

# Learning Analytics: Supporting Teaching and Learning through Learner's Data Analytics and Visualization

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**Abstract**— This paper reports on the design and development of a new learning analytics application for the Moodle learning management system. The uniqueness of this application lies in its ability to provide transparent access to learner's data interaction for both instructors and students. This application allows instructors to monitor their students' online learning activities, interaction and performance and facilitates the provision of personalized and enhanced advice to students. It also provides students with new visual and analytical tools and opportunities to regularly manage their learning activities and interactions in order to be able to compare their performance with their peers in an ongoing and real time manner. This paper addresses the target analytics conference theme.

**Keywords**— Learning analytics; learner's big data; visualization; data analytics; learning management systems.

## I. INTRODUCTION

The widespread development of online teaching and learning and the introduction of numerous online courses and programs have presented new challenges and opportunities for the institutes of higher learning to develop and apply new ways and tools for monitoring and evaluating online teaching and learning. Terms such as educational data mining, academic analytics and more commonly adopted term 'learning analytics' have been used in the literature to refer to the methods, tools and techniques for gathering very large online data about learners and their activities and contexts. The first International Conference on Learning Analytics and Knowledge (LAK 2011) [1] defines learning analytics as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs". Clow [2] provides a learning analytics life cycle to conceptualize successful learning analytics work, including four key components, namely learners, data, metrics, interventions. Learner means a student who may take an online course or courses that make use of a learning management system. The second step in the cycle is the generation and capture of data about or by the learners, including login and clickstream data. The metrics stage refers to the processing of data using various metrics, examples of which may include visualization, dashboards, list of at-risk students, comparison with previous cohorts, etc. The final stage of the cycle refers to, for instance, dashboards for learners in order for them to be able to compare their activities with their peers or previous cohorts, etc.

The advantages of learning analytics have been enumerated by Siemens et al. [3] and Siemens and Long [4], some of the important ones include:

- Early detection of at-risk students and generating alerts for learners and educators
- Personalize and adapt learning process and content
- Extend and enhance learner achievement, motivation, and confidence by providing learners with timely information about their performance and that of their peers
- Higher quality learning design and improved curriculum development
- Interactive visualizations of complex information will give learners and educators the ability to "zoom in" or "zoom out" on data sets,
- More rapid achievement of learning goals by giving learners access to tools that help them to evaluate their progress

A recent report on the state of learning analytics concludes that there is widespread interest, both within the academic community and beyond, in learning analytics and the possibilities they offer for tailoring educational opportunities to each learner's level of need and ability [5].

## II. CONETXT AND PRIOR RESEARCH

There have been a number of learning analytics tools developed for various learning management systems, such as Moodle, Desire2Learn, Canvas and Blackboard. There are two general categories of learning analytics tools. The first category is exclusively designed to be used by instructors and course designers with features and functionalities for analyzing and visualizing data related to student activities. The second category provides additional features and functionalities for students, as well as instructors with access to learners' interaction and activity data. A significant number of these learning analytics tools are open source applications, some of which are still being developed and others have not been kept up to date. In the following, a review of ongoing and useful projects is presented.

SNAPP (Social Networks Adapting Pedagogical Practice) is a browser plugin that has limited functionality and creates social network diagrams that can be used to identify isolated students, network patterns and interaction occurring between student participants. This tool allows

instructors to evaluate student behavioral patterns against learning activity, design objectives and intervene as required in a timely manner [6]. It can be used within Moodle, Blackboard, and Desire2Learn.

The Moodle Analytics and Recommendations block is a small scale project that uses colour coded charts and tables to allow students to quickly view their participation. Teachers are able to view single, comparative analytics and global analytics. This block is not currently maintained up to date or supported [7].

LOCO-Analyst is an open source educational tool that provides teachers with feedback regarding student activities and usage. The application does not provide any features and functionalities for students to compare their learning data with their peers. This application is still being developed [8].

