Multi-stakeholder Analytics for Learning Design: A Case Study of Location-based Tools

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ABSTRACT
The current access to mobile devices and the emphasis on situated learning are contributing to bring learning beyond the classroom. Taking this opportunity, more and more location-based tools are being used in learning scenarios outside the classroom. Multiple stakeholders could benefit from understanding the learning and teaching processes triggered by these tools. Teachers and instructional designers could not only monitor and regulate the implementation of their learning designs (LDs) but also assess the impact and effectiveness, tasks especially challenging when learning happens outside the classroom. Also, the community around specific mobile learning tools -such as researchers, managers of educational institutions, or developers- could use the feedback from the assessments to better understand how the tools are being adopted and how to improve them further. For this purpose, data analytics could help to collect, analyse and visualise the evidence gathered from learning environments. This paper presents the first steps of the development of a location-based authoring tool that incorporates multi-stakeholder analytics for LD features. We investigate how analytics can support specific LD needs of stakeholders from two existing location-based authoring tools: Avastusrada and Smartzoos. Specifically, we conducted two sets of interviews: contextual inquiry interviews with teachers, as well as semi-structured interviews with managers of educational institutions and researchers. Results emphasise the specific technical implications, as well as the potential of multi-stakeholder analytics for LD in the context of location-based learning tools.

Author Keywords
Multi-stakeholders analytics, learning design, location-based learning tools, authoring tools, mobile learning, situated learning

INTRODUCTION
Advances in mobile and wireless technologies have made possible the design of technology-enhanced learning scenarios in many contexts, such as in classrooms, museums, around a city, in a thematic park, etc. Location-based authoring tools are an example of these technologies, which allow the creation of context-aware mobile learning activities outside the classroom. Such mobile learning environments can help students to put explorative skills into practice, as well as foster their motivation and reflection (Elias, 2011; Santos et al., 2011).

Teachers and instructional designers can adopt location-based authoring tools to create learning activities in line with their LD goals. However, assessing the impact and effectiveness of LDs in these environments is hard and time-consuming for teachers. It usually consists of collecting and analyzing students input from surveys and interviews after the activities. This fact also affects another group of stakeholders, the community around a specific tool(s). In general, the research field of LD has considered as community stakeholders the community of teachers around a specific LD tool(s). However, understanding the teaching and learning processes supported by LD tools is a matter of interest for other stakeholders as well. For example, understanding the usage, impact and adoption of the tools could help researchers, developers, or managers of educational institutions. All these community stakeholders could use the results from the assessments to better understand how specific mobile learning tools are being adopted to design learning scenarios and how to improve them further in this aspect.

Multiple authors have highlighted the synergies that may emerge with the alignment between analytics and learning design (Lockyer et al., 2013; Emin-Martínez et al., 2014; Persico & Pozzi, 2015; Mangaroska & Giannakos, 2018). LD can help to guide and contextualize the analysis, by making them more meaningful for the involved stakeholders, while from the other part analytics can contribute by informing design decisions, as well as to evaluate the LDs. In the context of mobile learning, there are only a few works which inquire about the benefits of aligning analytics and LD (e.g. Melero et al., 2015; Hernández-Leo & Pardo, 2016). At the same time, these works have focused only on teachers and do not consider all stakeholders around the specific tools which have an interest related to LDs.
In order to understand how data analytics could serve the LD needs of different stakeholders of location-based learning tools, we have focused our study on two such mobile tools: SmartZoos1 and Avastusrada2. In this paper, we present the insights and feedback from different stakeholders about how analytics can support their specific needs related to LD. The study is driven by the following research questions: (RQ1) what kind of information could help teachers during the creation of LDs outside the classroom with a location-based authoring tool? (RQ2) what aspects of the LDs would teachers like to monitor, or assess from the students? (RQ3) how would teachers assess the effectiveness of the LDs? (RQ4) what the community stakeholders would like to know about the creation and usage of LDs? To answer these questions, we carried out a contextual inquiry interview with 5 teachers and educational instructors (with a main focus on RQ1, RQ2 and RQ3) and semi-structured interviews to collect feedback from 4 community stakeholders (based on RQ4).

