit.ly/2rZxDra

The session was recorded for later thematic analysis with open coding. First of all, before coding we created a preliminary conceptual model based on our reference model, based on the contextual inquiry and scenarios that we have offered to the participants. The themes that emerged already from those scenarios, followed an iterative and comparative process, using inductive and deductive reasoning [30]. This approach helped us validate existing themes and categories and find emerging ones, thus evaluating and redefining the model presented in section 3. In the end, we used axial coding to structure and report our data.

5.2. Conceptual Design of Observata

In order to answer RQ2 and evaluate the conceptual model from engineering and epistemological perspective [31], we have developed a conceptual design of Observata through a contextual inquiry phase. Observata is envisioned as a lesson observation application for tablet computers devoted to collect data according to our reference model.

To enable the integration with the learning context and design, the envisioned tool will allow users to import the scenario from an authoring tool or to create it on the spot (with activities, actors, objects, tools and layout). Out of multiple authoring tools, we have chosen LePlanner[12][32] to integrate our observation tool. This on-line tool managed by Tallinn University is compliant with our reference model and semantics can be easily retrieved based on the scenarios developed by it, or by creating it in the Observata directly. Observata and LePlanner will share the same user accounts, allowing Observata users to view and use learning scenarios from LePlanner as a basis for annotating a lesson observation. Yet, Observata could also be used as a stand-alone tool, without any learning scenario required for lesson observation.

Lesson scenario in LePlanner (Figure 3) contains a set of in-class (blue) or off-class (green) learning activities arranged sequentially on the timeline, along with related learning resources, linked to learning outcomes and marked with an indicator from a pre-defined taxonomy. For instance, in the Figure 3, the width of the learning activities represents their duration, and the length of the bar below timeline indicates the co-authorship level of the learner on the 7-point scale [33] (0 - consuming content, 1 - annotating, 2 - interacting with content, 3 - commenting, 4 - expanding, 5 - remixing, 6 - creating). Code-sets for observations are predefined (partly by the LePlanner scenario) and compliant with the syntax of xAPI statements. Observer can also create theory-driven code-sets, e.g. levels of educational outcomes from Bloom's taxonomy or modes of presence from Communities of Inquiry framework. In addition to predefined code-sets, a user can also use ad hoc codes (folksonomical tags). Thus, the envisioned application allows for structured and unstructured observations (open coding through note taking by adding an observer as an actor, defining verb and object) and semi-structured observations by vocabulary expansion based on codes created on the fly. The observer can use several code-sets in parallel, at the same time. There are several stakeholders that implement observations in different ways but the data is always consistent with context and enacted practice. Observation transcripts

[12] https://leplanner.net

that can be compared to each other and edited using a video transcript. Finally, xAPI compliant data can be exported to Learning Record Store to be combined with other MMLA data sources.