GISMO (Graphical Interactive Student Monitoring Tool for Moodle) is a graphical interactive monitoring tool that provides useful visualization of students' activities in online courses to instructors. Using GISMO instructors can examine students' attendance, reading of materials, and submission of assignments. While GISMO is designed to work with Moodle, the version available is not compatible with University of Alberta eClass platform. Another major limitation of the application is that GISMO focuses mainly on instructors and there is very limited functionality for students to be able to use the system and interact with their own data [9].

The Academic Analytic Tool (AAT) is an open source ongoing project at the Athabasca University, which allows instructors to access and analyze student behaviour data in learning systems. It enables them to extract detailed information about how students interact with and learn from online courses, to analyze the extracted data, and to store the results in a database and/or CSV/HTML files. While AAT is compatible with Moodle, it has primarily been developed for learning designers [10].

In addition to the above applications, there are other learning analytic tools developed for Blackboard, Desire2Learn and Canvas. The main point is that learning analytics are becoming an integral and expected component of learning management systems. In this paper we report on the design and development of a learning analytics application for eClass, a learning management system that is based on Moodle and is currently used by the University of Alberta in Canada and many universities around the world. This new application provides learning analytics functionalities for both students and instructors and given that it is created for an open source learning management system, it can be adopted by other universities and colleges that use Moodle as their learning management system. Course and learning management systems such as Moodle hold very large data sets related to student interactions and

activities. However, student tracking capabilities in these systems are usually limited and as a result the depth of extraction and aggregation, reporting and visualization functionality of these built-in analytics has often been basic or non-existent [11]. While Moodle has reporting functions for students and instructors, these functionalities are not easy to use. For instance, Moodle data can be downloaded as an Excel file, but it still requires analysis in order to be useful for students and instructors. The University of Alberta eClass environment does not currently have learning analytics tools to provide support for analyzing, visualizing and making sense of very large student and instructor activities datasets. The eClass reporting features and logs provide only limited and basic level data, such as time, IP address, course view, forum view, resource view, and actions such as 'add', 'delete', 'view' for forum or blog posts. These data points are presented separately from one another, with no analytical, comparative or visual functionality to allow for a real time understanding of the individual and class performance. Therefore, instructors are not able to use these data points in a multidimensional way to make detailed and comparative inferences about student activities and interactions within one particular course activity or across the entire course content. For instance, it is not possible for an instructor to a) comparatively and visually identify the most frequently used resources within a course, b) detect the kinds of resources used by high performing students in class, or c) identify the nature of course materials not used by low and average performing students. The overarching goal of the analytical tool reported here is to facilitate access to and making sense of learning data for students and instructors.

### III. METHODOLOGY

This project will draw upon [2] learning analytics life cycle to design an application that will support the four stages of the learning analytics life cycle, namely learner, data, metrics and interventions. The learning analytics tool that will be designed in this project will support both instructors and students and will be compatible with the eClass environment. Moodle databases collect large multidimensional data files from student activities, clickthrough data, access to various digital objects, history of pages viewed, number of hits for each day of the course. However, this data is available in a tabular format and it is very difficult to understand the structure and organization of data or to be able to make sense of various types of data collected. The learning analytics tool that is developed in this project will provide the following key components:

- Data repository: Data collection and amalgamation
- Data transformation mechanism to organize and cluster raw data
- Data processing to support large data analysis

- Data and information visualization functionalities to visualize and demonstrate individual and comparative views of the following data points:
  - Logins
  - Submissions
  - Interaction with learning objects (resources accessed and frequency)
    - Frequently used content and media
  - Interaction with discussion forums, lessons, quizzes etc.
  - Student interaction and social networks
  - Blog and discussion forum analysis and visualization
  - Time spent (on individual pages, on average, across the course, etc.)
  - Detection of low, average and high performing students

The application makes use of a broad range of technologies, including PHP (Hypertext Preprocessor) and MySQL (Structured Query Language), information visualization technologies, and text and data analysis tools.

