Connecting pattern-based learning designs with analytics: The case of the PyramidApp

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Abstract. This paper presents preliminary work aiming to identify learning analytics that can be presented to teachers or learning designers to support (re)use or (re)design of learning scenarios based on the pyramid (a.k.a. snowball) pattern by using the PyramidApp. A pattern-based analytics approach considers teacher´s metacognition in three levels, t*he pedagogical intent, pedagogical method/structure* of a CLFP pattern and the *practicalities* to implement a learning scenario. Learning analytics are proposed to inform these three dimensions. A case scenario where $N = 38$ secondary school students in a face to face classroom used the PyramidApp was analyzed from the log files of the App. The recommended analytics for teachers are visualized in such a way that are hypothesized to foster decision making for customization of specific design elements of the pyramid pattern.

Keywords: Learning Design, learning analytics, teacher´s metacognition

1. Introduction

Current research on the design of computer mediated learning and monitoring of students´ interactions in a learning environment proposes the presentation of information to teachers with the aim to support customization of their initial plans as the learning scenario unfolds (Rodríguez-Triana et al., 2015). The adaptation of their learning scenarios can be referred to decisions made at design time (Lockyer, Heathcote, & Dawson, 2013) and possible revisions. These decisions usually are triggered by the pedagogical intentions of the teacher which can be documented in a learning design, the specific context of the students (e.g., educational level, knowledge level) and concerns on practicalities such as classroom constraints and amount of students (Mor, Craft, Hernández-Leo, 2013).

Particularly, in Computer Supported Collaborative Learning where the complexity of student's interactions increases specific focus is given on the design of effective collaborative scenarios (e.g., design of scripts) (Dillenbourg & Tchounikine, 2007; Hernández-Leo et al., 2006; Kobbe et al., 2007; Weinberger et al., 2009) and on data-driven reflections on these situation (Martínez-Monés et al., 2011; Rodríguez-Triana et al., 2015). Although the emphasis is to improve student's learning, the increasing use of technology implies the work of teachers as designers of technology enhanced learning (Kali et al., 2015, Laurillard, D. 2012). The use of evidence to reflect on and customize instructional plans and learning activities (Gerard et al., 2010) is currently being discussed. On the one hand, pedagogical patterns as scaffolds for teachers and learning designers consist of teaching-learning activity sequences which are designed to lead in a specific learning outcome and describe a pattern in terms of "context", "educational problem" and "solution" (Goodyear, 2005). On the other hand, data-driven reflections address the need to intervene during an implemented learning scenario (regulation) or to improve future learning designs (redesign). However little research so far addresses the support of teachers on how to link pedagogical decisions and reflection with data collected from technological tools. Few practical examples regarding the design of computer supported collaborative learning activities show the connection between the learning design of the teacher and the collection of learning analytics which can help potential re-use or re-design of an implemented learning scenario.

In this paper, we aim to connect the design of a collaborative learning scenario with the collection of learning analytics data by using Collaborative Learning Flow Patterns (Hernández-Leo et al., 2006; Hernández-Leo et al., 2010) as a boundary object. We focus in a particular example of the pyramid (a.k.a. snowball) pattern and the use of an innovative tool called PyramidApp (Manathunga & Hernández-Leo, 2016). PyramidApp enables configuration and enactment of collaborative learning activities based on a pyramid pattern. The design of activities with the PyramidApp allows teachers to structure potential interactions growing from smaller to larger groups until building consensus in a specific topic by fostering accountability and interdependence between students. Instead of focusing on events happening during the learning scenario and possible real-time interventions/regulation by teachers we address the issue of teachers reflection on past pyramid implementations and cohorts in view of redesign purposes. By providing visual analytics, the teacher might consider possible revisions and different configurations or can inform other teacher´s how to design a pyramid learning scenario.

Our research question tackled in this paper is the following:

RQ: Which learning analytics derived from the use of the PyramidApp can help designers in reflecting about re-use and re-configurations of pyramid activities in different contexts?

