

# Employing learning analytics for monitoring student learning pathways during Problem-Based Learning group-based group work

*a novel approach*

Triantafyllou, Evangelia; Xylakis, Emmanouil; Nilsson, Niels Christian; Timcenko, Olga

*Published in:*
7th International Research Symposium on PBL

*Publication date:*
2018

*Document Version*
Publisher's PDF, also known as Version of record

# Employing learning analytics for monitoring student learning pathways during Problem-Based Learning group work: a novel approach

Evangelia Triantafyllou[1], Emmanouil Xylakis[2], Niels Christian Nilsson[3] and Olga Timcenko[4]

[1,2,3,4] Department of Architecture Design and Media Technology, Aalborg University, Denmark
evt@create.aau.dk, em@create.aau.dk, ncn@create.aau.dk, ot@create.aau.dk

## Abstract

Learning Analytics (LA) aims to improve the learning process by analysing learning data, and communicating the results of this analysis to both educators and learners. LA has been employed in a few cases for improving PBL group work but the literature has yet to discuss in detail the incorporation and potential of LA in this context. In this paper, we describe our approach that aims at developing a platform employing LA for monitoring students' learning pathways during Problem-Based Learning (PBL) group work. The platform is developed in Moodle, and it provides a communication and information channel between project supervisors and students, and between students belonging in the same group. Moreover, the platform provides ways for student groups to better manage their projects, and at the same time enables project supervisors to follow groups' progress during the semester. The platform is also used as a place, where students hand-in assignments that are related to their project work and report their status in the project. In this platform, we employ various LA tools offered by Moodle in order to monitor both group and individual student activity. Such tools provide learning data on individual student engagement and activity within the platform, generic statistics on the use of the platform, and insights into the exchange of information in the platform. In this paper, we present the functionality of the various modules that build up this platform, and discuss the type of learning data generated and the methods to analyse this data. We conclude this paper with a discussion on the benefits and the limitations of this approach.

***Keywords***: PBL group work, learning analytics, Moodle, educational data

***Type of contribution***: best practice paper

## 1 Introduction

In the last decades, the introduction of digital technologies (such as online learning environments, learning management systems, social media etc.) in education has led to the generation of a variety of multimodal learning data (Siemens & d Baker, 2012). This data is generated while educators and learners interact with such technologies and can provide valuable insight into the learning process. However, there was limited use and analysis of such data up to 2010, when Learning Analytics (LA) gained momentum as a research field (Siemens & Long, 2011). LA aims at providing ways to gather and make sense of educational data in order to improve the learning experience for learners and teachers, and better adapt courses' design. According to the Society for Learning Analytics Research (SoLAR), learning analytics is defined as follows:

*"Learning analytics is 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)*

In this paper, we describe our approach that aims at developing a platform employing LA for monitoring students' learning pathways during Problem-Based Learning (PBL) group work, we present the functionality of the various modules that build up this platform, and discuss the type of learning data generated and the methods to analyse this data. The paper is organized as follows: section two refers to other approaches that used LA for better supporting group work, section three describes the proposed platform, while section four discusses the methods employed in a trial where this platform was employed. Section five presents the categories of the educational data gathered on the platform, and section six discusses our plans for the analysis of the educational data gathered, and the evaluation of the trial. We conclude this paper with a discussion on the benefits and the limitations of this approach.

## 2 Background

Although group work is assumed to have positive effects on student learning, experiences from educational practice indicate that it can also introduce problems for both students and teachers. Examples of such challenges include students who only maintain an appearance of being actively involved, or students who let others do the work, also called free-riders (Salomon & Globerson, 1989). Therefore, research has paid much attention to the problem of differentiation of individual contributions in group projects (Earl, 1986; Goldfinch & Raeside, 1990; Kommula, Oladiran, & Uziak, 2009). Later on, researchers attempted to mitigate free-rider problems and improve students' perceptions about group work (Brooks & Ammons, 2003; Elliott & Higgins, 2005). All these approaches were based on student assessments of the performance and contribution of their group members and in some cases student self-assessments. With the rise of LA as a research field, educational researchers attempted to address the challenges in group work by employing LA methods.

