Learning Analytics Tools to Analyze Progress and Results With Moodle LMS Data

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***Abstract*—Teachers can benefit from the information provided by learning analytics data for multiple purposes. Visual learning analytics dashboards provide near real-time information while more complex offline tools are commonly used to synthesize and transform the data gathered into interpretable information for teachers. The extended use of Learning Management Systems in universities, such as Moodle or Canvas, provides a rich environment to capture learning analytics data from students' interactions while they are progressing in their courses. In this paper, we present two different learning analytics tools aimed at teachers to obtain information about students' progress and results using data from the Moodle LMS at different stages of their learning process: (1) a progress visualization plugin for Moodle, which provides teachers with real-time information about the progress achieved by students in their courses, and the different goals set for their plans; and (2) an analytics Jupyter Notebook tool with a pre-defined set of analysis and visualizations to apply to data gathered from default activities in Moodle. The plugin is in an initial validation stage, while the analysis tool has been tested in a case study in a university course. Combined, both contributions can enrich the information that teachers have during and after the academic year, adapting their classes to better fit students' progress and needs, as well as providing overall results and comparison between groups after the course has finished.**

***Index Terms*—learning analytics, dashboards, visualization, LMS, Moodle**

I. Introduction

Learning analytics (LA) aims to collect and analyze data for multiple purposes, including awareness and assessment [1]. Among the stakeholders who can benefit from the information gathered through these analytics, teachers are commonly targeted in these applications and tools. From real-time data while applying interactive learning tools in their classes, to offline analysis for improving their assessments, teachers can take advantage from the whole lifecycle of information gathered from LA data [2].

The large amount of interactive data generated by Learning Management Systems (LMSs), such as Moodle[1] or Canvas[2], can provide richer information for teachers and educators. These systems are commonly integrated in universities, providing a clear opportunity to implement LA procedures to help teachers in the analysis and improvement of their daily work by having a clearer understanding of their students' actions and progress in their courses [3].

Among these opportunities, teachers can use the gathered LA information both during their courses at near real-time, to monitor progress and (partial) results of students, and after courses end, to obtain descriptive information about the overall results of students, as well as more complex analyses to detect learning patterns or compare different groups.

In this paper, we present two different learning analytics tools aimed at teachers to obtain information during and after a university course, based on data gathered from the Moodle LMS:

1) A progress visualization plugin for Moodle, which provides teachers with real-time information about the progress achieved by students in their courses, and in the different goals set for their plans.
2) An analytics Jupyter Notebook tool with a pre-defined set of analysis and visualizations to apply to data gathered from default activities in Moodle.

The rest of this paper is organized as follows. First, Section II describes relevant works in the fields of learning analytics, and similar studies with plugins for Moodle, as well as analyzing data captured from Moodle. Next, we present our two contributions: Section III-A describes the Moodle plugin visualizing progress for both teachers and students based on their activities in the course, and Section III-B details the analytics Jupyter Notebook tool to analyze and visualize data

[1]https://moodle.org/
[2]https://www.instructure.com/es/canvas

gathered from Moodle. Both sections present the tools, their design and development, as well as their early evaluations. Finally, we present the main conclusions of the tools and the study, discussing limitations and future lines of work in Section IV.

II. Related Work

In this section, we analyze some works related to learning analytics, with particular interest on similar learning analytics plugins for Moodle, as well as studies analyzing Moodle data.

A. Learning Analytics

Learning analytics (LA) is the field that aims to collect, analyze, and interpret data from educational contexts to understand and optimize learning and its learning environments. It encompasses a range of techniques, including data mining, predictive modeling, and statistical analysis, applied to educational data [4]. Its primary goal is to enhance the learning experience by providing insights into student behavior, engagement, and performance. Through the systematic analysis of data generated from various educational technologies, such as LMSs, online assessments, and digital resources, LA aims to support informed decision-making for educators and institutions.

LA serves various stakeholders in education, with teachers being one of the primary beneficiaries [5]. For educators, LA offers insights into individual student progress, learning patterns, and areas where students might need additional support. By identifying struggling students early, teachers can provide personalized interventions, adaptive learning strategies, or additional resources. Moreover, LA helps in curriculum design and instructional planning by providing feedback on the effectiveness of teaching methods and learning materials. Other stakeholders, such as administrators, policymakers, and students themselves, can also benefit from LA by gaining insights into educational trends, resource allocation, and personal learning progress [6].

