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Design of a Learning Analytics Dashboard Based on Digital Textbooks and Online Learning

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Abstract: In general, online learning provides functions such as access to video and learning materials, assessments what learners have learned, and participation in community activities. However, it is difficult to provide a learning environment that meets the achievement level or needs for each learner by providing such a function, and it is especially limited to prescribe in a proper situation. Learning analytics, which has received much attention in recent years, provides a tool to collect and analyze learning activity data. Since the process of collecting and analyzing data is generally performed in the system, the information presented by the analysis results is very important as an interface that users meet. Therefore, research on how teachers and students design intuitively to understand results and messages from data analysis bas a great implication on the place of learning analytics. This study introduces the process of designing a dashboard on users' requirements to intuitively express the collected data based on digital textbooks and online learning.

Keywords: Learning Analytics, Dashboard, Digital Textbook, Online Learning, Visualization

1. Introduction

Online learning is widely available today, catering to students of all age groups and interests in all subjects. Examples include the virtual classes and the Educational Broadcasting System (EBS)' college entrance preparation lectures for primary and secondary school students, the college lecture courses provided via the Cyber University and Korea Open Course-Ware (KOCW), and the remote training programs for teachers and other adult workers.

Online learning today typically involves providing video-recorded lectures, hardcopy textbooks in the forms of books or document files, evaluations by students on what they have learned, and online interactions among students.

The typical and current format of online learning, however, is incapable of providing effective help for students of different learning achievement levels or with different needs. Learning analytics has emerged recently as a potential solution to this problem. Learning analytics is a technology for collecting and analyzing data on the learning behavior of students and providing proper learning prescriptions and feedback at timely moments toward maximizing students' motivation and performance.

The emergences of data analysis technologies have inspired many to seek and develop their applications to learning. Examples include the learning management system (LMS) and virtual learning environments (VLE) analytics dashboards, predictive analytics, adaptive learning analytics, social network analytics, and discourse analytics (Cho, 2013). In this study, our focus is on learning analytics dashboards that can analyze and visualize data collected from digital textbooks and online learning activities. More specifically, our goal is to design a dashboard that can deliver such information in a more intuitive manner.

To this end, we first review the progresses that have been made so far with respect to learning analytics dashboards, identify the necessary elements of design, and develop a method for designing such a dashboard.

Second, we design a dashboard that provides visualized data on digital textbooks and online learning activities. For this, we analyze the patterns of users' use of online learning services and identify the dashboard functions they require. We also analyze users' preferred visualization methods.

Third, we analyze the visualization tools that can be used to create our dashboard.

2. Literature Review

A dashboard is the panel-type device installed in the cockpit of a car or an airplane facing the driver or a pilot and featuring diverse switches for operation. A dashboard used in learning analytics and other such systems can be defined as a device for visually displaying the most important information required for achieving one or more given goals. Such a device displays key information on one surface or panel so that users can easily check and monitor such information.

Learning activity data gathered via learning platforms are often in formats that are machine-readable. However, these data are not so comprehensible to users, whether students or teachers. Presenting these data in the form of an intuitive dashboard is crucial to enable users to understand the meaning provided by data.

Most of existing studies on the designs of these dashboards focus on providing learning support for online learning environments and teaching activities. Commonly visualized types of data include those on the learning output and hours, interactions between teachers and students, results on tests and assignments, and the use of learning content. Bar, pie, and line graphs are frequently used to display these data. There are also a number of studies analyzing how convenient dashboard designs are to users, reflecting the predominance of interests in computer science and software engineering in the discipline. There are also numerous studies analyzing the effectiveness of existing dashboards (Jin & Yu, 2015).

One important Korean study analyzing the educational effects of dashboards concern a university located in Seoul (Park & Cho, 2014). The authors of this study surveyed users' perceptions of online learning activities. Based on the findings of this opinion poll, the authors designed and developed their own dashboard, and investigated whether it was useful. The authors applied their dashboard to a virtual campus environment and analyzed students' virtual learning activities. The authors then surveyed participants in the virtual learning activities on how closely the dashboard catered to their expectations of needed information, how useful they perceived the dashboard to be, and how easy it was for them to understand and use the dashboard. The survey also asked open-answer questions regarding the improvements to be made to the dashboard. The conclusion of this study can be summarized as follows.