The paper is organized as follows: Section 2 describes the connection between learning design, teacher´s metacognition and learning analytics. Section 3 refers to pattern-based analytics in the Pyramid pattern while Section 4 their application in the PyramidApp through a case scenario. Sections 5 and 6 are devoted to the presentation of learning analytics for teacher´s reflection followed by discussion and conclusions.

2. Supporting metacognitive knowledge of learning designs with learning analytics

The field of Learning Design or "design for learning" has currently emerged as means to facilitate educational practitioners towards sharing, modification and reuse of their pedagogical plans (Persico & Pozzi, 2015). It studies the art and science of designing meaningful and effective scenarios for learning and proposes tools to support the design process by enabling their explicit representation in sharable formats (Mor, Craft & Hernández-Leo, 2013; Lockyer et al., 2009). One of the underlying principles supported by researchers in this field is the implementation of active learning approaches in the design of learning environments. In this direction, Collaborative Learning Flow Patterns (Hernández-Leo et al., 2006; Hernández-Leo et al., 2010) describe well-known collaborative techniques such as Jigsaw pattern or Pyramid pattern which can be used, revised and shared by teachers as scaffolds for the design and instantiations of collaborative learning activities. Although the design and decisions made by teachers can be documented, the teacher might not have a specific picture on what happened during the deployment of the activity with a specific technological tool. Metacognitive knowledge of teachers was introduced as support for the reflection on and adaptation of their learning scenarios and as a way to unveil hidden features during their implementations (Lin, Schwartz., & Hatano , 2005; Porayska-Pomsta, 2016). *Metacognitive knowledge* in this context can describe teacher´s beliefs towards the efficacy and facility of applications of various collaborative techniques. It consists of *declarative* (what are the available strategies and their intentions), *procedural* knowledge (knowledge of how to do the things) and *conditional* knowledge ("why" and "when" to apply each strategy) (Metallidou 2009; Schraw, 1998). Little research so far focuses on teacher's metacognition after enacting a learning scenario with students (Porayska-Pomsta, 2016). The connection of teacher's metacognition with the use of learning analytics data for reflection is being described in this paper.

Several authors proposed that the process of Learning Design, except of pedagogical grounding can also be informed by the collection of learning analytics data which show how students experienced a learning design (Lockyer et al., 2013; Melero et al., 2015; Mor, Ferguson, & Wasson, 2015; Persico & Pozzi, 2015; Rodríguez-Triana et al., 2015). Learning analytics has been 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" (Ferguson, 2012, p. 2). It is useful to differentiate between the purpose, the target groups and the time that this data is presented. For instance, learning analytics can be used for self-regulation of students, for the regulation of the learning scenario by the teacher and may be presented during the learning process or after learning sessions (Duval, 2011; Wise, 2014). The current problem is that often teacher's needs for designing learning activities do not align with information provided by learning analytics tools. Relevant research in collaborative learning proposes the alignment of scripting methods with monitoring support (Rodríguez-Triana et al., 2015) for improving the management of learning activities by teacher´s as the learning scenario evolves. Constraints of CLFPs were used as mediators to collect behavioral data of student's actions (e.g. edits, uploads, access to resources, attendance) and to compare it with the desired state of a learning scenario. Pattern-based analytics and feedback to the teachers concerning missing monitoring data was identified as useful to better orchestrate student's activities as the learning scenario evolved. However, little is known for the types of data that teachers might need after the implementation of the learning scenario for being able to re-use or re-design it in different contexts. Lockyer, Heathcote, & Dawson (2013) describe that during the process of designing new activities or a course, teachers often recall past experiences with students. At design time, data-informed decisions regarding past implementations may facilitate the re-design or re-use of learning activities with different students. However, there is a lack of profound understanding around which learning analytics data can be especially useful for this purpose.