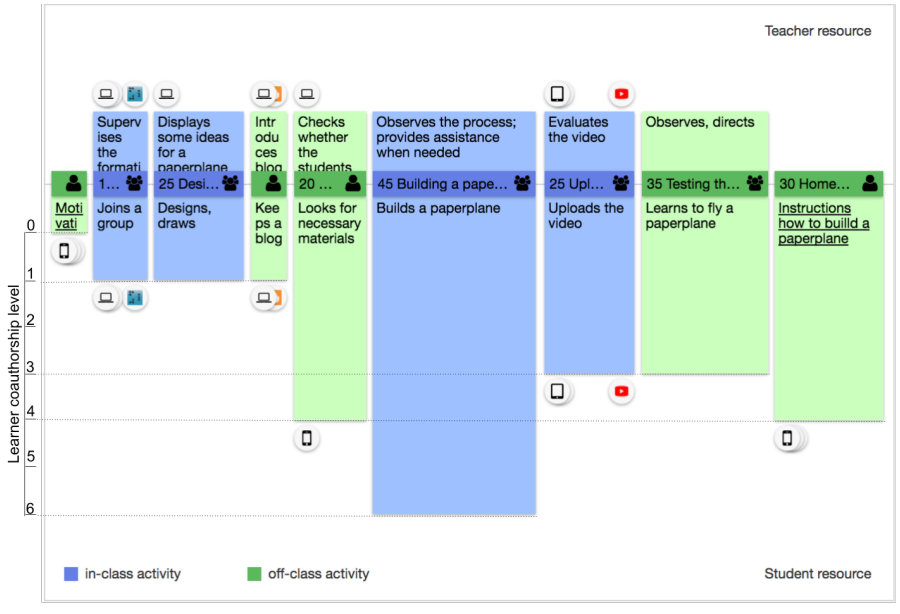

Fig. 3. LePlanner learning scenario creation and sharing tool (learning scenario timeline view)

5.3. Findings

The findings of the participatory design session helped us refine our LA model for lesson observation (RQ1) and better understand the process, elements, motivation of different stakeholders (RQ2). In general, most of the themes/concepts have been validated and accepted by the participants. Regarding the representation of observation data to enable the integration in LA datasets (RQ1), we found out that the most accepted idea was the predefined verbs (code-sets) – the idea was further developed into using several types of predefined code-sets; this was suggested by participants in order to record different types of foci of interest. Regarding the process, elements and motivation of the stakeholders (RQ2) we understood that process was regarded as feasible and the idea interesting. The motivation and the need for such application exist and the idea is well accepted. The *unit of analysis* for data collection was also regarded as appropriate, realistic and feasible.

Structured feedback below gives a more detailed overview of the findings:

- **Feasibility and interest**. All the participants regarded the prototype and the scenarios as feasible and interesting. Events were perceived as a realistic and appropriate *unit of analysis* for observations. The predefined verbs were regarded as relevant for the easiness and consistency of data collection. Moreover, participants have expressed their interest in the following ways:

"When will this app be ready? It is exciting to wait for that minute to see real examples, how it is planned, observed and recorded".

- **Usefulness of the solution**. Overall, the prototype was perceived as useful. The importance of its use in teacher training was highlighted, because observing others' lessons is the part of the teacher training. It was regarded as an effective scaffolding solution. The idea of testing a learning tool in an authentic setting and have the data on its usage was perceived as very promising. Since observations usually are done not in a structured way, predefining the observation protocol and verbs make the approach more systematic. In addition, the idea of comparing enacted practice with teacher intentions (learning design) using several observation transcripts (enacted practice) was well appreciated. Indeed, comparison of the transcripts was regarded as a common practice, and it was suggested to use learning analytics to compare the transcripts, so this part of our model was reinforced. Finally, combining observation data with MMLA datasets (data coming from a tool used in the lesson) was one of the most interesting ideas for the teachers.
- **Recommendations about the observation process**. Regarding the observation process, the participants made several remarks. In terms of data gathering, the use of predefined vocabularies was understood and accepted as a prerequisite to combine observations with other LA datasets. In addition, the participants highlighted their interest in predefining several code-sets, attending the different observation foci. For example, several elements of the lesson observation for students were stressed as important. According to the participants, there must be certain foci predefined (such as work planned, tasks, tools used, or the social level of the activities) and observed (e.g., emotions, motivation, environmental metrics, …) in order to connect the observations and the analysis with the learning context.

  Regarding the following phases of the observation, the participants stressed the importance of reflection and comparison between the learning scenario and observation transcript (e.g., documenting the time difference between the planned and the enacted), and recommended the usage of student feedback to enrich the MMLA dataset.
- **Instrumental/app recommendations**. The participants highlighted the need for reusing the protocols (learning scenario), storing transcripts (contextualized learning scenario) and contextualizing later analysis. Since sharing the transcripts was considered by the participants as a potential scenario, it will be necessary to preserve the privacy of the transcript author (observer) and the anonymity of the participants in the learning scenario.
- **Limitations for adoption**. In terms of data gathering, despite the fact that participants acknowledge the need of predefined and agreed vocabularies to ensure that other observers or LA tools are able to interpret the observations, they reinforced the importance of open coding. Also, they have underlined the importance of a shared and agreed meaning of ad-hoc added codes (which is also relevant for the LA purposes).