Visualizations and more complex dashboards are essential components of LA tools [7]. These tools translate complex educational data into accessible and understandable formats for stakeholders. These visualizations allow educators to quickly grasp trends, patterns, and correlations in student performance, engagement, and behavior. Moreover, interactive dashboards enable stakeholders to drill down into specific data points for deeper analysis and decision-making [8]. Effective visual representations play a crucial role in making data-driven decisions and fostering data-informed practices in educational settings [9].

LA is increasingly integrated into LMSs to enhance the teaching and learning process [10]. LMS platforms collect vast amounts of student interaction data, course activities, assessments, and progress. LA within LMS can offer personalized recommendations, adaptive learning paths, and early warning systems to identify at-risk students. These systems can track and analyze student engagement with course materials, time spent on tasks, and performance on assignments. Additionally, they provide educators with tools to assess the effectiveness of instructional strategies and course design, enabling continuous improvement in teaching practices and learning outcomes within the digital learning environment [11].

One of the outstanding examples of LMS is Moodle. Established in 2002, it is a leading open-source LMS that offers a platform for online learning and course management, equipped with features like content management, discussion forums, quizzes, grading, and collaborative tools. Its interface allows educators to create learning activities while tracking student progress through analytics. Moodle also allows the possibility to integrate different tools or plugins to expand its features [12].

B. Moodle Plugins for Learning Analytics

Several Moodle plugins specialize in providing analytics features, including the *Learning Analytics* plugin; the *Progress Bar* plugin and the *Learning Locker* plugin.

The *Learning Analytics*[3] plugin offers comprehensive reports on how learners are meeting course objectives. By leveraging specific learning goals set within a Moodle course, the plugin gathers data on student progression in achieving those objectives. It provides visualization options like graphs and charts, aiding teachers in understanding student performance and their journey towards meeting these learning goals. This functionality empowers educators with detailed insights, enabling them to tailor teaching strategies and interventions to enhance student learning outcomes effectively.

The *Progress Bar*[4] plugin is widely used in online courses to visualize and track students' progress. Its primary function is to motivate students and maintain their engagement in the learning process. This plugin presents a progress bar that visually represents students' advancement in the course. It offers configurable options to showcase progress based on completed activities, time invested in the course, or other relevant criteria specific to the course content. Alongside displaying student progress, it can also provide additional details such as the expected course completion date or the percentage of completed assignments. This feature-rich tool benefits both students and teachers by enabling the evaluation of student progress and facilitating interventions to enhance performance. Moodle administrators can set criteria determining student progression, enhancing its adaptability and usability within various educational settings.

The *Learning Locker*[5] plugin serves as an open-source repository and analysis system designed to store and analyze learning data within Moodle. Its integration allows users to gather and assess student learning data, facilitating improvements in teaching methodologies and learning outcomes. This plugin operates by centralizing the collection and storage of learning data derived from various sources, encompassing activities within Moodle, surveys, and diverse

[3]https://moodle.org/plugins/local_learning_analytics
[4]https://moodle.org/plugins/block_progress
[5]https://learningpool.com/learning-locker-moodle-plugin-xapi/

assessment types. Using the Experience API (xAPI) format[6], an industry-standard for monitoring online learning activities, *Learning Locker* captures and retains comprehensive learner performance data. This data encompasses executed activities, accomplished objectives, and utilized resources. Once stored within Learning Locker, this learning information is accessible for analysis through different tools. These tools aid in identifying performance patterns, discerning areas of strength and weakness, and monitoring student progress, enhancing educators' capacity to tailor interventions and refine teaching strategies.

C. Analysis of Moodle Data

Moodle allows to capture a wide range of data based on every interaction made by students in the LMS [13]. These data has allowed researchers to explore diverse areas like student engagement, learning behaviors, and the effectiveness of teaching methods using Moodle's extensive dataset. These studies reflect an ongoing quest to derive actionable insights that inform better teaching practices and enhance learning experiences within digital environments.

For instance, the MoodleStat system [14] uses data mining algorithms to examine and assess students' interactions within Moodle, offering teachers valuable insights for enhancing their teaching methods. This system collects data from students' interactions with Moodle, enabling both individual and comprehensive analysis. It categorizes student information based on faculties and courses, examining data on student access and activities. It primarily focuses on analyzing student access and engagement records, organizing data according to different course parameters (such as subject, month, semester, and time of day) and student demographics (gender, age, and academic year).