The rest of the paper is structured as follows: section 2 presents the related work; section 3 gives an overview of the context of the research; section 4 describes the research methodology; section 5 presents the main findings of the interviews; section 6 maps these results using the AL4LD framework, and presents a reflection about the opportunities and design implications of AL4LD in the specific case of location-based authoring tools; section 7 presents a design proposal; section 8 concludes the paper and gives an outlook of future work.

RELATED WORK
The research field of LD has been promoting teaching quality and facilitating the integration of technology into teaching and learning (Laurillard, 2013; Lockyer et al., 2009). Contributions from this field include representations (e.g., Lockyer et al., 2009), authoring tools (e.g., Hernández-Leo et al., 2014), design frameworks (e.g., Mor & Mogilevsky, 2013) and methodologies that support teachers to create, share and implement LDs (e.g., Laurillard, 2013). In the context of mobile learning contributions include authoring tools (e.g., Santos et al., 2011), learning design frameworks (e.g., Parson et al., 2006), and tools that integrate learning designs across spaces (e.g., Hernández-Leo & Pardo, 2016).

Apart from satisfying research interests, data analytics support decision making of the different actors involved at different stages of the learning process (Persico & Pozzi, 2015). In the case of mobile learning, we can find different kind of solutions including frameworks (e.g., Fulantelli et al., 2015), guidelines, and monitoring systems (e.g., Muñoz-Cristóbal et al., 2018) among others. Even, some examples can be found that are specific for location-based learning, e.g., a monitoring system for awareness and reflection in ubiquitous learning environments. The system is evaluated in three studies involving web, augmented-physical, and 3D virtual world spaces. Although the focus is on learning orchestration rather than LD, monitoring reports produced by this system are organized according to the predefined LD structure and could be potentially used to reflect about the effectiveness of the LDs. These works focus only on teachers and do not consider other community stakeholders which can have related interests about the usage, adoption and improvement of the support that the proposed tool(s) offer to LD practices.

CONTEXT OF THE RESEARCH
The research presented in this paper has been carried out within the context of two projects: Avastusrada and SmartZoos. Both projects focused on designing and developing web-based mobile applications for outside the classroom use (SmartZoos relevant particularly for a zoo context). These applications allow to create and conduct gamified learning activities as tracks consisting of a number of location points with different tasks in each. For creating a learning activity, the tools offer a list of templates with different types of tasks (such as one correct answer; multiple correct answers; freeform answer; match pairs; embedded content; photo). The user can freely choose desired location points on the map, attach a task(s) to every location point and form a meaningful track. While following the track, the location points get

1 https://smartzoos.eu
2 https://avastusrada.ee
activated when users reach close enough to the particular location and will change the colour as soon as the answer to the task has been submitted. In that way the tools help to keep track on which tasks have been completed already. Additionally the SmartZoos tool provides immediate formative feedback to the tasks completed in location points. Depending on how the track has been defined, the users can visit location points randomly or in a predefined order. The achievements of the SmartZoos users will be awarded by badges. At the end of the game the user can see the overall result of the submitted answers. Both tools collect and display data on the dashboard about the learning tracks, time spent on going through the track, the number of correct and wrong answers provided by a user at every location point, etc.

**METHODOLOGY**

Since our research questions were closely related to the stakeholders perceptions, to help them elicit their needs and prompt reflections, we used interviews as a data collection method. In the first study (S1), we conducted contextual inquiry interviews with teachers in order to understand their practices and needs related to the design and evaluation of location-based learning scenarios outside the classroom. In the second study (S2), we conducted semi-structured interviews with managers of educational institutions and researchers that had previously worked with Avastusrada and Smartzoos, to collect further requirements and feedback related to AL4LD from their perspective. For both studies, the data analysis followed qualitative methods. Table 1 provides an overview of the scope and purpose of each study.