Tempelaar et al. (2014) proposed a LA infrastructure that combines learning dispositions data with Learning Management System (LMS) student engagement/activity data, and data extracted from computer assisted formative assessments. Their study ran in an introductory mathematics and statistics module combining face-to-face PBL sessions with e-tutorials, and investigated the predictive power of learning dispositions, outcomes of continuous formative assessments, and other LMS generated data in modelling student performance and their potential to generate informative feedback. The results of this study showed that computer assisted formative assessments were the best predictor for detecting underperforming students and academic performance, while basic LMS data did not substantially predict learning.

Conde et al. (2017) developed a LA tool that enables teachers to perform teamwork competence assessment of a group of students taking into account how the individuals acquire the essential components of such competence. This tool uses the Comprehensive Training Model of the Teamwork Competence in Engineering Domain (CTMTC) method to gather competence evidences, and it was used in two Bachelor courses on Computer Science. In this comparison case study, the tool was incorporated in Moodle, where the teachers of the two courses posed an activity that should be completed in teams applying the CTMTC methodology. The Moodle forum was the main space for interaction, and the Moodle wiki was used by students to display the outcomes of the activities. The work done in the wiki had to incorporate the phases described in CTMTC. The results of this study showed that there was a significant correlation between posts/views and individual final grades in both courses and this can be taken into account when analysing group members' use of educational resources and interaction that takes place in the web of data. Moreover, it was found that the perception of teamwork competence acquisition among students has changed after the application of CTMTC, and that teachers perceived this tool as applicable in different contexts, flexible and portable.

Spikol et al. (2017) employed multimodal LA (MMLA) in order to understand what happens when students are engaged in collaborative, project-based learning activities. They developed a MMLA platform, where various streams of data are collected, and multimodal interactions are processed and extracted with the aim to identify which features of MMLA are good predictors of collaborative problem-solving in open-ended tasks in project-based learning. Moreover, manual entered scores of collaborative problem-solving were regressed using machine-learning methods. In this research study, the authors found that where the students are looking, the distance between them, the motion of their hands are key features for identifying collaboration in small groups of engineering students. Therefore, they proved that the physical aspects of collaboration is an important part of this type of learning and that MMLA provides new methods for providing evidence about the impact of such learning approaches.

In this paper, we present a platform that supports PBL group work by using LA to exploit the data generated during this kind of learning. The aim of this approach is to gain insight into student progress, group cooperation, and supervisor-group collaboration while students engage in this kind of group work. Moreover, the platform seeks to provide student groups with methods to manage their work (meet milestones, organize their time, etc.) and share information within the group and with their supervisor. In the next session, we describe the various components of this platform.

## 3 The Proposed Platform

The proposed LA platform is implemented in the Moodle LMS, which keeps track of user activity and provides other LA tools for monitoring student progress. Since the platform targets group work, the students are divided in groups. It is assumed that group forming takes place outside the platform, and that each group is guided by a teacher, called supervisor. Each group in Moodle contains the group members and their supervisor. The platform is separated in sections, which support different purposes and contain activities to serve these purposes. The activities that take place within the group (or between the group and their supervisor) are set in “Separate groups” mode in Moodle, meaning that each group sees their own version of this activity.

The first section is a placeholder for general information regarding the group work. This section contains two forums: one is dedicated to announcements by teachers, and the other is devoted to an open discussion about group work. In the first forum, students do not have posting rights. This section contains also resources (files), which teachers consider relevant to the process or the content of group work. Lastly, this section contains an assignment activity, in order for groups to send their initial problem statement to their supervisor, according to the PBL approach. This activity is set to “Separate groups”, so this information is only exchanged between groups and their supervisor.

The second section contains activities that support group communication and management. There is a forum activity and a chat activity for internal communication regarding the group work. Moreover, there is a checklist activity, which serves as a simple Gantt chart, and contains the main tasks of the group work based on the PBL approach. The tasks are defined by the teachers, which encourage students to add additional tasks, if needed. The groups can mark as done all completed tasks, thus facilitating project management, and at the same time informing their supervisor on their process.

The third section in the platform serves as a communication and document-sharing channel between groups and supervisors. This section includes assignment activities, which represent milestones of PBL group work. These assignments require specific deliverables and they are due on specific dates, facilitating project

management for the groups. The section contains a forum activity that supports communication between the group and their supervisor. This activity is meant to replace all other online communication channels, (e.g. emails, sms, Facebook, etc.) between these two parties. Lastly, there is a wiki activity, which is used by the group as a progress report and an agenda before each physical meeting with the supervisor. Since the wiki activity keeps its previous versions, the groups and the supervisors get an overview of the progress of the work at the end of the semester.

