Behaviour Analytics - A Moodle Plug-in to Visualize Students' Learning Patterns

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Abstract. Learning Management System (LMS) is widely used in higher education. How to track students' learning behaviours in a LMS like Moodle becomes an important issue. This research designs a Moodle plug-in that not only can visualize students' learning behaviour patterns from the log but also can cluster students into different groups based on their patterns. Teachers can easily see how students went through one learning object to another; review the common learning pattern that students in the same group have; and, annotate the learning pattern a group or an individual student has based on his or her observations on the pattern's details. The annotations made by the teacher can be a support for researchers to further analyse and design mechanism and algorithm to automatic recognize and identify a student's characteristics and conditions like learning styles, preferences, at-risk, and potential required assistances via the features extracted from a learning pattern and notify the teacher or administrative staff automatically.

Keywords: Behaviour Analysis, Pattern, Clustering, Learning Management System, Visualization, Learning Path, Graph Theory.

1 Introduction

Based on Papamitsiou and Economides' study, most of the learning analytics are using classification or clustering methods [4]; only a few studies are working on visualizing students' learning behaviours. Graph structure is also used for representing learning objects in the learning environments. For example, Cui and Yu uses a knowledge graph tool in the Learning Cell System and ask students to create the knowledge graph based on the relations among the learning cells [1]. This research's goal is to design a Moodle plug-in that can visualize the relations among the learning objects and activities in a Moodle course as well as visualize the students' learning behaviours of accessing particular learning objects in the course. Moreover, the plug-in is capable of clustering students into different groups based on their learning behaviour patterns.

The rest of the paper is organized as following. The methods of generating knowledge structures and representing the learning behaviour in the LMS in this study are explained in Section 2. Section 3 demonstrates the Moodle plug-in the research

2

team has designed based on the proposed methods. At the end, the summary of the works in this research and the proposed future works are described in Section 4.

2   Research Method

Teachers usually organize the learning resources/activities in sections. The plug-in designed in this study retrieves the section information to group the resources/activities and create a graph structure. Fig. 1 shows an example of how to organize the learning resources/activities in a graph structure. In the example a course has two sections: the section "Topic 1" has two webpages and one assignment, and the section "Topic 2" has two webpages. The plug-in constructs a graph with three nodes for sections, four nodes for webpages, and one node for the assignment. The learning resources/activities are directly linked to the section they belong to.
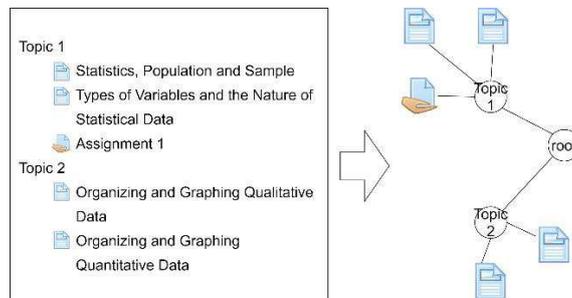
Fig. 1. A graph structure constructed from the learning resources/activities in a course.

At next stage, the plug-in retrieves students' learning behaviours from the Moodle log and generate the graph structure. For example, Fig. 2 shows that Amy prefers to work on the assignment first and then walks through the materials; on the other hand, Betty likes to read the materials in the beginning and at the end she works on the assignment. Their behaviours generate different learning paths.
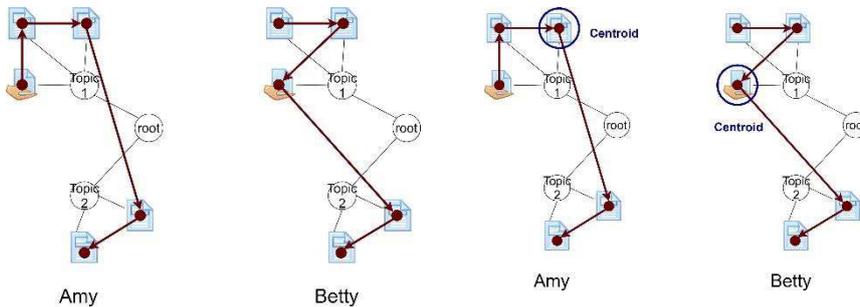

Fig. 2. Learning paths of two students.   **Fig. 3.** Centers of the two learning paths

After students' learning paths are discovered, the teacher can use the plug-in to cluster students into different number of groups according to his or her needs. This research uses centroid subgraph [5] based on the centroid decomposition [2] to find the center of a learning path. The centers of Amy and Betty's learning path in previous example then can be found in Fig. 3.