<table>
<thead>
<tr>
<th>Study</th>
<th>Type</th>
<th>Participants</th>
<th>Targeted RQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Contextual inquiry</td>
<td>5 practitioners</td>
<td>RQ1, RQ2, RQ3</td>
</tr>
<tr>
<td>S2</td>
<td>Semi-structured interviews</td>
<td>4 (2 researchers and 2 managers)</td>
<td>RQ4</td>
</tr>
</tbody>
</table>

**Table 1. Mapping studies with research questions**

**S1) Contextual Inquiry Interviews**

**Participants.** We recruited teachers and educational instructors that had previously worked with us during the SmartZoos and Avastusrada projects. There were 5 participants, 3 females and 2 males. Namely, 1 middle-school teacher from an urban school, who had previously worked with Smartzoos and Avastusrada; 2 educational instructors from partner zoos from the Smartzoos project; 1 educational instructor from the Avastusrada project; 1 in-service teacher trainer that uses Avastusrada and Smartzoos in training sessions. All the participants had extensive previous experience with at least one of the tools. For practical reasons, in the rest of the paper we will refer to all of them as practitioners due to their similar interests related to the design, deployment and evaluation of mobile learning activities outside the classroom with location-based authoring tools.

**Procedure.** Contextual Inquiry is a user-centered design process, part of the Contextual Design method (Raven & Flanders, 1996), which is used to gather field data from users in order to understand who the users are and how they work. The focus of the contextual inquiry was to gather feedback from practitioners about the process of designing and evaluating learning activities outside the classroom (RQ1, RQ2, RQ3). We focused on: the features that they use, or that they would like to use (features not currently available in the tools that practitioners use), to design a learning activity; the information that they collect, or that would like to collect; how they use the collected information to improve their LDs and what complementary information could be useful in this direction. We used an Artifact Walkthrough implementation of a contextual inquiry. With this method, the participants have to recreate a specific process using the artifacts that they would normally use to deploy it. This method is used when an activity is not continuous, involves several people, or is sporadic over a period of time (Raven & Flanders, 1996). We prefer this method because the design and implementation of a location-based learning activity outside the classroom includes different phases that are usually done in different moments, as well as for the difficulty of organizing pilots with practitioners that were recruited from different projects.

Practitioners were asked to start designing a learning scenario with their selected tool in a personal computer. After this process, they were requested to take the role of a student and perform the designed activity. This part was added to help practitioners reflect about the kind of information needed to improve the LD, that can be gathered from the deployment of the activities. After performing the activity, each practitioner checked the reports and general statistics produced by the tool, and thought about the support that they provide to evaluate the LD. During the entire process, practitioners were requested to speak loudly what they were doing, by also reflecting on any issue that they were facing, any missing feature, or information that they thought that could improve the design and evaluation processes. During this time, the observer did not interrupt the practitioner. In the end we performed a follow up interview with each practitioner with open questions regarding the observation and our research goals.

The entire process of contextual inquiry interviews was video recorded and resulted in approximately 8 hours (around 90 minutes per participant). All video recordings were transcribed to text. We used Interpretation Sessions and Affinity Diagramming to analyse the data. Three researchers were involved in this process. Interpretation Sessions are a team...
work that aim to create a shared understanding of the data by writing on post-it notes key issues and insights from each participant. When duplicates occurred they were placed under each other, and when a question related to a note was raised, the people who did the specific interview had the last word to settle it. Affinity Diagramming is a subjective technique used to discover patterns. In our case it was used to create clustering groups from the post-it notes, where an agreement between the three researchers had to be reached for each cluster. From the analysis we created approximately 400 notes, which were grouped into clusters that were later filtered based on the focus of our inquiry, namely RQ1, RQ2, and RQ3. The final result were 15 clusters (see Table 2, needs of RQ1, RQ2, RQ3).

(S2) Semi-structured interviews

Participants. We considered as community stakeholders around SmartZoos and Avastusrada: the community of practitioners that use one of the tools; the managers of educational institutions that apply the tools as part of their mobile learning strategies; and researchers involved in at least in one of the projects. As we already performed separate interviews with practitioners, in this case we focused on the managers of educational institutions and researchers. We recruited participants from both the projects, Avastusrada and Smartzoos. The participants were 4 community stakeholders, 2 from Smartzoos, 1 from Avastusrada, and 1 that had been involved in both projects. Two participants had an academic profile and had been involved in the development and research activities around the tools. The other 2 were zoo coordinators for the SmartZoos project from two of the partner zoos and had an interest to understand the adoption of SmartZoo as part of the educational activities organized in their respective zoos.