The fourth section is dedicated to feedback activities. There are feedback activities for students, where each student can provide feedback on the group forming, collaboration, and progress anonymously. These feedback activities provide teachers with information on issues within the groups. There is also a feedback activity, where supervisors are required to evaluate their groups twice: once at midterm and once at the end of the semester.

# 4 Methods

The platform described in the previous section has been applied to gather, process, analyse, and interpret educational data during the second semester project at the Medialogy bachelor program of Aalborg University Copenhagen. Medialogy is an education that focuses on research and development, which combines technology and creativity and looks at the technology behind areas such as advanced computer graphics, games, electronic music, animations, and interactive art, to name a few. According to the PBL – Aalborg Model, which is applied in all programs at Aalborg University, the Medialogy program curriculum is mapped onto semesters, where students spend approximately 50% of their time on course work (3 courses) and the other 50% on a semester project, where students collaborate in groups. The semester courses support project work, which follows the PBL approach. Each semester is governed by a fixed theme, which is selected to serve as the context, where the courses and the semester project address the learning objectives. Each group of students is assigned a supervisor, who guides the students during the project, and makes sure they are progressing according to the goals of the semester.

The theme of the second semester at Medialogy is “Human-Computer Interaction”, so during the semester project the students should foster key competences in designing, developing and evaluating an artefact, such as a desktop or a mobile application, using a user-centred approach. While pursuing this aim, they are able to apply knowledge and skills in mathematics, programming and interaction design. The platform was used for the semester project module during the spring semester 2018, where 94 Medialogy students were divided in 14 groups. In this semester, six teachers acted as supervisors for the semester projects (some teachers supervised more than one group). The structure of the platform adjusted to this case is shown in Figure 1. In the next section, we present the educational data gathered during this semester project module.

# 5 Educational Data Gathered

The various components of the platform allow for the collection and analysis of different type of educational data. In the following, we present the different categories of data.

## 5.1 Student engagement and interaction with the LMS

Student engagement and interaction with Moodle data is gathered and analysed using the standard functionality of Moodle (reports), and three plugins for Moodle (GISMO, Statistics, and Heatmap). This type

of data is gathered as students use the platform in order to shape an understanding of their overall engagement with the LMS.

