Learning Analytics Dashboard for Monitoring Students' Free-Practice Learning Activity

Independent Study

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Dec 7, 2020

1. Introduction

Currently, hybrid instruction models are being adopted by many universities, which have led to the generation of different types of learning data, including assignments, lab activities and students' free practice. However, it is hard for instructors to analyze their students' learning status given the large amount of data.

In this study, I designed the prototype of an interactive dashboard system where instructors can check students' progress in non-mandatory learning activities to quickly estimate their learning status.

In this study, I followed a user-centered design approach for determining the features that a group of programming instructors prioritized to have in a learning analytics dashboard. I delivered a survey prepared based on existing learning analytics literature. Based on the collected requirements, I designed a prototype that aggregates the real-time information about success rate, attempts count and estimated knowledge level at two levels of granularity: per week and per topic within the course. To show how multi-variables affect students' learning performances jointly, the dashboard uses the different sizes and colors in a dot matrix to show different learning statuses. A radar graph is adopted to display detailed multivariate data so that instructors can understand the weaknesses and strengths of specific students and the whole class on average.

2. Survey

Survey section focuses on gaining some information and real needs from the real instructors. I divided the survey into three categories, background questions, class-related questions, and student-related questions.

The background information includes age, gender, school/institute, teaching year, teaching courses/labs, etc. Based on current data, the courses they have been taught are basically programming-related courses. And around 88% of them have more than 40 students for each course, which may inflect that instructors can hardly know their students' background of specific course or learning status in detail. As for the current pedagogical actions they use for their programming course, all of them use homework assignments, and almost 90% of them use online programming practice system. Meanwhile, over half of them adopts lab sessions, online lectures and flipped classroom to help teaching. In this way, I can know that analyzing data for homework assignment and online programming problems is essential to help instructors better understand students' learning status.

The common strategy instructors adopt when a student ask for help is discussing the problem, analyzing the responses with student via mail or in-person. Most of them are confident about current strategy about solving students' problem.

More than half of instructors have used learning analytics dashboard before and fount it helpful. And most of them have confident in interpreting students' & classes' progress by using learning analytics dashboard. Half of them think it is somewhat easy to access the knowledge of class and students. Most of instructors find it difficult to gain information about the error students made and misconceptions through dashboard.

In class-related questions section, I evaluated what type of support instructors would like to have on their teaching duties. Top 5 actions related to the whole class instructors would like to involve is:

1. Identifying who are the students at-risk (i.e., low performers)

2. Detecting the most common mistakes the overall class is making when solving the learning activities

3. Identifying the concepts (i.e., modulus, substring, if-else, for loop, etc.) that are being hard for students to grasp

4. Identifying subgroups of students facing similar problems in their learning process

5. Exploring the most common responses submitted by students on each problem.

From this, I can assume that the main goal for designing teacher dashboard system is to help instructor quickly locate some important features of students, such as common mistakes, misconceptions, time spent common responses, similar problems, so they can quickly alter student when they are at-risk.

In the student-related question part, I designed questions to find out what the most common way for instructors is to identify students at risk. Based on their feedback, there are 5 most important features: current score, estimated level of knowledge at conceptual level, number of attempts, overall success rate and number of mistakes.

Also, I evaluated top 5 information that can help instructors better understand students' learning status: attempts, common mistakes, number of mistakes , overall success rate and current score.

I also found out that most (over 70%) of instructors think learning analytics dashboard should focus on most recent progress of students, which is last couple days or weeks. And over a half of instructors think it may be helpful to also aggregate student performances by academic topics.

3. Prototype

Based on the feedback from instructors, I designed the structure and functionality of the system:

1. Aggregate and show information in both week and topic unit.

2. Use Matrix Dot Graph to show multi-variables jointly. Use size and colors of each dot in the dot matrix to show different learning status. In dot matrix, each row represents each week, and each column represents each student.