- Learning analytics dashboards should display only information that students themselves think is useful.
- While students in general understood the dashboard and its operation quite well, they indicated confusion and difficulty over interpreting the mixture of diverse types of information displayed in each single graph.
- The most important question students asked was whether the information provided by the dashboard was really useful to their learning.
- The preliminary opinion poll revealed that the degrees of students' active participation in virtual campus environments were dependent on the natures of the given subjects and the characteristics of professors.
- It is important to inform students that the data displayed by the dashboard on students' online learning activities do not decisively affect their final performance.

The Society for Learning Analytics Research (SoLAR) also provides a standard process for designing a learning analytics dashboard in the Handbook of Learning Analytics (Klerkx, Verbert & Duval, 2017). Below is a summary.

(1) Understand the given objective(s) by answering the following questions:

- What is the purpose of visualizing the given data?

- Who are the target users?
- What types of data are to be visualized?
- How can the given purpose be accomplished through the visualization of data?
- How can users communicate using the visualized data?

(2) Collect and process data. Gather raw data first. Next, calibrate and sort the data to analyze them. Finally, using the questions raised in Step (1), sort the relevant or useful data that are to be visualized.

(3) Map the data. This involves choosing the way to give forms to the answers given to the questions of Step (1). Select the scale to be used for each type of data (quantitative, ordinal, etc.) and find the method for visually encoding the given data.

(4) Document the process. Indicate what criteria were considered in making the decisions that were made, what alternatives were considered and eventually abandoned, and how the final product is better than the initial design.

(5) Add techniques for interaction. It is important for the teacher to understand the process of learning analytics in order to understand students' behavior better. This involves:

- Comparing the values and patterns of data with a view to identifying similarities and differences;
- Arranging the data according to diverse criteria and measures;
- Filtering the data that satisfy the given requirements;
- Visually emphasizing data with certain values;
- Gathering or grouping similar items together (using means, numbers, and other such criteria);
- Annotating the findings and opinions; and
- Ordering or recording certain attributes of the data to enable effective searching and browsing.

(6) Evaluate the product on an ongoing basis. The user-centered design (UCD) approach requires the developer to design, realize, and evaluate a given system repeatedly by taking into account the target user's perspective. Effectiveness, efficiency, and usability should be the three main criteria for evaluating the product.

Creating a learning analytics dashboard using this process would involve answering and reviewing the three key questions, i.e., (1) what types of information are to be displayed by that dashboard, (2) how the target types of information are to be displayed, and (3) what help the displayed information can provide for users.

3. Designing the Dashboard

3.1. Preliminary Survey

In order to design a dashboard based on digital textbooks and online learning, it was necessary, first, to survey elementary school students and teachers—the main target users—before designing the

dashboard. This preliminary survey was conducted to identify the patterns of users' use of digital textbooks and online learning services as well as the needs they have for a dashboard.

In order to collect opinions from various members, we classified the schools, teachers and students who will participate in the survey as the following criteria:

- The area where the school is located (e.g. city or rural area)
- Career, Gender and the academic year of their students (For Teachers)
- Academic year and gender (For Students)

Surveys for students and teachers are conducted using questionnaires. We gathered personal information that can distinguish the group, according to the above criteria for the collection and utilization of users' feedback.

The questions used in the preliminary survey were as follows:

(1) What devices do you usually use with your digital textbooks and online learning services? (Select from: PC, smartphone, or tablet.)
(2) When and in what situations are digital textbooks and online learning services used? (Select from: during class, before or after class as part of preview or revision, other situations, or not using at all.)
(3) What are the features or functions you use most frequently? (Select from: reading texts, video clips, submission of assignments, or evaluation.)
(4) We are trying to develop a service that gathers learning activity data from students and teachers using digital textbooks and online learning services, and display those data in a visually intuitive manner. Do you think such a service is necessary? (Select either yes or no.)
(5) (If the user chose "yes" to Question (4)) What types of information do you want the service to display? (Select from: progress with reading, progress with watching video clips, progress with submission of assignments, results of evaluation, or other.)
(6) (If the user chose "no" to Question (4)) Why do you think such a service is not necessary? (Select from: Not using such services often, fear of privacy violation, irrelevant to academic performance, or other.)

Based on these questions, we identified users' patterns of using digital textbooks and online learning services and determined whether they needed a dashboard of our design. We also used the findings of the preliminary survey to determine the best way to visualize data based on multiple requirements for the functions such a dashboard should have.

3.2. Survey on Users' Preference for Visualization Styles

In visualizing data, we must consider (1) what types of data are to be shown to users and (2) how such data are to be presented to users.