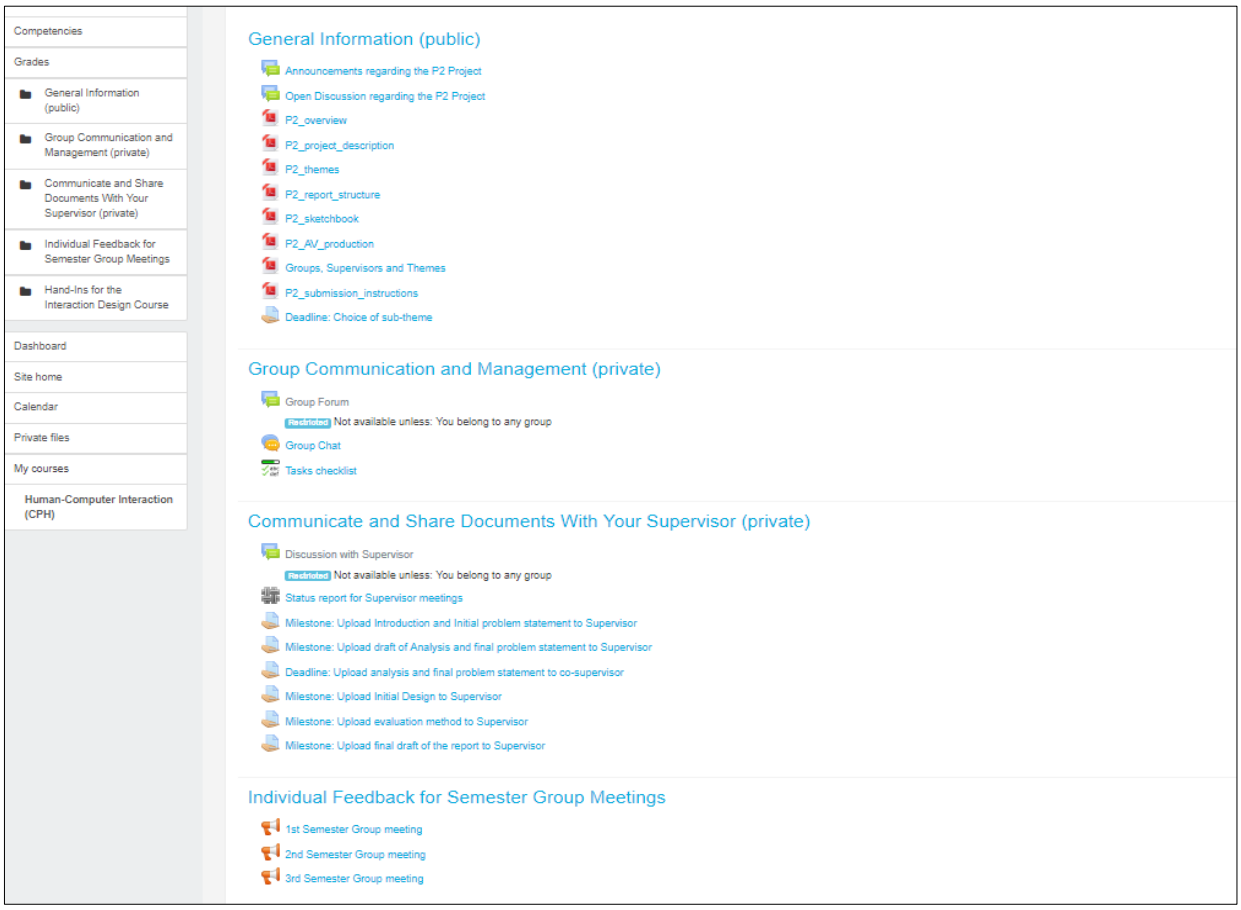


Figure 1: The platform adjusted for the semester project module in the second semester of Medialogy (Student view).

By employing the logs for the specific Moodle page, we are able to extract student action reports. Moodle distinguishes between the following actions on the various activities: create, view, update, and delete. The activity report provides the total number of views by number of users, and the date of the last access on each activity. Moreover, through the course participation reports, Moodle provides information on views and posts per activity. An overview of the views and posts for the wiki and the four forum activities per student of a random group are shown in Table 1 (we use the name “group A” to ensure anonymity). This information provides an overview of each group member engagement with all activities (numbers on the other activities not show here to save space). By adding the total number of views and posts for all group members, we can create a metric for the group engagement with the different activities (last column in Table 1). If we divide this metric by the number of students in each group, we get a “normalized” metric for each group engagement with each activity, and in this way we are able compare the engagement of different groups. Table 2 shows the total and mean value of views and posts on the wiki, forum, and file (resources) activities for group A.

In order to better visualize and combine the data provided by the Moodle reports, we installed the LA plugin GISMO on the platform. GISMO is a graphical interactive monitoring tool that provides visualization of students' activities in Moodle. With GISMO, we are able to visualize various aspects of student engagement, such as reading of materials, submission of assignments, engagement with forums etc. Figure 2 shows four

graphs on student engagement for group A created in GISMO. The value of the GISMO graphs are that they are interactive and can be easily adjusted in time, or for individual students.

Table 1: Number of views and posts per wiki and forum activity for the seven students of a random group (group A, s1= student 1, s2=student 2,etc.)

| Activity (Action)/Student | s1 | s2 | s3 | s4 | s5 | s6 | s7 | Total |
|---|---|---|---|---|---|---|---|---|
| Wiki (View) | 0 | 9 | 4 | 3 | 0 | 17 | 12 | 45 |
| Wiki (Post) | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 4 |
| Wiki (Total) | 0 | 9 | 4 | 3 | 0 | 20 | 13 | 49 |
| Discussion with Supervisor Forum (View) | 3 | 87 | 75 | 67 | 0 | 32 | 27 | 291 |
| Discussion with Supervisor Forum (Post) | 1 | 2 | 11 | 0 | 0 | 6 | 2 | 22 |
| Discussion with Supervisor Forum (Total) | 4 | 89 | 86 | 67 | 0 | 38 | 29 | 313 |
| Announcements Forum (View) | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 4 |
| Open Discussions Forum (View) | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 4 |
| Open Discussions Forum (Post) | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Open Discussions Forum (Total) | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 5 |
| Group Forum(View) | 0 | 2 | 3 | 0 | 1 | 0 | 1 | 7 |
| Group Forum(Post) | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| Group Forum(Total) | 1 | 2 | 3 | 0 | 1 | 0 | 2 | 9 |