In this paper, we aim to tackle this issue by providing a practical example with a specific tool. We focus on the design and deployment of collaborative learning activities based on the Pyramid pattern with the use of an innovative tool called PyramidApp.

3. From Pyramid based-designs to Pyramid-based analytics

Our approach to connect the collection of data in a specific tool with the pedagogical intentions of a learning design can be described as pattern-based analytics. This approach was already applied by Rodríguez-Triana et al. (2015) to support regulation of learning scenarios as they unfold. However, our purpose is different as we aim to support reuse and redesign of the learning scenarios once they have been implemented. To study this problem we focus on the metacognitive process of teachers concerning two aspects of the Pyramid pattern: the *pedagogical intent* (declarative) and the *pedagogical method/structure* (procedural), as well as on one aspect relevant with its particularization and the *practicalities* (conditional) to instantiate the learning scenario.

As *pedagogical intent* we refer to the rationale of this pattern (Gibbs, 1992; Hernández-Leo et al., 2010) which can be described as reach consensus in a specific topic, promote active participation from all the students. promote the feeling that each participant's opinion counts in order to succeed and positive interdependence between students, foster discussions in order to solve a problem and enhance negotiation skills.

To achieve that, teachers or learning designers will design specific activities while particularizing the Pyramid. Reflection on the pedagogical intent can refer to the desired state of students behavior which can be later compared with the final state of students behavior (Dimitrakopoulou et al., 2006; Soller et al., 2005;). Aggregated data of the overall activity can inform teachers for this reflection. Questions regarding *the pedagogical intent* can define possible data collection of the overall activity as the following: Did the students actively participate? How the discussions of the students were and what did they discuss? Data collection relevant to answer these questions could include amount of interactions, comparisons between groups, content of the discussions for their analysis or summarization.

As *pedagogical method/structure* we refer to the flow of the activities in the different phases of the pattern. The Pyramid pattern proposes a sequence of learning activities for a context in which several participants aim to solve the same complex problem or task. To achieve that, students are studying initially the problem individually or in small groups and propose a solution. Then, they formulate larger groups to compare and discuss their proposals and finally propose a new shared solution. This process is repeated until all the students conclude with a final agreed solution.

Questions regarding the *pedagogical method/structure* can be the following: How was the progress of the students from level to level? Which solutions were proposed from level to level? Data collection in this case should show light about to what extent students follow the specific phases proposed by the pattern (e.g., students actually participate in tasks proposed for each level). Data can also include students solutions (artifacts) developed per level.

As *practicalities* we refer to the specific context in which the learning scenario was instantiated. Analytics about the contexts and relevant constraints derived from it can be useful to interpret analytics answering the previous aspects and also support reuse and redesign reflection processes. Relevant aspects in this category include the scale in terms of amount of students that the activity was able to attend and the time used to carry out the activity.

Questions regarding *practicalities* can be the following: How long did the activity and each phase of the scenario last? Data may include the time of the overall activity as well as the time per each phase of the pattern.

4. Case scenario: the PyramidApp

In this section, we describe how our approach for pattern-based analytics can be applied on the Pyramid pattern with the use of an authoring and deployment tool called PyramidApp (Manathunga & Hernández-Leo, 2016). PyramidApp enables the design of scalable and flexible collaborative learning activities inspired by Pyramid flow pattern, where students may join or leave the activity without interrupting the on-going flow, accomplishing a fruitful collaborative activity. In the individual phase, participants propose their solutions for a given task (e.g., an answer or a question for the task). Starting from smaller groups, growing to larger groups in a repeated process of discussions and peer ratings, they reach a common consensus at the last level as a collective effort where they conclude with one option. Figure 1 shows a sample screen of rating and discussion in an intermediary phase of such pyramid activity designed using PyramidApp.