  Due to the time constraints during the learning activity, it may be difficult to register observation especially in those cases where the teachers themselves make the observations. To solve this problem, it was suggested to revise and

post-edit the transcript. An interesting idea coming from the participants was to videotape the whole process to have a reliable overview of the sessions. This approach could help to synchronize the observation events with other LA data sources. However, videotaping the session would also require special attention to ethics and privacy issues.

Last but not least, the participants raised their concern about the complexity of the proposal - "It will require a lot of training for teachers to adopt this innovation".

The participatory design session allowed us not only to address the research questions but also to elicit a number of functionalities required by the users, contributing to the basis of the first tool prototype. Most of the functionalities presented in the usage scenarios have been validated and some were added. Both the model and the participants' recommendations (methodological and instrumental) have been translated into the first mockups of Observata which is currently under development.

6. Discussion

The findings show that the participants, who represent the main stakeholders of the model and the lesson observation application, have evaluated and accepted the reference model. The findings made it possible to refine the model, and include the methodological and instrumental changes that were posed by the participants and discussed with the researchers. Thus, as a result of the participatory design, we obtained a validated conceptual design of Observata and a refined LA model for lesson observations.

The sub question RQ2 was answered by the participatory design that helped us understand the process, elements, and motivation of different stakeholders. We have defined, explored and validated the process, elements, motivations and *unit of analysis* for observation data collection. We have included the recommendations and suggestions coming from the stakeholders and redefined the app conceptual design and the reference model behind it. The sub-question RQ1 is answered by the fact that the reference model was regarded viable and it was refined: through the use of Observata tool we can identify, code and combine LA-compliant observation data.

Despite of the positive feedback, it is understandable why participants foresee that adopting this kind of solutions may require "a lot of training": it entails the adoption of the different elements involved in the proposal (LD, LA and MMLA); and the teacher/observer workload is already high before, during and after the observed sessions by default. Nevertheless, we envision that, through user-involvement in the implementation of Observata, we may alleviate those concerns.

Regarding the model, a number of limitations have been detected at the practical and conceptual level. To enable the integration in MMLA datasets, the vocabularies and identifiers should be shared and agreed with the different data gathering sources and analysis tools. However, the observers' need for open coding approaches (where they can add ad-hoc verbs) restricts the affordances for analysis. Another practical limitation is caused by the time constraints. Observations require time to process and register what is happening in the learning context. Thus, since events registered via observations cannot be timestamped with the same accuracy than other computer-

mediated data gathering techniques (e.g., logs), there is a synchronization problem. Moreover, regarding the applicability of our LA model for lesson observation, we acknowledge that the connection with the learning design is not always straightforward. First, it implies a computational version of a learning design, which often does not exist. Second, it is necessary to have access to the instantiation of the learning design in the technological setting, in order to use the appropriated identifiers that will be used by the rest of the data gathering mechanisms. In our case, to establish the connection with the learning design, Observata will be implemented to be compliant with an authoring tool (LePlanner). Alternatively, Observata could be also used with technologies such as GLUE!-PS and GLUE!-CAS that enable the design, instantiation and design-aware data gathering from multiple data sources in CSCL scenarios [11]. Nevertheless, it should be noted that for adoption purposes, as envisioned in the first scenario (see Table 2), Observata could be used as a mere observation tool independently of a learning design. In those cases, observers will be able to define or import the required context and vocabularies directly in the tool.

7. Conclusions and Future Work

In this paper, we have discussed the importance of connecting the learning context, the teacher intentions, and the data gathered from multiple sources during the learning activity in order to provide relevant and rich analysis. We have argued that in this respect, lesson observations are relevant source to include into MMLA datasets. To make it feasible, we have presented learning analytics model for lesson observations that guides the data gathering, aggregation and analysis.