Procedure. The goal of the semi-structured interviews was to gather input from community stakeholders about the data related to LD that could be useful for them. We focused on information that can help them: to have an overview of the designed activities; to understand the usage of the activities; to know more about the general usage of the tool and its adoption (RQ4). The participants were given minimal guidance in their responses. The questions were open ended. When needed, follow-up questions were asked to elicit in-depth responses, and clarification questions were asked to confirm the intended meaning by the participant. Interviews were all audio recorded and resulted in approximately 4 hours. All audio recordings were transcribed to text. The interview data were first coded according to the type of information that participants were reporting. The segments related to a particular information were then coded according to how the gathered data would inform the stakeholders. For instance, under the theme “Labeling learning designs” (see section 5, under RQ4), the codes “It would be helpful for me to search for designed activities based on topics”; “I need to have an overview of the designed activities and their goals”; “I would be interest to see what kind of activities practitioners have designed” were categorized into the code: “Type of activities designed by practitioners”. Results from both the studies are presented in the next section.

AL4LD framework

Hernández-Leo et al., (2019) propose the analytics layers for learning design (AL4LD) framework which identifies three layers where analytics can support LD, namely: learning analytics, design analytics, and community analytics. In this paper, we use the AL4LD framework to map the results from the studies and structure the proceeding discussion based on the layers of the framework. The learning analytics layer is concerned with engagement, progression, achievement and satisfaction metrics of learners during a LD. Analytics in this layer raises awareness and reflection on the effects of LD, as well as helps to identify LD elements that might be revised. Data sources in this layer derive for the learning environment where the LD is implemented. The design analytics layer deals with characteristics of a LD and metrics of design decision prior to their delivery. Analytics in this layer can provide awareness and reflection about decisions made during the creation of LDs and for future implementations. The data can be analyzed from the perspective of the entire community, a member of it, or a comparison of both of them. Data sources depend on data made available by the LD tools. The community analytics layer is concerned with patterns and metrics of design activity within a community of related stakeholders and might encourage collaboration by raising awareness and reflection over activity patterns (individual, or collective), as well as by orientations on improving design practices. Analytics in this layer depends on what is available to collect in a community environment.

RESULTS

(RQ1) What kind of information could help teachers during the creation of LDs outside the classroom with a location-based authoring tool? From the Contextual Inquiry interviews, we found that practitioners use location-based authoring tools to design learning activities in line with their pedagogical goals. These goals can be learning objectives, skills, or competences, which are influenced rather by competence frameworks (like in the case of the in-service practitioner trainer), or the local curriculum. One practitioner expressed that it would be helpful for her if the tool would offer templates of LDs with predefined structures based on specific pedagogical goals, or curriculum subjects. A common issue expressed by the participants was the importance of being familiar with the situated environment where learning activities will take place. One practitioner mentioned that, “this requires extra time in order to go in person and check the place”, which directly influences practitioners’ workload. We found that practitioners prefer a detailed level of customization when designing learning activities with location-based tools, which directly affects the kind of information that they might need. These include options related to the social planes, like individual, collaborative, or collective; general metrics, such as duration or difficulty level; and type of tasks, e.g., quizzes, assignments, or other assessment
tasks (that should be performed by students, or evaluated by practitioners). All the practitioners expressed that students’ data from previous activities, such as performance metrics, process metrics (e.g., behaviour, engagement, collaboration), or students’ satisfaction and preferences, could help to understand which parts of the design are effective and which should be modified. Practitioners working with Smartzoos liked the option that allows them to reuse and adapt existing learning designs, done previously by them or others. One practitioner mentioned that, “this has a direct impact on my workload, as I do not have to create the activity once again from the beginning, when I want to change just a part of it”.