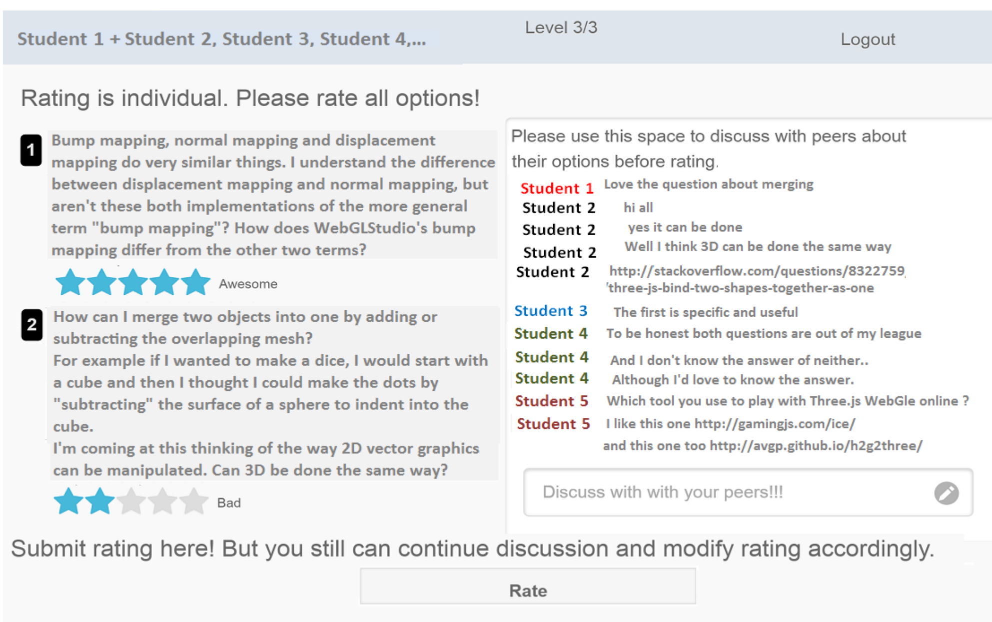

Figure 1. Rating and discussions in the PyramidApp of the student view

Although the design of the learning scenario and specific configurations can be planned in advance, students may experience the activity in different levels. Currently, teacher's configurations in the PyramidApp include design of the task, number of levels in the Pyramid, number of students per pyramid in order to facilitate multiple pyramid creation (to promote flexible and smaller groups) and the duration of specific sub-phases of the activity (ratings, submission of the task). Diverse data elements are collected from the application such as rating values, messages per student, time duration of each event and number of participated students among others (see table 1).

Table 1. Metacognitive dimensions, teacher's configurations and types of analysis.

Dimensions	**Configurations**	**Unit of analysis**	**Data**
Pedagogical intent	Design of the task	Participation, Consensus building, Negotiations, Content	Messages, Ratings
Pedagogical method/structure	Number of levels	Overall activity, Levels of the pyramid	Messages, Ratings
	Number of pyramids	Overall activity, Levels of the pyramids	Messages, Ratings,
	Students per group in the second level	Students per level	No of students
Practicalities	Submission time	Overall duration and per level	Time

The three metacognitive dimensions which we propose for reuse and redesign reflection can be aligned with design configurations in the tool and the collection of learning analytics data relevant with these decisions. A log file analysis might provide useful information on how these decisions can be refined based on the *pedagogical intent*, *the pedagogical method/structure* and *the practicalities* (see table 1).

A case scenario of a total of N = 38 students in a secondary school was analyzed to test our pattern-based analytics approach. The students used the Pyramid App in classroom and their main task was to propose an interesting outdoor activity to their teacher. Students were encouraged to discuss the different options in groups and after negotiations and peer rating to conclude in one proposal. An individual researcher acted as the learning designer of this task and configured the learning scenario in the Pyramid App. The evaluation study was initially planned to test other aspects of the App such as scalability, flexibility and usability and thus the design of the activity as well as the epistemic task was used as testing prototypes (Manathunga & Hernández-Leo, 2016). Log file analysis in this study aimed to identify potential analytics that might be useful for teachers to reflect on the enacted scenarios based on the three metacognitive dimensions. In table 1 we define the data collection process by considering teacher's feedback for the pedagogical intent and the practicalities and propose their form according to the pedagogical method/structure.