3. Features include attempts, common mistakes, overall success rate, estimated knowledge level and misconception.

4. Use Radar graph to show weakness and strengths of students and whole class.

5. Use filter column to let instructors find specific student quickly especially in a very large class.

The following figure shows the main hub of system in prototype:

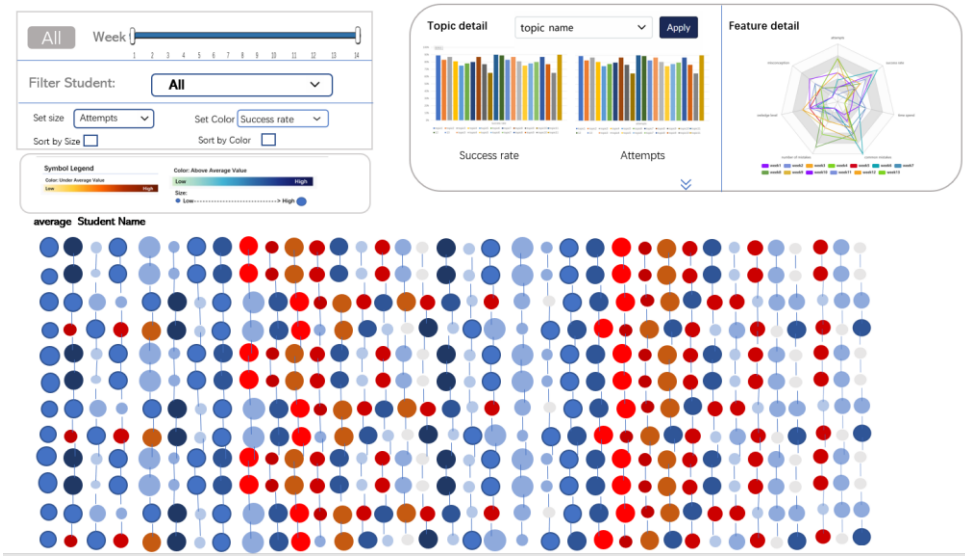

Figure 1. Main Hub

Mouse-over each dot:

Figure 2. Mouse over each dot

Filter students & view group detailed information by clicking each group:

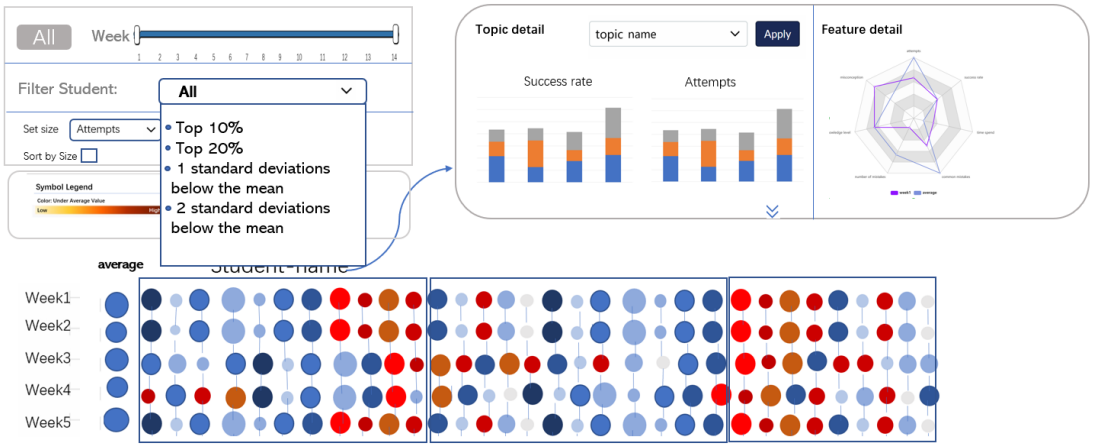

Figure 3. Group students

4. Implement the prototype

I use VUE Web Framework to design the front-end section. The following figure shows the overview of the dashboard:

Figure 4. Overview of the dashboard

In the dashboard design, I divided the interface into three panels. Upper left panel is the control part of the dot matrix graph. I use a slider to filter the week range and drop-down box to select students and variables.