The learning path centroids' coordinates are used to present students' learning behaviours. The plug-in uses k-means algorithm [3] to cluster students. Based on the design, the research team developed the Moodle plug-in, Behaviour Analytics, for showing teachers their students' learning behaviours in their Moodle courses as well as the common behaviour patterns that different student groups have.

3   Behaviour Analytics Moodle plug-in

After Moodle system administrator installs the Behaviour Analytics plug-in, the course teacher could enable the plug-in through the course management interface. Fig. 4 shows the page that displaying the relations among learning resources and activity. The node colors represent the different types of resources/activities in the course. When moving the cursor over a node in the graph, the plug-in shows which learning object the teacher is looking at. It would be helpful when the teacher reviews his or her students' learning behaviours. If the teacher believes a learning resource/activity in the course is not useful for clustering students' behaviours, he or she can remove the node from the graph by unchecking the resource/activity at the right-hand side panel or simply clicking the node and choose to hide it.
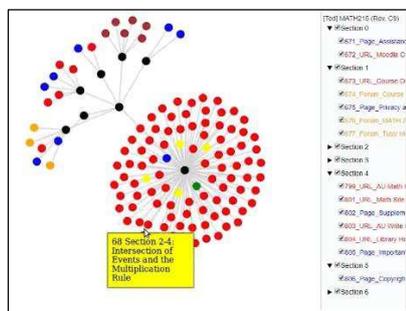
Fig. 4. Graph representation of the relations among learning objects in a course.
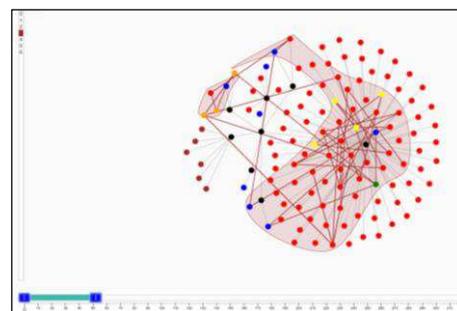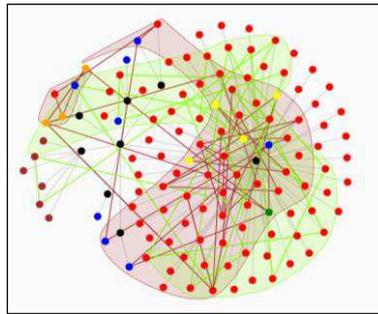
Fig. 5. Student's learning behaviours and the correspondent learning-object coverage.

Teachers can also review students' behavior through the plug-in as Fig. 5 shows. At left-hand side of the page, the plug-in lists all of the students (with anonymous number) and hides students' information in order to protect student privacy. The teacher can select one (or more) student(s) to check their correspondent learning behaviours. The plug-in not only shows the learning behaviours of selected student(s) but also presents the learning resources/activities coverage for the selected student(s). The teacher can also review the learning behaviours in a specific time period by adjusting the timeline

4

slider at the bottom. When the teacher selects more than one student as Fig. 6 shows, he or she can compare the learning resources/activities coverages among them easily in the plug-in.


Fig. 6. Comparing two students' learning behaviours and their learning-object coverages.

At the next stage, the teacher can use the plug-in to cluster students into groups. As Fig. 7(a) shows, the plug-in first finds the centroids of students' learning behaviours with triangles symbols in different colors. The teacher can decide how many groups he or she would like the plug-in to group students. When the teacher decides to cluster the students into three groups – assuming each group will have significant different academic achievements, learning preferences, learning styles, or personality traits, the plug-in randomly puts three cluster centers (i.e., the cross symbols in different colors) on the plane as shown in Fig. 7(a). After a few runs, student #0, #1, #2, #3, and #5 are clustered into the same group which is presented by the blue cross; student #4 (i.e., the dark green triangle) is clustered into another group presented by the red cross; the last group presented by the orange cross includes student #6 (i.e., the orange triangle) as Fig. 7(b) shows.

(a)   (b)
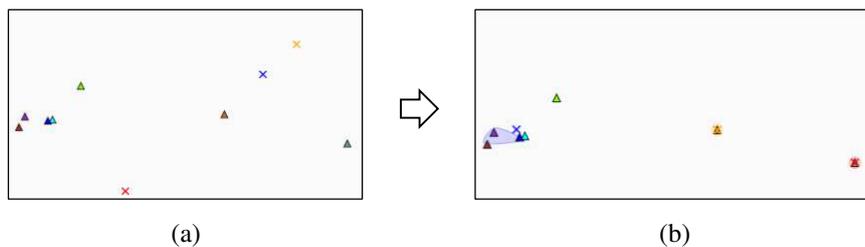
Fig. 7. Clustering students' learning behaviours into three groups.