#### IV. LEARNING ANALYTICS TOOL FUNCTIONALITIES

The following graphs will depict a number of screenshots of our newly developed learning analytics application. The screenshots provide visual representation of learner’s data analyzed using our application.

##### A. Visual dashboard for engagement data

Our application provides a number of features to analyze and visualize content engagement, forum engagement, forum usage over time and events by user over time. Fig. 1 shows an example of a graph that depicts students’ engagement data across a number of activities, such as visiting various course webpages, interacting with forums, files or blocks.

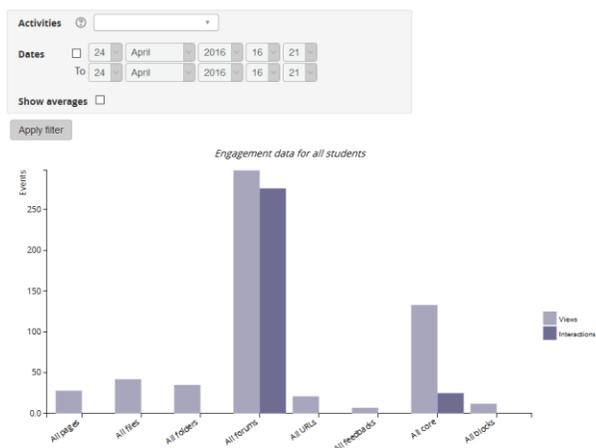


Figure 1. Visual dashboard for engagement data

Through this graph students are able to visually identify how students within a class have viewed and interacted with different parts and components of a course. It also allows individual students to choose a particular time range to view their own engagement and activities for the time period.

Fig. 2 provides a longitudinal view of engagement data for students. This functionality allows for a holistic view of all activities over a certain period of time. They can also choose a particular activity, such as contributing to a forum or blog and view how they have been using or interacting with the forum over time. This feature allows them to keep track of their own use of various learning objects over the period of a semester.

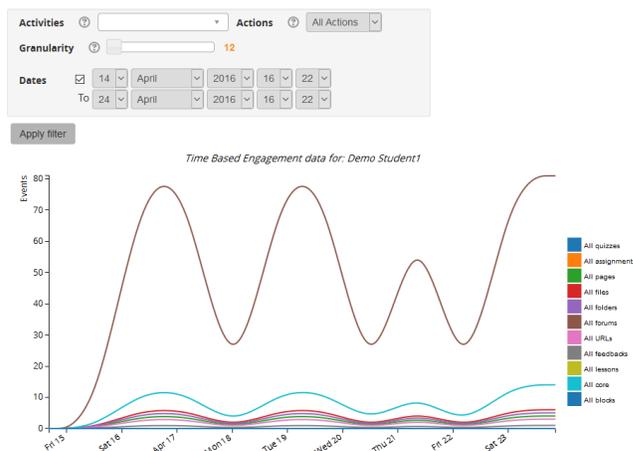


Figure 2. Time-based engagement data

The granularity function shown in Fig. 3 allows students to narrow down the timeline to days and hours. This function will be useful for identifying how active students are before or after a particular quiz.

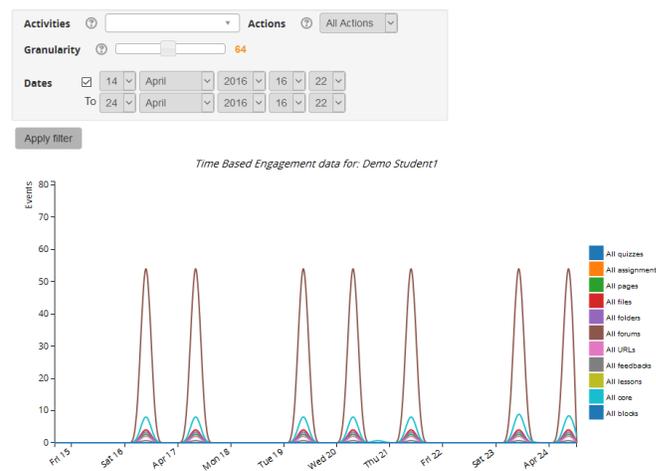


Figure 3. Time-based granularity for learning objects

B. Visual dashboard for weekly discussion and selected students

In order to allow students to gain a collective perspective of performance within a class, engagement data for all students are shown in Fig. 4. This graph is useful for instructors and students to quickly and visually see how students contribute to a discussion forum across several weeks.