The Heatmap plugin is another tool that was added in the platform. This tool overlays a heatmap onto a course to highlight activities with more or less activity in order to help teachers gain insight into the use of the various elements of their courses. The Heatmap paints each activity with a colour from pale orange to vivid red depending on the number of user views on this activity (pale orange being the less used, and vivid red being the most used activity). Under each activity, the tool provides specific numbers of user views and the number of users, who viewed the activity. Moreover, it adds a small block with a summary on total views and distinct user views for the whole module (Figure 3). This information is only visible to users with a Teacher role.

Table 2: Total and mean value of views and posts on wiki, forum, and file activities for group A.

| Engagement summary | Total | Mean |
|---|---|---|
| Accesses on wiki | 49 | 7.00 |
| Accesses on forums | 331 | 47.29 |
| Accesses on files | 54 | 7.71 |

The Statistics plugin for Moodle was installed on the platform in order to have a quick overview of accesses to the platform per day. This plugin adds a graph in the Moodle page, where total connections per day are shown for the last 30 days (Figure 3). When a teacher clicks on the “More details” link, the names of the users connected on the current day are shown.

## 5.2 Forum discussions content

The content of forum posts on the platform provides insight into the discussions taking place among group members, and between groups and their supervisors. In order to identify the issues raised during these discussions, we apply an inductive approach for qualitative analysis on discussion data (Miles & Huberman, 1994). During this data analysis, consensus on findings is sought among three researchers in order to ensure a deep reflexive analysis, and to strengthen the validity of the findings. One of these researchers is actively involved in the second semester of Medialogy (not as a supervisor), which greatly assists in interpreting students' and supervisors' posts. The goal of this analysis is to create a list of the various topics raised and their frequency during the semester for each group (internally, and during communication with the supervisor), and then correlate the data in the list with the other type of data gathered on the platform.