We identified the following four features required by users for the dashboard based on digital textbooks and online learning services. The figures in the parentheses indicate the units to be used in displaying the data.

(1) Progress with text reading (%);

(2) Progress with watching video clips (%);

(3) Whether assignments have been submitted (Yes/No);

(4) Evaluation results (scores).

We developed multiple prototypes featuring these data or functions, and surveyed users' preferences for different styles of visualization. We also let users indicate whether they had preferred styles of visualization other than the ones we presented, and specify what these were. Users' answers were used to improve our prototypes.

As for the progress with text reading, we presented users with two examples (Figures 1 and 2) and asked them which they preferred. Figure 1 uses bubble charts to distinguish texts that have been read from the texts that have not been read, and also indicates the progress rate in percentage below the bubble charts. Figure 2 indicates the progress rate using a pie graph.

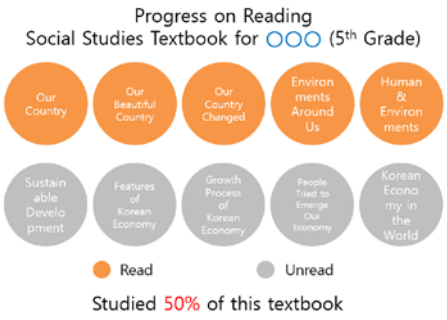

Figure 1. Progress Rate on Text Reading: Bubble Chart

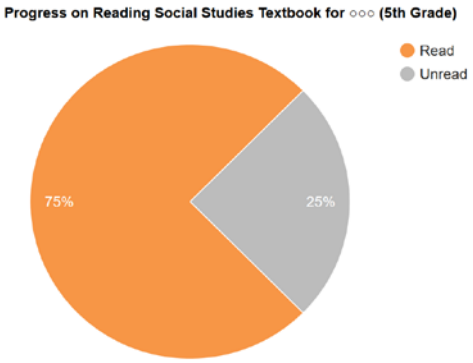

Figure 2. Progress Rate on Text Reading: Pie Graph

We also developed two different ways—a pie graph and a dashboard—to indicate the progress with watching video clips (Figures 3 and 4). Both prototypes indicate the average progress rate of other users next to each user's own graph so that the user can compare his or her progress with those of others.

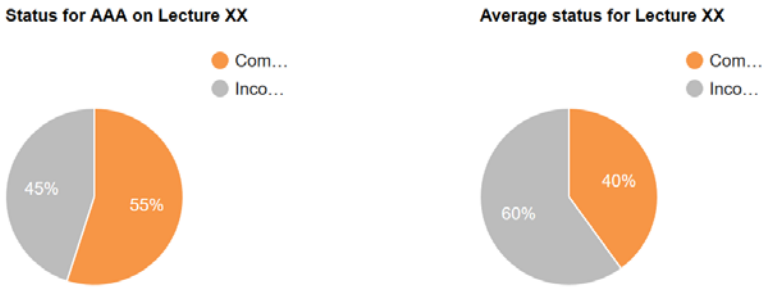

Figure 3. Progress Rate on Watching Video Clips: Pie Graph

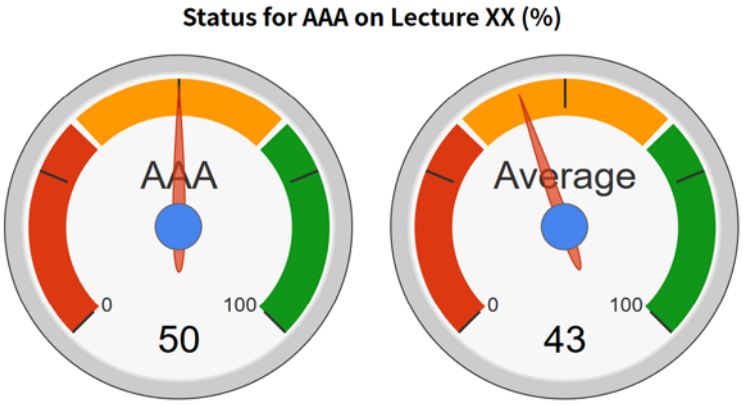

Figure 4. Progress Rate on Watching Video Clips: Dashboard

As for presenting information on whether assignments have been submitted, different types of information should be presented to different types of users (teachers or students).

Students would likely require information on the assignments they have recently submitted or on whether they have submitted required assignments. This can be visualized in two ways: using traffic lights (Figure 5) or simple “O” and “X” signs (Figure 6). If an assignment is due shortly, the dashboard should also indicate the approaching deadline and urge the user to hurry.