Moodle itself contains some analytics features: teachers can access various reports, including records of students accesses, activities completed, participation, scores, tests, or comparison between students, for all activities configured and integrated within the Moodle course. Students can also benefit from these integrated features, obtaining information about their results and progress, depending on the configuration established for the activities.

III. Learning Analytics Tools

In this section, we present our two learning analytics tools to analyze progress and results with Moodle LMS data: *GoalTracker*, a Moodle plugin to track progress in course goals, and *MoodPy Analytics*, a Jupyter Notebook tool to analyze obtained results based on Moodle data.

The following subsections detail, for each tool, a general description and its main goals; the design and implementation of the tool; the specific Moodle data used; the evaluation or case studies carried out to test the tool; and, finally, their limitations and future lines of work.

[6]https://adlnet.gov/projects/xapi/

A. First Tool: GoalTracker, Moodle Plugin

1) Description: To increase the information that teachers have during their courses about their students' progress, we developed *GoalTracker*, an integrated plugin for Moodle which displays a visualization of students' progress in the course, and on each of its topics or goals.

The main purpose of the plugin is to provide teachers with near real-time information about the progress achieved by their students in the overall course, as well as on any defined specific goal. For that, the plugin facilitates teachers' monitoring, assignment, and creation of goals and tasks to be able to carry out the visualization of students' progress. With the features included in the plugin, teachers can define different goals for their courses, assign different pre-defined Moodle activities to contribute to those objectives, and automatically obtain the corresponding information on progress achieved by their students in those goals.

2) Design and Implementation: The design of the plugin *GoalTracker* was established to be simple enough so that teachers could easily understand its parts and use it without any previous technological background. Consequently, the plugin design includes a simple interface with minimum tasks for teachers to define goals and assign Moodle activities to contribute towards the progress of such goals.

The plugin was developed to be integrated into the Moodle LMS, therefore using PHP, JavaScript, HTML and CSS. Indeed, the plugin was integrated with the Moodle educational platform using the platform's development framework.

3) Use of Moodle Data: The plugin uses Moodle data from the predefined activities: quizzes and assignments. Quizzes are automatically ranked by Moodle (based on their configuration), while assignments are evaluated by teachers through the platform. In both cases, if the quiz or assignment has been passed, it will contribute to the corresponding goal.

a) Teachers visualization: Fig. 1 shows the main view for teachers of the Moodle Plugin. From that view, we can access three different options:

- The first option "List students progress" displays all students and their progress per course goal, as well as an overall average progress per course goal and for all the course. The information is displayed in a Table as depicted in Fig. 2.
- The second option "Create goal" allows teachers to add a new course goal (Fig. 3) by providing a name, and a course to assign the goal to (by default, it shows the current course).
- The final option "Assign task to goal" allows teachers to assign an activity to a course goal, by selecting a goal (from the list of predefined goals), an activity (from the list of activities available in the current course), and a weight for the task (Fig. 4).

b) Students visualization: In addition to teachers' side, the plugin has an interface for students as well. This interface provides students with a visualization of their individual progress, as well as a comparison with their peers, in each of the goals created by the teacher (Fig. 5).

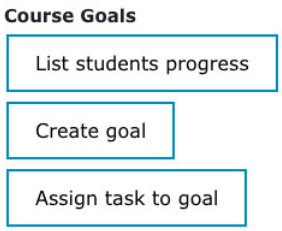

Fig. 1. Moodle Plugin: teacher view, main page.

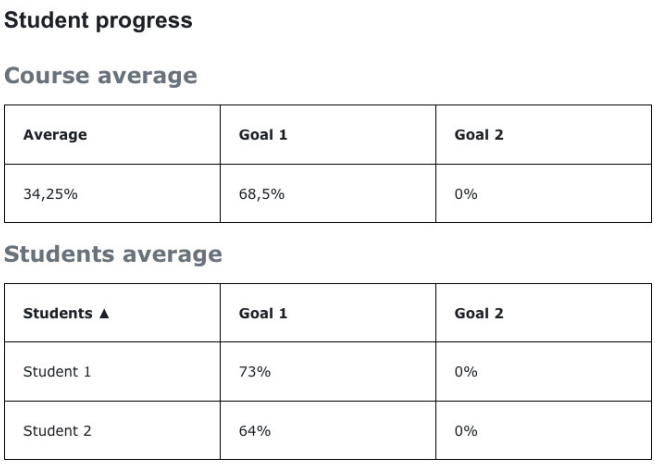

Fig. 2. Moodle Plugin: teacher view, progress of students.