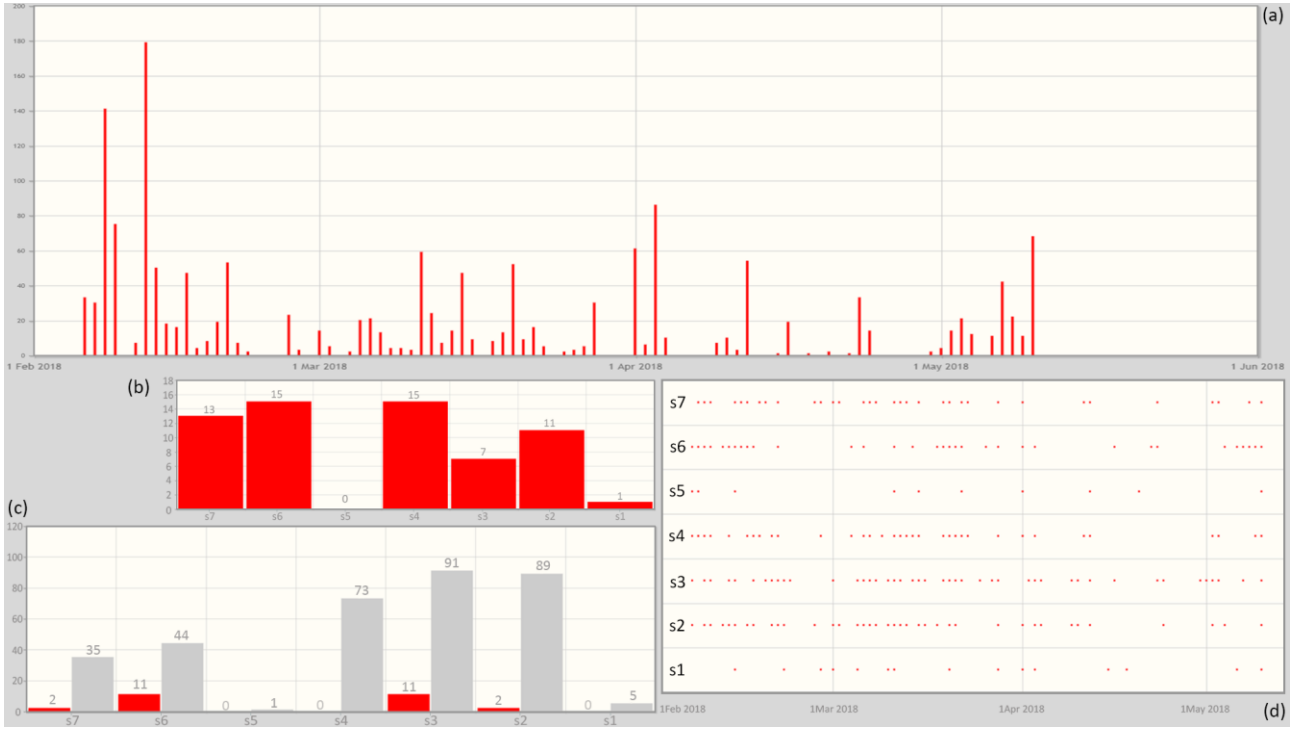


Figure 2: (a) Total accesses to the platform per day, (b) Total accesses to the files (resources) on the platform per student of group A, (c) Forum posts/views per student of group A (red=posts, gray=views) 4. Student accesses to the platform over the semester (dots represent days they).

## 5.3 Assessment data

The last type of data gathered is group and individual assessment data. Group assessment data is gathered through a feedback activity, where supervisors are asked to evaluate their groups in four aspects: group internal collaboration, group collaboration with their supervisor, project management, and overall performance. Supervisors fill out this feedback two times: once at midterm, and once at the end of the semester. At midterm, supervisors are also asked to provide an estimation of the group's final grade (referring mainly to the final product of the project, since students get individual grades during examination). Group assessment data are also gathered from the student side. Students evaluate their group's formation, internal collaboration, collaboration with the supervisor three times during the semester by using the feedback activities before each semester group meeting.

Individual assessment data is available after the final examination on the semester project module. The final examination is group-based, i.e. all members of the group present parts of their project and then answer questions posed by two examiners (the supervisor and a censor). However, at the end of the examination, the group members get individual grades depending on their performance during the presentation, and the Q&A round.


Figure 3: The Moodle platform with the Heatmap and Statistics plugins enabled.

### 5.4 Further data analysis

The aforementioned data was used once in the semester in order to identify groups that were at risk (low engagement data, late/lack of submissions of assignments, few/no wiki updates) and inform the respective supervisors. It was left to the supervisors to decide if they had to take some action. Moreover, student feedback was accessible by supervisors, so they could adjust their collaboration with the groups during the semester. At the end of the semester, we aim at applying statistical correlation and regression tests on the various sets of data in order to identify if and which pairs of data are related, and if some data can be used to predict the outcome of other sets of data. The qualitative analysis of the forum discussions will also provide insights into the learning and collaboration process of each group, and into the collaboration between groups and supervisors. By analysing posts, where feedback was given on specific parts of the project by the supervisors, the status reports, and each group's submitted assignments, we also aim to extract qualitative group assessment data.

## 6 Discussion and Conclusion

This paper presents a platform for applying LA methods to PBL group work. This platform was developed in the Moodle LMS, and provides teachers with different type educational data. By employing Moodle plugins, and quantitative and qualitative analysis on this educational data, we aim at getting insight on both the progress and the process of the PBL group work. Moreover, we are able to get data on the engagement and progress of individual students. In order to pilot the overall LA approach, and the functionality of the platform, we introduced it to the semester project module of the second semester of the Medialogy program. During this semester project module that follows the PBL pedagogy, the collaboration, interactions, and progress were taking place offline until now. It was therefore only the supervisor of each group, who had an overview of the group collaboration, and progress during the semester. However, in cases where the groups did not

communicate with their supervisor, there was no way even for the supervisor to have such an overview. Moreover, it was challenging even for the supervisor of a group to get insight into the individual contributions to the project among the members of the group, at least before the final examination. Finally, it was difficult for supervisors to evaluate intermediate phases of the project, if the groups did not inform the supervisor about them, or they did not refer to such phases in their final report.

Our approach provides an overall view on student engagement and actions in the LMS supporting their semester project. Such an overview can be used to address groups or students at risk during the semester. Although student engagement in LMS is not always predictive for learning, we believe that low engagement is indicative of underperforming students. This assumption can be also mitigated on a group level, i.e. groups with lower engagement metrics were less productive during the semester. A few cases of students who dropped out during this semester agree with this assumption, which still has to be proved by the analysis on the collected data. The assignment activities that were introduced for groups to submit intermediate milestones to their supervisor, and the analysis of the forum discussions, and the wiki posts can be used in order to better evaluate the progress and the intermediate phases of the project.