To develop the model, we have followed contextual inquiry and participatory design stages of research-based design process. To evaluate and redefine our model, we have used the conceptual design of Observata in a scenario-based participatory design session using focus group. The findings point out the feasibility and usefulness of the approach. Nevertheless, some aspects such as the management of data privacy issues and the concern about the additional workload (in terms of time and potential complexity of the tasks) remains still open and will require special attention in future iterations. Besides, the focus group made explicit certain limitations of the model regarding the nature of the observations and time constraints while coding. Despite the fact that structured observations may be especially convenient to apply quantitative analysis to aggregated data including observations and user activity traces (e.g., for activity tracking), both the literature [15] and the focus group participants highlight the preference for unstructured and open coded or semi-structured observations. Thus, in the future, we will enable the collection of less structured observations via xAPI. With this extension, we expect to enable more qualitative analysis and to promote the contextualization of the quantitative data. Secondly, even if the privacy issues do not represent our direct concern, since our model deals with the data collection, we will add data anonymisation functionality in the app. And also, we address time constraint and data synchronization issues with specific functionalities by introducing post editing of coded events, photo and video capturing (event-oriented, small videos) functionalities.

The reference model and the conceptual design have informed the prototype of Observata. Following the research-based design process, our next step is to develop the stable prototype through iterative process and further refine the reference model. Software will be tested through use cases, user stories and finally, presented as hypothesis. The reference model behind it will be evaluated through field trials and mixed method approaches (quantitative, qualitative, interviews) and MMLA data (Observata semantic annotations and log data). The data will be analysed with specific pedagogical frameworks.

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References

1. Eradze, M., Väljataga, T., Laanpere, M.: Observing the use of e-textbooks in the classroom: Towards "offline" learning analytics. In: Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2014).
2. Soller, A., Martınez, A., Jermann, P., Muehlenbrock, M.: From Mirroring to Guiding: a review of the state of the art in interaction analysis. Int. J. Artif. Intell. Educ. 15, 261–290 (2005).
3. Sutherland, R., Eagle, S., Joubert, M.: A vision and strategy for technology enhanced learning: Report from the STELLAR Network of Excellence. Last accessed. 7, (2012).
4. 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: ACM International Conference Proceeding Series. p. 329 (2016).
5. Mor, Y., Ferguson, R., Wasson, B.: Editorial: Learning design, teacher inquiry into student learning and learning analytics: A call for action. Br. J. Educ. Technol. 46, 221–229 (2015).
6. Ferguson, R.: Learning Analytics: drivers, developments and challenges. TD Tecnol. Didatt. Vol 22, Iss 3, Pp 138-147 VO - 22. 138 (2014).
7. Rodríguez-Triana, M.J., Vozniuk, A., Holzer, A., Gillet, D., Prieto, L.P., Boroujeni, M.S., Schwendimann, B.A.: Monitoring, awareness and reflection in blended technology enhanced learning: A systematic review. Int. J. Technol. Enhanc. Learn. 9, 126–150 (2017).
8. Ochoa, X., Worsley, M.: Augmenting Learning Analytics with Multimodal Sensory Data. J. Learn. Anal. 3, 213–219 (2016).
9. Eradze, M., Rodríguez Triana, M.J., Laanpere, M.: How to Aggregate Lesson Observation Data into Learning Analytics Datasets ? In: CEUR Workshop Proceedings (2017).
10. Leinonen, T., Toikkanen, T., Silfvast, K.: Software as hypothesis: research-based design methodology. In: Proceedings of the Tenth Anniversary Conference on Participatory Design 2008. pp. 61–70. Indiana University (2008).
11. Rodríguez-Triana, M.J., Martínez-Monés, A., Asensio-Pérez, J.I., Dimitriadis, Y.: Scripting and monitoring meet each other: Aligning learning analytics and learning design to support teachers in orchestrating CSCL situations. Br. J. Educ. Technol. 46,