(RQ2) What aspects of the LDs would teachers like to monitor, or assess from the students? For each of their students, practitioners try to track their performance and improvement. They tend to create a specific profile for each student, rather formally, by adding information into a moodle database (2 practitioners), or informally (3 practitioners expressed that they create an idea about their students performance based on their results as shown in the tool and their engagement in the complementary activities). Performance metrics are the main source of information that practitioners would like to monitor, as expressed by all of them. Some of these data are found in Avastusrada and/or Smartzoos like, responses to quizzes and questions, or the number of mistakes. Other performance metrics that practitioners emphasized that would like to monitor, and which are not currently available in the tools that they use include, real-time location of users (5 practitioners), location and time spent by students performing a specific task (4 practitioners), visualizing the path that was followed by students during the activity (2 practitioners). Other performance metrics were related to gamification elements. One practitioner, who works with SmartZoos, mentioned that connecting badges to some curriculum outcome could be useful for practitioners. Another theme that emerged from the analysis was the need for process metrics, which includes among other things, students’ behaviour, engagement, collaboration, as well as where and when a specific process occurred. Another practitioner suggested the usage of hints, which usage can be later monitored. Each group, or individual student would have a number of limited hints which can be requested in case they need help with a specific task.

(RQ3) How would practitioners assess the effectiveness of the LDs? We found that practitioners use a variety of data to assess their LDs done with location-based authoring tools. Most of these data do not come directly from the tools but from discussions, complementary tasks, or assessments that happen before, or after the activity. All practitioners pointed out that they would like to assess activities based on specific pedagogical goals, which can be learning objectives, or learning outcomes. These goals could be evaluated through the results related to the individual or group performance of the students. Various students’ satisfaction criteria emerged from the analysis. Out of 5 practitioners, 4 considered that some kind of students’ satisfaction and preferences feedback would be useful to assess the effectiveness and improve LDs. Two practitioners mentioned the usage of stars and ranking by students to evaluate the experience, one of each suggested the usage of stars not only for the entire activities, but also for specific tasks. Two considered that voluntary comments by students could be helpful to assess the LDs. Practitioners’ design effort was another theme that emerged from the analysis. Two practitioners expressed that they would like to know how much time they spent on a LD, or specific parts of it.

(RQ4) What the community would like to know about the creation and usage of LDs? From the semi-structured interviews, we found that community stakeholders are mainly interested to understand the adoption that these location-based authoring tools are finding in practitioners’ LD practices, as well as in an institutional level (like a school, or a zoo). All 4 stakeholders expressed that they would like to understand what kind of LDs practitioners are creating by having some visualization of general metrics about the characteristics of LDs (e.g., of type of tasks, or numbers of designers per subject). Two stakeholders with research interest mentioned that they would want to label learning designs based on different characteristics like pedagogical approach, curriculum target, objectives, or target users. One stakeholder with research interest related to Avastusrada mentioned that it would be useful if the system would help to find patterns related to the situated environments that were chosen by practitioners, which might help to identify situated learning environment that might be adequate for particular curriculum subjects, or learning objectives. Stakeholders with a research interest related to Smartzoos, which allow to copy and modify existing LDs done by others, expressed that they would like to understand how the LD artifact evolves, in terms of the reusability of learning designs by others (versioning), as well as which LDs (with which characteristics) were being re-used the most. Since the user experience can affect not only the adoption but also condition the teaching and learning process, another aspect that emerged was related to usability metrics. These could be technical issues or feedback that helps to understand if the application is intuitive enough and if it is perceived as useful in supporting the creation of LDs. As an example of technical issues, one zoo manager mentioned that a considerable part of their zoo is covered with trees, which makes the usage of location-based systems difficult. A community stakeholder with research interest mentioned that the system support an export option for the data (e.g., as a csv file).