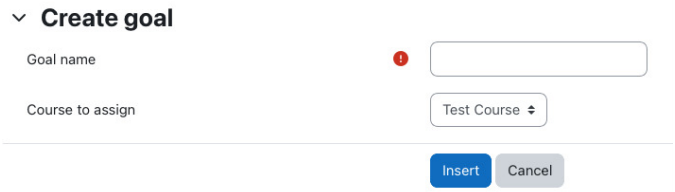

Fig. 3. Moodle Plugin: teacher view, progress of students.

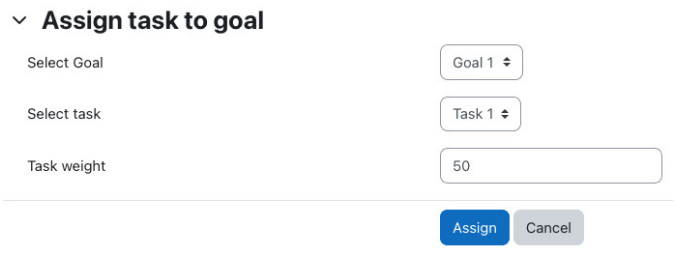

Fig. 4. Moodle Plugin: teacher view, progress of students.

This way, students can also receive information about their achieved progress in the course as well as on each of the defined goals. For each goal and the whole course, each student will see both their individual progress and the average achieved by all students in his/her group. The goals displayed in the visualization have been previously created by the teacher. The progress in each goal and the course are automatically updated depending on whether the course teacher approves the activities or quizzes performed by the student. As the teacher adds new goals, they will also appear in the student's visualization.

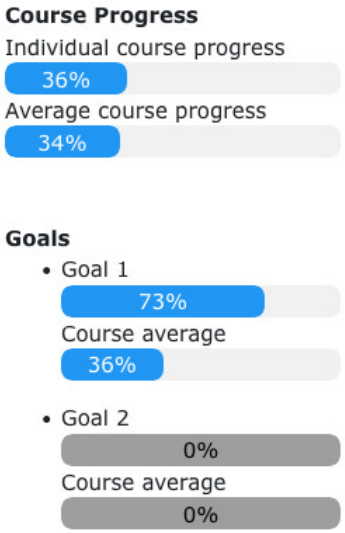

Fig. 5. Moodle Plugin: student view.

4) Evaluation: After its integration with the latest version of the Moodle LMS, the plugin has been tested to ensure its quality and functionality, including unit coding tests to verify the performance.

The plugin is currently undergoing an initial evaluation by an expert group of at least 5 teachers (experts in the fields of computer science, data analysis and visualization, learning analytics tools, and technology-enhanced learning) for usability and understandability, to obtain feedback to improve it before its large-scale application.

5) Limitations and Future Work: The main limitation encountered during the development of the plugin *GoalTracker* was the impossibility to complete its integration with the University Moodle LMS due to privacy regulations and concerns. After developing and testing the plugin with Moodle, we contacted the University Moodle coordinator to start the integration of *GoalTracker*. The coordinator explained the lack of new plugins being integrated into the University Moodle LMS, due to the use of student data that required many privacy regulations that could not be ensured with new developed plugins. To begin with, the process to integrate a new plugin into the University LMS required a previous evaluation by the

Moodle community and its publication in the official Moodle plugin repository, which has not yet been possible to complete.

As such, we plan to continue the expert evaluation of the plugin to develop any needed updates and improvements before its publication, in the long-term hope of reaching an integration of the plugin with the University Moodle LMS.

The latest version of *GoalTracker* is available at the following GitHub page: https://github.com/la-tools/GoalTracker.

B. Second Tool: MoodPy Analytics, Analytics Jupyter Notebook Tool

1) Description: To obtain relevant information from the large amount of Moodle interaction data, we developed *MoodPy Analytics*, a tool to process, analyze and present visual results from Moodle data. The gathered Moodle data can provide teachers with useful information that allows them to have a better understanding of the behavior and work of students so that they can improve their teaching practice and adapt it to their students' learning process.