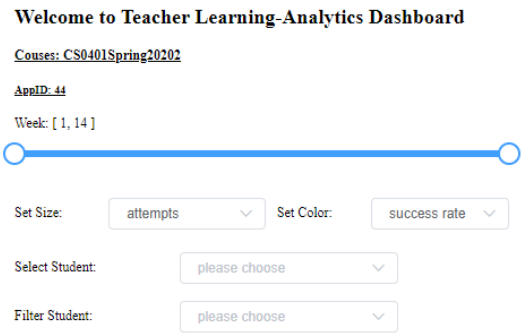

Figure 5. Upper left panel

Size and color are used to display multi-variables jointly in the dot matrix graph. In this way different combined patterns can be detected.

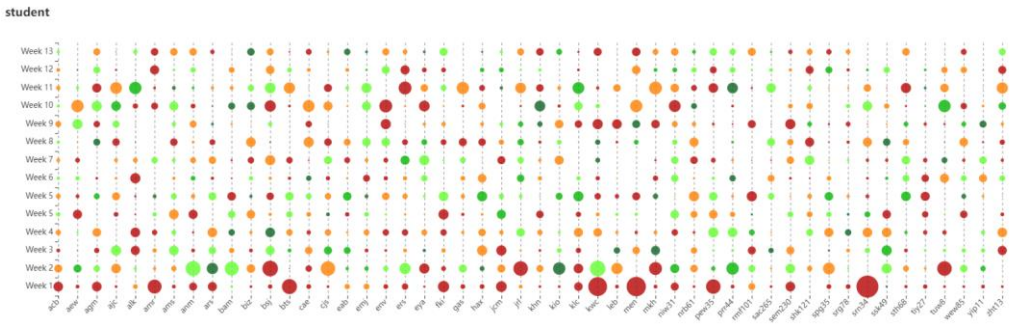

Figure 6. Dot matrix graph

In the above figure, I select ‘Size’ to display number attempts and ‘Color’ to display success rate, the size and color of each student's dot are very different each week, which means that they have different success rates and number of attempts for specific activities.

The larger the circle, the more attempts the student has made. Green color means students have a success rate over the upper 60% and red color means below the lower 60%. The closer the color of the dot is to dark red, the lower the accuracy of the student. The darker green, the higher success rate. In this way, instructors can easily find the high-performance and low-performance students from the graph. Also, they can find which week the class overall success rate is higher and which week more students tried more attempts than others.

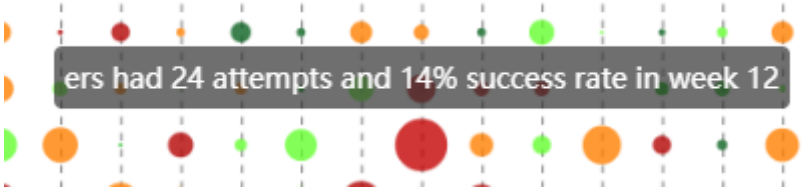

Figure 7. Mouse over red dot

To let instructors find specific students quickly, especially in a very large class, this dashboard allows users to select specific students from a drop-down list. Then, instructors can easily see the evolution of specific students during the whole academic term by examining the evolution along the different rows.

Figure 8. Evolution of specific student

The upper right panel shows the overall learning situation of the class from another dimension, different from time, like it is the course topics' structure.

Because in most cases, the instructor arranges each teaching week as a unit module, but sometimes the boundaries throughout the term get diffuse. According to our survey, more than half of instructors hope to check the students' learning situation in a certain learning unit (such as if-else, while loops, arrays, etc.). In our topic panel, you can choose the specific topic from the dropdown list to see the average success rate and attempts for that topic. Also, you can choose the specific week from to see the information of topics included in a certain week.