5. Visualizations for the case scenario and discussion

Once the teacher designs the activity using PyramidApp, the tool visualizes a summary of the final learning design which is documented and saved for later retrieval. However, to reflect on questions regarding the *pedagogical intent* (participation, active discussions, consensus building) he/she may needs to know the overall levels of participation, content of the discourse and peer interactions after the activity. In our case, data for this purpose includes the messages and the peer ratings. Figure 2 shows visualizations providing feedback to the teacher on the levels of students´ participation by considering the overall learning activity and the structure of the learning design in the PyramidApp. The left graph shows the overall level of messages in the activity (green color) and messages per sub-pyramids (red, blue color) in each level (Level 1,2,3). Graph on the right shows levels of students' participation in each sub-pyramid.

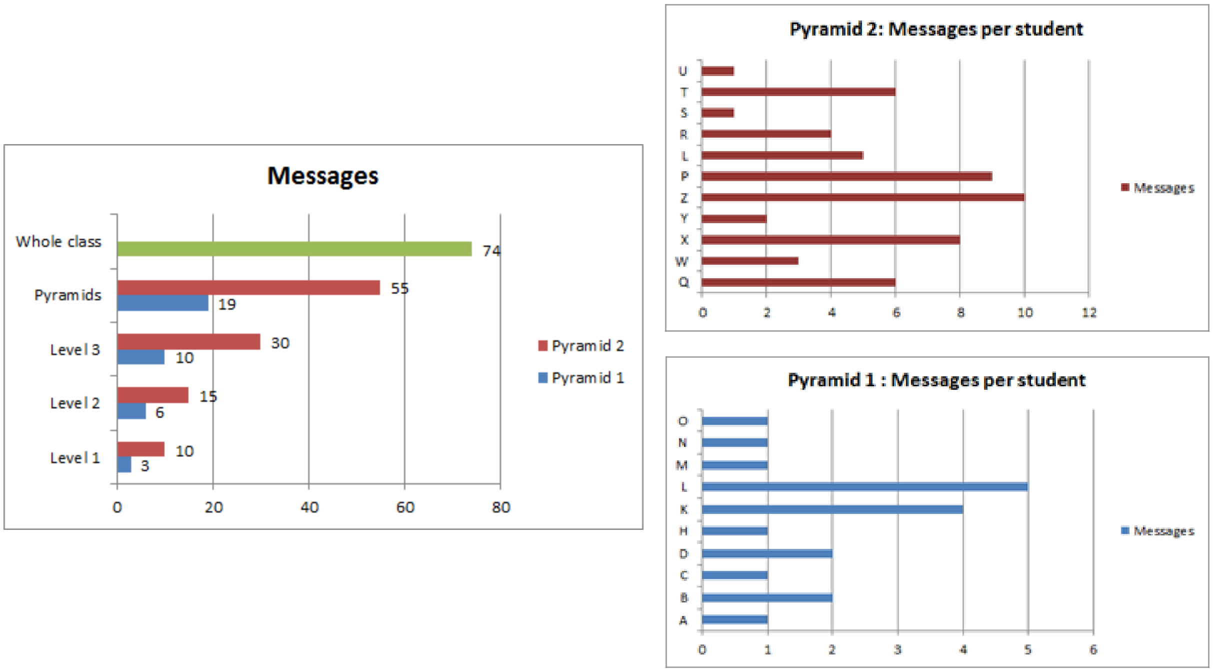

Figure 2. Levels of participation (messages) in the case scenario. Reflection on the *pedagogical intent*