HOW ANALYTICS CAN SUPPORT LD IN A LOCATION-BASED LEARNING CONTEXT
We mapped the research questions according to the layers of the AL4LD framework, and grouped the results (needs) attending to whether they were needs referring to the general technology-enhanced learning context, or specifically to location-based learning (see Table 2). We will conduct the discussion based on the layers of the framework.
### Table 2. Classification of findings according to the AL4LD framework

<table>
<thead>
<tr>
<th>AL4LD Layer</th>
<th>RQ</th>
<th>General AL4LD Context</th>
<th>Location-based Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning analytics</td>
<td>(RQ1,</td>
<td>- Creating and updating students’ profiles.</td>
<td>- Real-time monitoring (e.g., live location).</td>
</tr>
<tr>
<td>for LD</td>
<td>RQ2)</td>
<td>- Time of the completion of tasks.</td>
<td>- Location of the completion of tasks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Performance metrics of a learning activity.</td>
<td>- Knowing the time spent per location.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Process metrics of a learning activity (e.g., behaviour, engagement).</td>
<td>- Visualising the path followed by students.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Students’ satisfaction and preferences.</td>
<td></td>
</tr>
<tr>
<td>Design analytics</td>
<td>(RQ1,</td>
<td>- Measuring the achievement of pedagogical goals (e.g., learning objectives).</td>
<td>- Bridging between analytics from physical and digital spaces.</td>
</tr>
<tr>
<td>for LD</td>
<td>RQ3)</td>
<td>- Properties of a learning design (e.g., type of tasks, social spaces).</td>
<td>- Identifying parts of the situated learning environment that need to be changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Identifying parts of a LD that need to be revised (learning re-design).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Practitioners’ design effort (in terms of time or actions).</td>
<td></td>
</tr>
<tr>
<td>Community analytics</td>
<td>(RQ4)</td>
<td>- Labeling learning designs (e.g., by pedagogical approach, curriculum subject, objectives, target users).</td>
<td>- Identify situated environments that might be adequate for particular curriculum subjects, or learning objectives.</td>
</tr>
<tr>
<td>for LD</td>
<td></td>
<td>- Metrics about the characteristics of LDs (e.g., number of designers per subject, or most used type of tasks).</td>
<td>- Usability and technical issues related to location-based learning (e.g., GPS problems).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reusability of learning designs by others (versioning).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Identifying successful designs that can be suggested (as templates).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Usability metrics.</td>
<td></td>
</tr>
</tbody>
</table>

Learning analytics for LD needs can be grouped into analytics that support awareness and reflection about LDs after the activities, as well as analytics related to monitoring of LDs during their deployment (real-time monitoring). Real-time monitoring might support not only the scaffolding of the learners, but also the adaptation of the LD during a learning activity. Apart from needs that can be considered as general to the context of technology enhanced learning (see table 2, under Learning analytics for LD and General AL4LD Context), the results also emphasise needs specific to the context of location-based learning. Visualisations of these specific analytics could enhance practitioners’ awareness about students’ performance and engagement, which is difficult in the context of situated learning with location-based technologies, due to the distributed nature of these learning environments, where students have to constantly be in movement to perform their tasks. It should also be emphasized that while multiple aspects may be of interest for practitioners (such as visualising the path followed by students, or knowing the time spent per location), which ones are appropriate to be monitored depends on the context, the content, and the learners.

Design analytics can support practitioners to create, track the performance, and re-design LDs in line with pedagogical goals that they have defined. Apart from identifying parts of the LD that might be re-designed, in the context of location-based learning practitioners could be supported to identify parts of the situated learning environment that might need to be changed. Data sources in this context usually come from both physical and digital spaces, which should be combined to better inform the process LD.

The adoption of location-based learning solutions depends not only on individual needs but also on community level aspects related, for example, to institutional decisions or local policies. Stakeholders with a managerial role are interested in analytics that help understanding the level of adoption and the efficiency that these tools offer to LD. Mapping the LDs...
with the curriculum for later analysis could be potentially useful to understand parts of the curriculum that are more suitable for this pedagogical approach and which ones could require some reinforcements.

Furthermore, we noticed three clusters of technical implications emerge from the results, which can be addressed by analytics for LD in location-based mobile learning:

- **Support compatibility at the technical level.** Practitioners talk about integration, or compatibility at the user level (i.e., with tools and devices already adopted). In order to make it happen, it is necessary to enable the compatibility at the technical level, e.g., using data formats that are widespread (both for LD and analytics) so that we can import the designs, the traces, carry out context-aware analysis, etc.