The analysis of the forum discussions will also provide insights into the supervisor-group communication, and collaboration, which so far were taking place via emails and physical meetings. Such insights can be used to identify different patterns of communication and collaboration, and investigate if and how the group's and the supervisor's approach to them affect the group's performance or other aspects of the semester project.

While this platform provides information on different aspects of PBL group work, it requires also extra effort from groups and supervisors, since both of them had to get used to a new way of collaboration. Moreover, the strength of this approach on providing rich educational data depends entirely on the dedication by both teachers and students to use it. For instance, the forum and the chat activities meant to support communication among the members of a group have not provided any valuable data, since students usually select other platforms to perform these tasks (mainly Facebook and Skype), and therefore hardly used them.

Apart from analysing the educational data, we aim also at gathering student and teacher perceptions on the use of LA methods in these PBL semester projects. In order to evaluate the overall approach and the functionality of the platform, we will distribute questionnaires to the students and the supervisors involved in this trial. The supervisors will be asked also to fill out a guided self-reflection report based on the LA data available at the end of the semester. For the self-reflection analysis, we employ Gibbs reflective cycle (Gibbs, 1988). The aim of this analysis is to make sense of what happened, and plan future actions. The results of this evaluation will be used to adjust the platform and design the next iterations of its employment in PBL project work.

## 7 Acknowledgements

The research presented in this paper was conducted under the PBL3.0 project, which is co-funded by the Erasmus+ programme of the European Union under the project number 562236-EPP-1-2015-1-EL-EPPKA3-PI-FORWARD. The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

## References

Brooks, C. M., & Ammons, J. L. (2003). Free riding in group projects and the effects of timing, frequency, and specificity of criteria in peer assessments. *Journal of Education for Business, 78*(5), 268-272. doi:10.1080/08832320309598613

Conde, M. A., Colomo-Palacios, R., García-Peñalvo, F. J., & Larrucea, X. (2017). Teamwork assessment in the educational web of data: A learning analytics approach towards ISO 10018. *Telematics and Informatics, 35*(2018), 551-563.

Earl, S. E. (1986). Staff and peer assessment - measuring an individual's contribution to group performance. *Assessment and Evaluation in Higher Education, 11*(1), 60-69.

Elliott, N., & Higgins, A. (2005). Self and peer assessment – does it make a difference to student group work? *Nurse Education in Practice, 5*(1), 40-48. doi:http://dx.doi.org/10.1016/j.nepr.2004.03.004

Ferguson, R. (2012). Learning analytics: Drivers, developments and challenges. *International Journal of Technology Enhanced Learning, 4*(5-6), 304-317.

Gibbs, G. (1988). *Learning by doing: A guide to teaching and learning methods* FEU.

Goldfinch, J., & Raeside, R. (1990). Development of a peer assessment technique for obtaining individual marks on a group project. *Assessment and Evaluation in Higher Education, 15*(3), 210-231.

Kommula, V. P., Oladiran, M., & Uziak, J. (2009). Self and peer assessment in engineering students group work. Paper presented at the *20th Annual Conference for the Australasian Association for Engineering Education, 6-9 December 2009: Engineering the Curriculum,* 937.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* Sage.

Salomon, G., & Globerson, T. (1989). When teams do not function the way they ought to. *International Journal of Educational Research, 13*(1), 89-99.

Siemens, G., & d Baker, R. S. (2012). Learning analytics and educational data mining: Towards communication and collaboration. Paper presented at the *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge,* 252-254.

Siemens, G., & Long, P. (2011). Penetrating the fog: Analytics in learning and education. *EDUCAUSE Review, 46*(5), 30.

Spikol, D., Ruffaldi, E., & Cukurova, M. (2017). Using multimodal learning analytics to identify aspects of collaboration in project-based learning. () Philadelphia, PA: International Society of the Learning Sciences.

Tempelaar, D. T., Rienties, B., & Giesbers, B. (2014). Computer assisted, formative assessment and dispositional learning analytics in learning mathematics and statistics. Paper presented at the *International Computer Assisted Assessment Conference,* 67-78.