Number of messages exchanged generally relates to the given epistemic task at any context. In this case scenario, the proposed epistemic task resulted with 74 messages from 38 participants implying a message frequency that can be interpreted as dissatisfying. Hence, a revised version of such pyramid activity could be driven by a different (redesigned) epistemic task requiring more active participation and peer interactions. In terms of the structure, we could see an increment of messages posting when groups grow larger. If the pyramid structure is designed to accommodate all 38 students into one pyramid, may be the number of messages can have an effect. However, sub-pyramids showed different participation levels. If revisions can be done to consider mechanisms like active and inactive participation when structuring pyramids, the pedagogical intent of implanting fruitful collaborations can be ensured.

To provide relevant information for the content of the messages as students´ messages might differ (length, content) we propose a summary of the discourse through the open source web-based application voyant-tools[1]. Teachers can paste the text of their students and perform basic text-mining functions (clouds, frequency of words) which show characteristics and different themes of the corpus. Figure 3 shows visualization of student's messages in the case scenario with the voyant tools.

[1] http://voyant-tools.org/

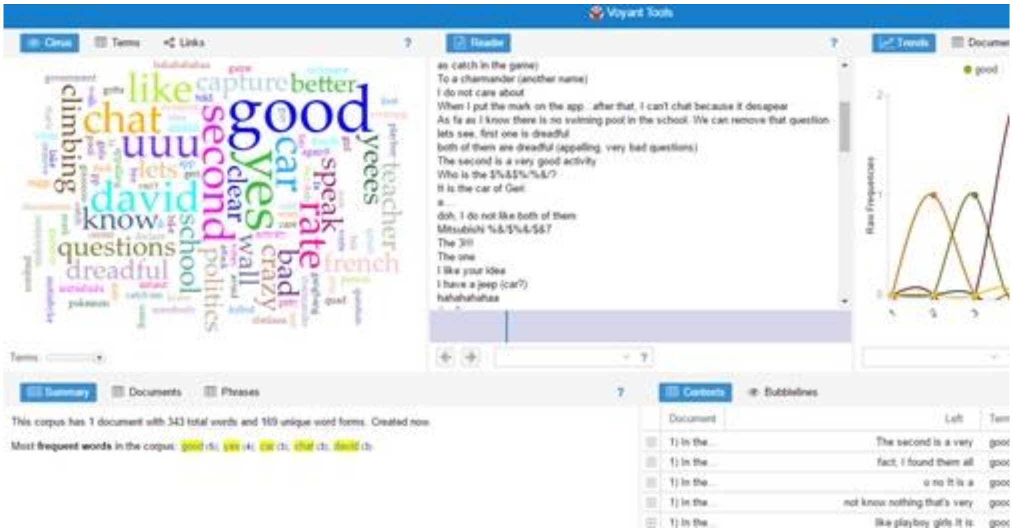

Figure 3. Summary of the discourse in the case scenario. Reflection on the *pedagogical intent*.

Summary of the discourse and topic identification may help teachers to better understand students´ engagement in the task. For instance, if the discussions were related with the learning task. Since in the case scenario, the largest part of the discourse was irrelevant future refinements may require additional scaffolds which foster more meaningful discussions.

By considering again the rationale of the Pyramid pattern and the *pedagogical intent*, the teacher might need to know how the students interacted until building consensus on that topic. In the PyramidApp, the ratings values can inform the levels of disagreement in each group regarding the different students' options. We identified this indicator as relevant to inform teachers for the learning process in the pyramid. The average level of disagreements is visualized in Figure 4 with the aim to provide feedback to the teacher on the disagreement levels based on the ratings. However, content analysis of the messages can provide additional insights for the topics of disagreement. Disagreements levels are calculated with the standard deviation of the ratings for each group. Then the mean value from all the groups is showing the disagreements of each level. Higher values show higher disagreement.