- **Adapt data sources to stakeholders data needs.** While often tools focus on digital traces and content analytics, integrating the mechanisms to collect data about the user perception (e.g., practitioners and student experience with the LDs, or with the authoring functionalities), would contribute to have a richer understanding of the LD at the different layers.

- **Support the process of LD.** It is important that the process of LD should not add a significant workload, but if possible the other way, lower it. Based on data analytics (e.g., from previous LDs), authoring tools can support practitioners with suggestions about LDs structures that are related with practitioners’ objectives, learning outcomes, specific competence framework or local curriculums.

**TOWARD THE DESIGN OF A LOCATION-BASED TOOL WITH MULTI-STAKEHOLDER ANALYTICS FOR LD FEATURES**

Based on our findings we propose a preliminary design proposal where multi-stakeholder analytics for LD features can be integrated into a location-based authoring tool.

**A system that supports analytics for LD.** The tool should track data related to performance, process and satisfaction metrics of LDs, by considering pedagogical goals (such as learning objectives), and properties of the LD (such as type of tasks, or social spaces). Data sources from both physical and digital spaces should be combined to support real-time monitoring, as well as awareness and reflection about LDs, by considering specific stakeholders needs.

**Analytics that reflect stakeholders’ needs.** Each group of stakeholders should have specific rights in the system. Practitioners should access a real-time monitoring dashboard that should help them deploy and monitor LDs, with information such as real-time location and real time performance metrics, time spent by students on a specific task, responses, and usage of hints. At the end of the activity practitioners should have access to a summary dashboard that supports awarenesses and reflection about the LD, by allowing an overall view of the activity, information about specific participants, or a comparison of both. This dashboard should include information such as performance and process metrics of the LD, visualisation of paths followed by students, as well as an overview of the design effort of the practitioner, in terms of time and actions. A ranking system based on starts, and comments from the students should be implemented. Practitioners could benefit from knowing the better ranked LDs, as well as could browse according to different LD labels to get ideas and potentially reuse existing LDs. The system should also suggest LDs that have been re-used the most by other practitioners, as well as situated environments that might be adequate for particular curriculum subjects, or pedagogical goals. Community stakeholders should have access to a higher level dashboard with general information about their institution (e.g., zoo coordinators), or the entire platform (e.g., researchers). Information on this dashboard should include metrics about the adoption of the tool (e.g., usage over time), and metrics about LDs (e.g., labels, authoring and collaboration). Information from all the dashboards should be exported as an external file (e.g., csv file).

**CONCLUSION AND FUTURE WORK**

This paper presents the first steps of the development of a location-based authoring tool with multi-stakeholders analytics for LD features. We assume that the tool will be more effective if it is based on a deep understanding of stakeholders needs in the context of location-based and mobile learning. We therefore gathered feedback through contextual-inquiry interviews from practitioners and through semi-structured interviews from community stakeholders of two existing location-based authoring tools. Results were interpreted using the AL4LD framework. Our findings provide novel insights about the needs of different stakeholders about analytics for LD in location-based settings. We found that different stakeholders have different needs. While practitioners would like a system that helps to monitor and evaluate the effectiveness of LDs, community stakeholders are more interested in the adoption and integration of these mobile learning solutions and the way that these tools support LD. To the best of our knowledge, this is the first study that investigates how multi-stakeholder analytics can support LD in a mobile and situated learning context. The findings may be useful for designers of location-based authoring tools and mobile learning systems in general.

Continuing our designed-based research process, the next goal is to use the results to design and evaluate low-fidelity prototypes. Findings from this future iteration will drive the decision of what features are more important for the stakeholders in a given scenario and how the data output should be presented to them in an easy-to-understand way. The interface of Smartzoos will serve as a platform where the new features will be integrated. Once this iteration will be fully
implemented, we will start conducting pilot studies in real settings to evaluate the effectiveness of the proposed features. Learners will also be involved in the future to co-design, not only LA solutions for them (e.g., for self-monitoring/assessment/reflection), but also about them (i.e., what data are students willing to expose without invading their privacy).

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