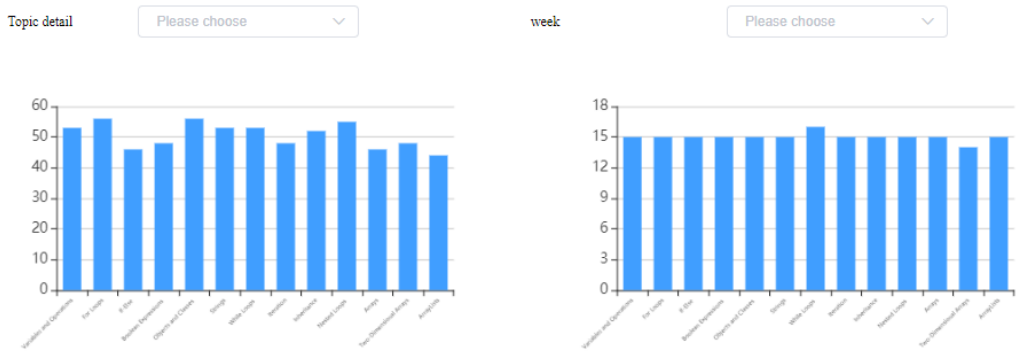

Figure 9. Upper right panel: topic

The radar bar on the right aims to show detailed information about average performances for topics. Each line shows information about each topic. By using the radar bar, instructors can easily see the strengths and weaknesses of specific topics. For example, they may change the following teaching actions if the average spending time is high.

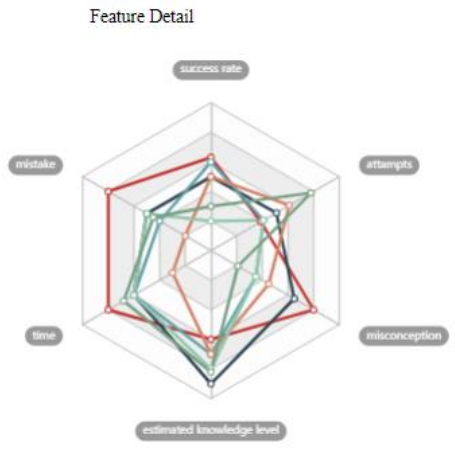

Figure 10. Upper right panel: radar graph

I tested the functionalities of this system prototype by using data derived from a 13-week college-level class taken by 55 undergrad students.

5. Interview

I designed both low-level tasks and high-level tasks.

Low level tasks include:

- Check student1's success rate
- Check the average attempt number in Topic Array
- Check the estimated knowledge level for week3
- Check the continuous learning status for specific student

High level tasks include:

- Identify the topic with highest success rate
- Identify the topic with longest time spent
- Identify the easiest topic (highest success rate) for specific student
- Identify the easiest topic (highest success rate) for certain week
- Identify the most difficult topic for certain week
- Identify the most difficult topic for specific student
- Identify potential problem by analyzing six variables (radar graph) of specific student
- Identify potential problem of certain week
- Identify potential problem of certain topic
- Evolution of each student

Interviewee: An instructor mainly taught classes in Information Science.

Most of the tasks spent less than 2 minutes with one attempt.

Advantages: Dot matrix graph can show student's performance clearly. Filter box can let instructors check students' evolution. Also, it's useful to include both week and topic information.

Suggestions: Labels of each student can show more detailed information, for example, show the activity name when mouse over each dot. Instructors may want to use the data from dot matrix graph directly, it's better to have 'export data' function to let instructor download the data from dot matrix graph.

6. Future work

In the future, the dashboard system should include ‘automatically group students’ functionalities. Based on our survey, most instructors think it is important that the system can group student based on chosen features automatically. With certain group condition (i.e., top 10% students, bottom 10% students), students’ column in the dot matrix graph will change. In this way, instructors can easily find out the differences between the ‘high-performer’ group of students and ‘low-performer’ group of students, especially from very large class.