The teacher can still review a student's learning behaviour at this moment. Fig. 8 shows student #1's learning behaviour in the center of the screen when the teacher moves the mouse cursor over the dark blue triangle. The teacher can also move the mouse cursor over other triangles to see the differences.
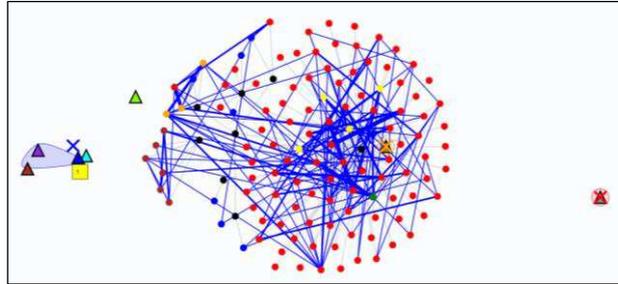
Fig. 8. Moving cursor over a student (i.e., a triangle) to see his/her learning behaviours.

The teacher can also check the common learning behaviour pattern that students in the same group have. Fig. 9 shows the common learning behaviour pattern that the group of students #0, #1, #2, #3, and #5 has, when the teacher moves the mouse cursor over the blue cross on the screen. When the teacher clicks the blue cross, he or she can add a note into the plug-in for the group based on his or her observation and thoughts on the group's learning behaviour pattern; for instance, he or she may identify that some learning objects or activities are always overlooked by this group of students. He or she can also do the same for individual student by clicking any triangle. After he or she reviews all students' learning behaviours in a group, the teacher can easily drag the triangle from one group and drop it to another one if he or she believes any of the students should be classified into another group.
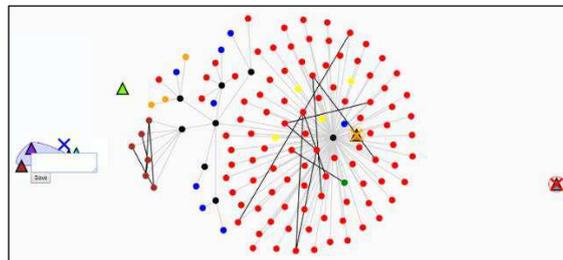
Fig. 9. Blue cross group's common learning behaviour pattern and the note taking textbox for the teacher.

4 Conclusion

This research designs a graph-based student behaviour representation and analysis Moodle plug-in. The plug-in first analyzes the relations among learning resources/activities in a Moodle course and then constructs the graph structure for the resources/activities. The plug-in next retrieves the students' learning behaviours from Moodle log and visualizes students' learning behaviours and the correspondent learning object coverage in graph. To cluster students into groups based on their learning behaviours, the plug-in uses centroid subgraph algorithm to find the centroids of the learning paths and

6

applies k-means algorithm to cluster students after the teachers decide how many groups they would like to divide students into. The plug-in has been reviewed and approved by Moodle community on September 22, 2020 and can be found, downloaded, and installed from Moodle plug-in repository. As of January 6, 2021 (i.e., in three and half months), it has been downloaded 127 times and installed in 72 Moodle sites around the world.

This research has some limitations. First, the learning resources/activities graph structure is based on the section organization in the Moodle course. If a course doesn't have its materials organized in sections, the learning resources/activities will be formed as a one-level tree structure. Another limitation is that the plug-in currently uses the centroids coordinates of learning behaviour patterns to cluster students into groups. When teachers change the positions of nodes in the learning resources/activities graph, it might also affect the clustering results. It is better to arrange the learning resources/activities nodes in a more meaningful and reasonable way automatically based on the relationship among the nodes.

To overcome both above-mentioned limitations, nature language processing could be considered in analyzing the content and/or meta-data of the resources/activities to construct a more meaningful graph. Currently the research team is developing the LORD (Learning Object Relation Discovery) Moodle plug-in with the help of WordNet and Natural Language Processing. The LORD plug-in can measure the similarity between two learning objects according to their content in English and create a more reasonable and objective Learning Object Graph (LOG) that represents students' behaviours among learning objects.

Last but not the least, the research team plans to analyze the annotations that the professors made for the common learning behaviour patterns according to their observations and thoughts. Based on the analysis results, a mechanism could be designed to recognize and identify the features from students' learning behaviours. The plug-in then can provide teachers more information about their students and remind them when specific learning behaviour traces/features are detected.

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