330–343 (2015).
12. Lockyer, L., Heathcote, E., Dawson, S.: Informing pedagogical action: Aligning learning analytics with learning design. Am. Behav. Sci. 57, 1439–1459 (2013).
13. Ferguson, R., Clow, D.: Where is the evidence? A call to action for learning analytics. (2017).
14. Marshall, C., Rossman, G.B.: Designing qualitative research. Sage publications (2014).
15. Wragg, T.: An Introduction to Classroom Observation (Classic Edition). Routledge (2013).
16. Cohen, L., Manion, L., Morrison, K.: Research methods in education. Routledge (2013).
17. Jackson, P.W.: Life in classrooms. Teachers College Press (1990).
18. O'Sullivan, M.: Lesson observation and quality in primary education as contextual teaching and learning processes. Int. J. Educ. Dev. 26, 246–260 (2006).
19. Di Mitri, D., Scheffel, M., Drachsler, H., Börner, D., Ternier, S., Specht, M.: Learning Pulse: a machine learning approach for predicting performance in self-regulated learning using multimodal data. (2017).
20. Bakharia, A., Kitto, K., Pardo, A., Gašević, D., Dawson, S.: Recipe for success: lessons learnt from using xAPI within the connected learning analytics toolkit. In: Proceedings of the sixth international conference on learning analytics & knowledge. pp. 378–382. ACM (2016).
21. Nistor, N., Derntl, M., Klamma, R.: Learning analytics: trends and issues of the empirical research of the years 2011–2014. In: Design for Teaching and Learning in a Networked World. pp. 453–459. Springer (2015).
22. Schwendimann, B.A., Rodriguez-Triana, M.J., Vozniuk, A., Prieto, L.P., Boroujeni, M.S., Holzer, A., Gillet, D., Dillenbourg, P.: Perceiving learning at a glance: A systematic literature review of learning dashboard research. IEEE Trans. Learn. Technol. 10, 30–41 (2017).
23. Hoadley, C.M.: Methodological alignment in design-based research. Educ. Psychol. 39, 203–212 (2004).
24. Gašević, D., Dawson, S., Siemens, G.: Let's not forget: Learning analytics are about learning. TechTrends. 59, 64–71 (2014).
25. Prieto, L.P., Maldonado, R., Spikol, D, Hernández-Leo, D., Rodríguez-Triana, M.J., Ochoa, X.: Editorial: Joint Proceedings of the Sixth Multimodal Learning Analytics (MMLA) Workshop and the Second Cross-LAK Workshop. In: Joint Proceedings of the Sixth Multimodal Learning Analytics (MMLA) Workshop and the Second Cross-LAK Workshop (2017).
26. Waltenburg, E., McLauchlan, W.: Exploratory Data Analysis: A Primer for Undergraduates. (2012).
27. Principles of Sociological Inquiry, http://www.opentextbooks.org.hk/ditatopic/29184.
28. Cooper, A., Reimann, R., Cronin, D.: About Face 3: The essentials of interaction design. (2007).
29. Brown, D.M.: Communicating design: developing web site documentation for design and planning. New Riders (2010).
30. Merriam, S.B., Tisdell, E.J.: Qualitative research: A guide to design and implementation. John Wiley & Sons (2015).
31. Frank, U.: Evaluation of reference models. Ref. Model. Bus. Syst. Anal. 118–140 (2007).
32. Kurvits, M., Laanpere, M., Väljataga, T.: Analysis of Tools and Methods for Describing and Sharing Reusable Pedagogical Scenarios. In: International Conference on Web-Based Learning. pp. 251–257. Springer (2015).
33. Väljataga, T., Fiedler, S.H.D., Laanpere, M.: Re-thinking digital textbooks: Students as co-authors. In: International Conference on Web-Based Learning. pp. 143–151. Springer (2015).