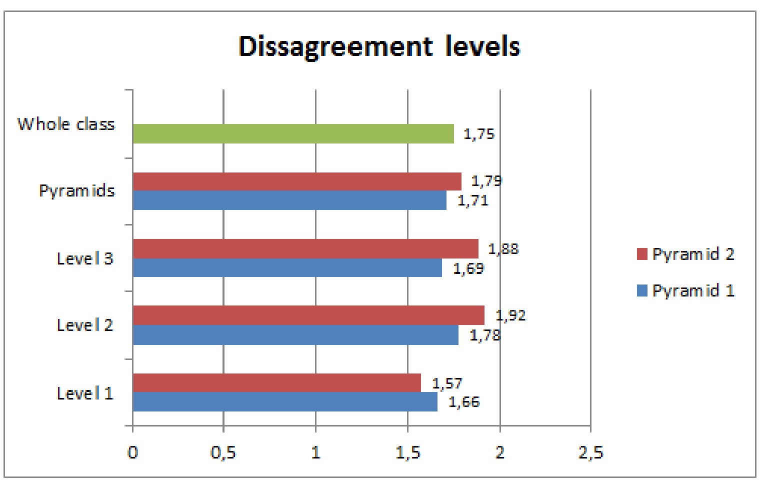

Figure 4. Disagreement levels in the case scenario. Reflection on the *pedagogical intent*

In both sub-pyramids we could identify that in the first level students disagreed less possibly because smaller groups were formed, in the second level more (larger groups) and in the final level their disagreement decreased. This can be a coincidence following the structural behaviour of a pyramid. Hence, when redesigning is considered, if the intention is to generate more debate and discussions, number of levels of the pyramid should be considered and also the epistemic task should incorporate it. However, analysis of the content of the messages can show how students disagreed. A future revision of a pyramid activity might consider the types of debates that want to achieve and then reflect on this issue.

During the application of the *pedagogical method/structure* the teacher and the students need to follow specific steps in order to achieve the intended outcomes. Reflection on these issues may include the number of students that participate in each phase (see Figure 5).

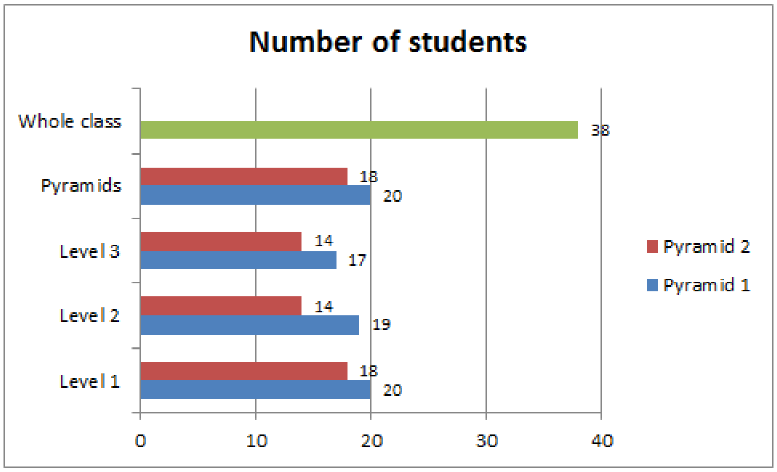

Figure 5. Number of participated students in the collaborative phases of the pyramid. Reflection on the *pedagogical method/structure.*

The number of participated students decreased from level to level in each sub-pyramid of the activity. One possible revision could be warnings and detailed instructions in order to ensure that each participant contributes to the final agreement. Last, regarding feedback about *practicalities*, the teacher might need to know the duration of the activity and relevance with the specific structure. Figure 6 proposes feedback to the teacher for the overall duration per level and per sub-pyramid.