The tool focuses on two types of Moodle reports: the results of quizzes, and the access logs. From those data logs, we can identify three elements that allow us to organize the information that the tool works with. The main element is the students, who are identified by a name or other identifier (e.g., mail address) with which they can be recognized in the tool. Each student will have the associated information that he/she has generated by interacting with the different Moodle resources. From the quiz logs, we have the corresponding information of each of the attempts made by the students, as well as the results and information related to that attempt. The general logs correspond to and collect the information on each of the events generated by students accessing each element available in the Moodle page.

2) Design and Implementation: For the analysis of Moodle data, we developed the analytics tool using Jupyter Notebooks. This tool allows the analysis and representation of data through different visualizations so that teachers can carry out detailed monitoring of student progress, as well as detect patterns in their work and performance.

The design of the tool follows the Jupyter Notebooks interface, coded in Python, in which each cell allows interaction from the user, therefore allowing a waterfall process of reading, analyzing, and obtaining results visualizations of the data.

The first step is the data read. For that purpose, *MoodPy Analytics* allows to select different data files from the user file system to be uploaded to the tool. These files are expected to have the default format in which Moodle allows to download the data. Fig. 6 shows the reading of data in the Analytics Jupyter Notebook tool: users can select multiple files from their local file system, providing a name for each of them (e.g., the course topic the data file corresponds to).

Next, the tool allows to configure different analyses, based on the information available in the Moodle data, including the possibility to compare information from different groups, filter by date ranges, and personalize the result visualizations.

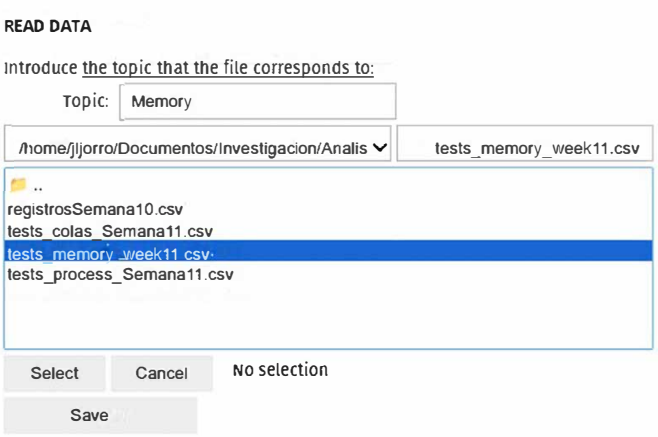

Fig. 6. Analytics Notebook tool: data processing.

Fig. 7 shows an example of the available configuration for the analytics Jupyter Notebook tool to provide a student ranking. This particular configuration includes selection of dates, students, and criteria to create the ranking for (average score, participation, passes, and percentage of passes).

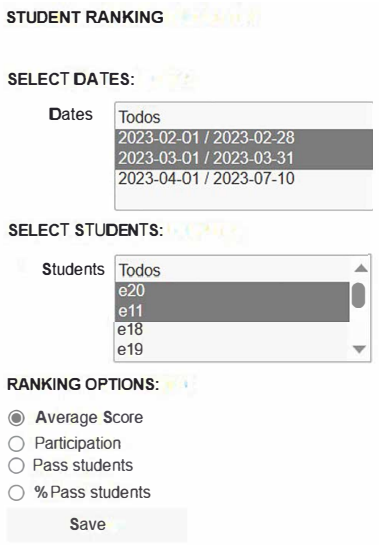

Fig. 7. Analytics Notebook tool: configuration.

Regarding the implementation, *MoodPy Analytics* is organized in different modules (Python files with `.py` extension), favoring the logic and maintenance of the program. These modules are integrated into and connected to the general Jupyter Notebook document that serves as a representation of the developed tool allowing the analysis and visualization of data automatically. By importing the modules we can access the defined classes and functions avoiding the duplication of code and facilitating the development of the project. In addition, it allows to hide the implementation details in a transparent way to the users.

3) Use of Moodle Data: As stated above, the *MoodPy Analytics* tool uses two types of reports: Moodle quiz activities

and Moodle data logs.

a) Moodle quiz activities: The first report collects, for a Moodle quiz activity, the results for each of the attempts made by the students, capturing the identifier of the student who has completed the activity, the status (whether the attempt has been completed or not), the start date, the end date, the time spent in completing it, the total grade and the grade for each of the questions of the quiz.

Moodle data logs. The general logs collect the actions carried out by the student interacting with the material and resources provided by the teachers, reporting the date and time at which the event occurred, the student who triggered it, the context, the component, the name, the description of the event, the origin and the IP address from which it was generated.