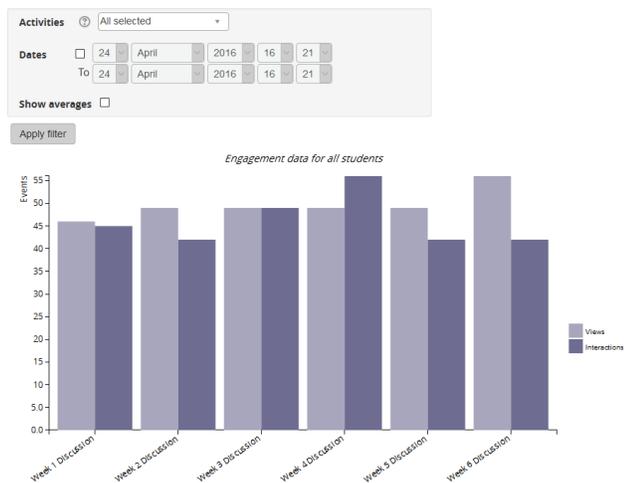


Figure 4. Weekly discussion engagement data for all students

Fig. 5 allows a student to gain a comparative perspective of how other students on average interacted with course content and where she stands.

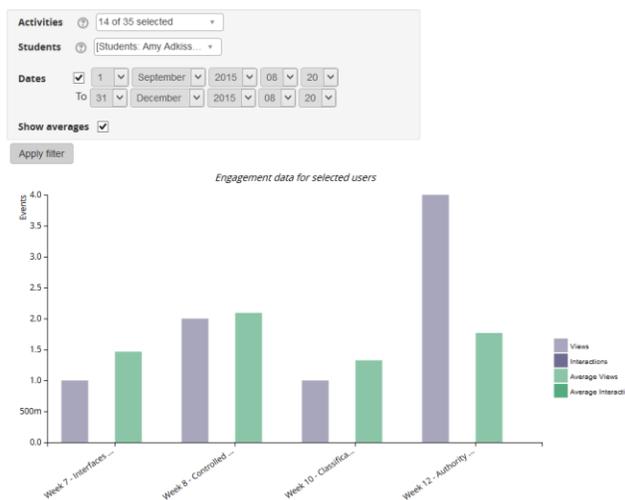


Figure 5. Engagement data for selected students across weeks

This will allow a student to see the level of engagement on the part of her fellow students.

V. CONCLUSION

The learning analytics tool that was reported in this paper provides a useful tool for universities and colleges that make use of the Moodle learning management system. This application supports instructors and students in monitoring learning and teaching activities and provides ways in which instructors can offer personalized and enhanced advice to students. The tool has the potential to be expanded to include department-level and campus-wide evaluation of learning and teaching to facilitate prediction, adaptation, personalization and intervention in the learning process.

For instance, at the department level, first year undergraduate courses with large enrollment can benefit from student engagement data analysis and visualization to allow the department to assess the usefulness of various learning objects and resources for a particular course. Further development of this application will focus on text analysis and visualization tools that will support instructors to create quick visual representations of large discussion forum data. We are currently conducting usability evaluation with students and instructors from a wide variety of disciplines to assess the ease of use, learnability and usability of our learning analytics tool. An initial analysis of the usability study data indicates a number of areas for further refinement of the tool, including the terminology used on the interface (e.g. views vs. interactions), analytical tools for the textual data on discussion forums, and ways to triangulate data with grades. Once the tool is finalized it will be shared openly with those using the Moodle system.

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