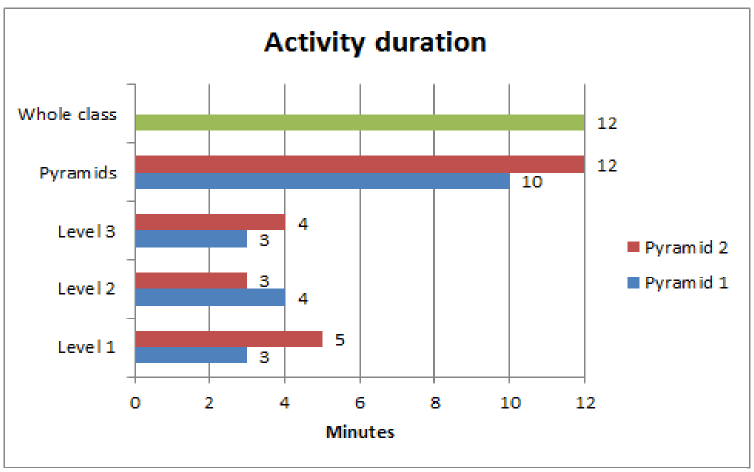

Figure 6. Activity duration in the case scenario. Reflection on *practicalities*

The overall activity lasted 12 minutes. This happened due to teacher´s configuration of the submissions timeout and the time that students used to discuss and rate. According to the available time in a classroom scenario, a teacher can re-design the activity to last more or less minutes. Feedback for the specific structure (per levels) can be interpreted according to teacher´s configurations and thus similar configurations can be used to achieve these results.

Data collected in the three dimensions can be part of the design process as they relate with teacher´s needs to design a pyramid activity. For instance the individual teacher might consider implementing another collaborative activity in the classroom. After knowing that this activity lasted 12 minutes similar time configurations would be recommended for achieving the same result. Moreover, after considering that in this task students showed low levels of engagement and the content of the messages was dissatisfying a further refinement may needs more explanations and scaffolds for the students.

6. Conclusion

In this paper we have presented preliminary work aimed to link teacher's decisions to design a learning scenario with the collection of learning analytics data in a specific tool called PyramidApp. Our approach was based on the Collaborative Learning Flow Patterns as a boundary object between the learning design of the teacher and collection of learning analytics data in different contexts. To support re-use and re-design of implemented pattern-based activities we consider teacher´s metacognition in three levels: *pedagogical intent*, *pedagogical method/structure* and *practicalities.* The aim was to foster teacher´s reflection towards the efficacy and application of different pyramid pattern-based activities.

PyramidApp helped to formulate the collaborative activity design considering the three dimensions of teacher's thinking; declarative, procedural and conditional. As declarative we considered the support for the pedagogical rationale of the pyramid pattern through the tool and as procedural we considered which structure or pedagogical method being followed in the tool (in the case of PyramidApp we have used consensus reaching based on rating augmented via peer discussions). As conditional we considered the practicalities to enact the learning scenario (timing) in a classroom context. We proposed learning analytics data which can inform these three dimensions and help teachers to reflect on their decisions and configurations.

The documentation of the implemented scenarios together with the proposed learning analytics may help teachers or learning designers to customize specific elements of the pyramid pattern (number of levels, pyramid structure-having multiple pyramids or not- details, additional scaffolds) according to the intended outcomes. Moreover, teachers after reflecting on practical constraints such as available time of the learning environment may save costs and time for their re-implementations of a learning scenario. All in all, this supports improvement in the teaching practice in a more systematic, effective and efficient manner. This, information can also be a starting point and analysis framework for designers who want to re-use a similar activity in a different context.

We are currently presenting the learning analytics to teachers to study the extent to which the visualizations and analysis are meaningful to support reuse and redesign thinking processes. Future work also includes exploration of how this approach can be applied to other CLFP such as the Jigsaw pattern according to its specific rationale and structure. Our method described the steps that a learning designer may follow from the explicit representation of the design, to possible questions for reflection on the design decisions and the definition of data collection for this purpose. Moreover, this process can inform the gathering of data in other enactment platforms (e.g., Moodle) supporting the implementation of CLFP-based scenarios.

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