4) Evaluation: To test its efficiency and improve the level of adaptation of the tool to teachers' needs, we have conducted an initial case study with data obtained from Moodle from two practice groups of a university course (40 students). The tool has allowed to obtain information of students' progress and results and to compare both course groups.

To carry out the case study, we proposed and developed the tool *MoodPy Analytics* for the analysis and visualization of the data on the platform that allows teachers to compare the performance and participation of two groups of students. During a semester, data was gathered weekly from Moodle for both groups, including both general logs data and logs from a set of quiz activities containing review questions for each course topic. All data was then imported into *MoodPy Analytics*, further allowing to detect bugs early and correct them.

The information presented by the tool allowed us to compare results of both practice groups, regarding their participation in the different activities, as well as their results. Additionally, the case study allowed us to detect errors and improvements that were incorporated during the final development of the tool.

Fig. 8 shows an example visualization created with *MoodPy Analytics*, depicting the average score obtained for several topics.

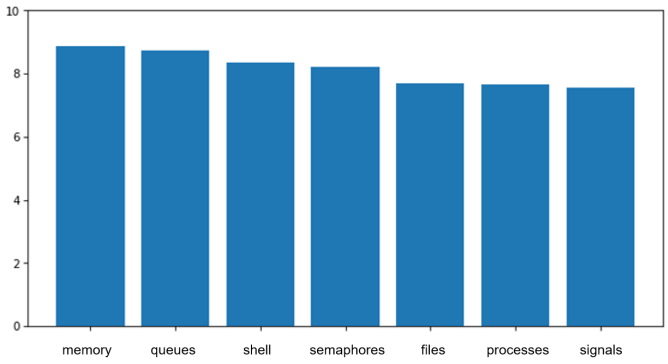

Fig. 8. Analytics Notebook tool: example visualization.

5) Limitations and Future Work: The current analytics notebook has a limited range of Moodle activities included, providing analyses and visualizations particular only to those activities. In addition, it is currently an external tool, not integrated with Moodle, possibly limiting its use for teachers, who may be more willing to work with a tool already embedded into their known teaching environment (the Moodle LMS).

Therefore, as future lines of work, it would be interesting to explore the possibility to integrate this tool in the Moodle LMS, or at least connect it as an external source accessible through Moodle. If possible, it would also be desirable to automatically connect the data gathered in Moodle with the tool, so that teachers do not need to download the data from Moodle to later import it to *MoodPy Analytics*. We consider that its connection with the Moodle LMS could expand its usage by the teachers. The range of analyses and visualizations included in the tool could be further expanded and improved, also analyzing data from different Moodle activities. With these additions, we also plan to test the tool with other datasets from a larger set of students and from different Moodle courses.

The latest version of *MoodPy Analytics* is available at the following GitHub page: https://github.com/la-tools/MoodPyAnalytics.

IV. Conclusions

The use of learning analytics has spread across different platforms and domains, including LMSs commonly used in education, particularly in higher education. The frequent use of these tools in day-to-day teaching facilitates the emergence of a large number of interactions that are automatically collected by the LMSs and whose potential is not always leveraged.

The two tools presented in this paper aim to use the potential of LMS learning analytics data exploring different possibilities of the large amount of data generated by students' interactions with the Moodle LMS, one of the most commonly used LMSs in universities.

The first presented tool, the Moodle Plugin *GoalTracker*, allows teachers to have near real-time information about the progress achieved by their students in their courses as well as in different course topics, while allowing to filter that information to obtain detailed data about individual students. In addition, the plugin also has a student interface so that students can also receive information about their individual progress and comparison with their classmates.

The second tool, the Jupyter notebook analytics tool *MoodPy Analytics*, allows for a richer analysis of students' actions and progress. By allowing to process different information from various data logs automatically available in Moodle, the tool presents a serious of default analyses and visualizations that teachers can automatically obtain. With its configuration options, teachers can also personalize the result information, comparing different data ranges, obtaining general information or filtering by particular students, and customizing the final visualizations.

Combined, both contributions can enrich the information that teachers have during and after a university course, adapting their classes to better fit students' progress and needs,

as well as providing overall results and comparison between groups after the course has finished.

We plan to continue developing and improving both tools, particularly testing the Moodle plugin and integrating it with the University Moodle, while adding additional features to the Analytics tool. With the results and feedback gathered from the validations carried out, we plan to extend and improve both tools and to continue their large-scale integration into university courses with the ultimate goal to help teachers during their teaching process.

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