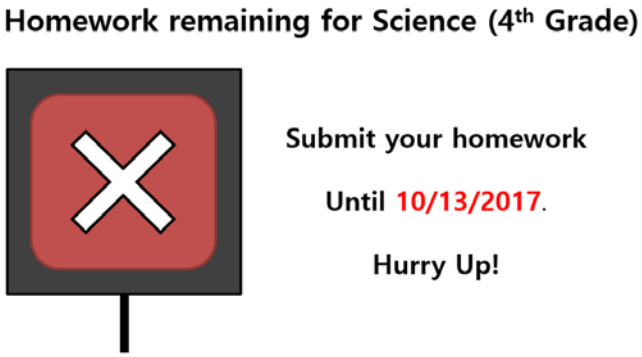

Figure 5. Submission of Assignments: Traffic Light (For a Student)

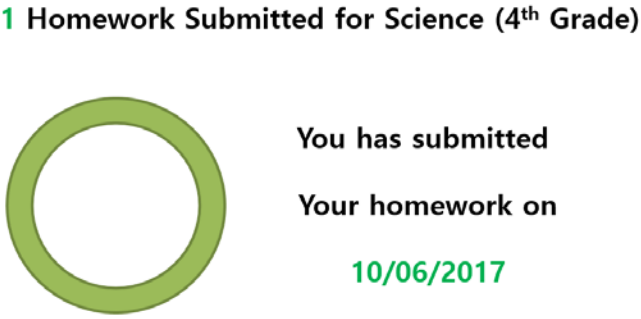

Figure 6. Submission of Assignments: O and X Signs (For a Student)

There are also two different ways to present information to teachers: either displaying whether each individual student has submitted a given assignment (Figure 8) or representing the ratios of students that have submitted assignments and students that have not in the form of a pie graph (Figure 8).

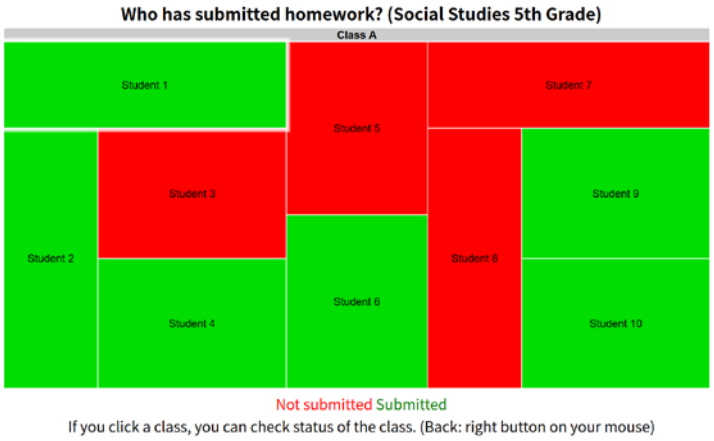

Figure 7. Submission of Assignments: Students' Status (For a Teacher)

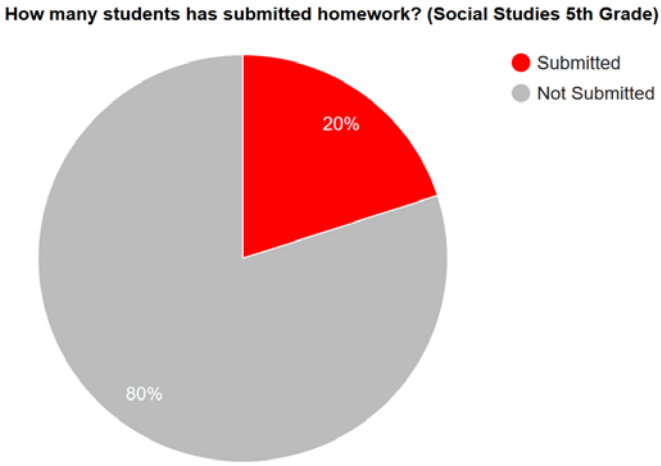

Figure 8. Submission of Assignments: Submission Rate Pie Graph (For a Teacher)

The evaluation results or scores can be presented in the form of either bar graphs (Figure 9) or dashboards (Figure 10), both designed to enable the user to compare his or her results to those of others. The colors used on the bar graphs should differ by the level of scores given. If a student's score falls below the average, his/her score should be indicated in red. If the student's score is above the average, it should be indicated in green. Where necessary, words of encouragement may be added to the graphs or dashboards.

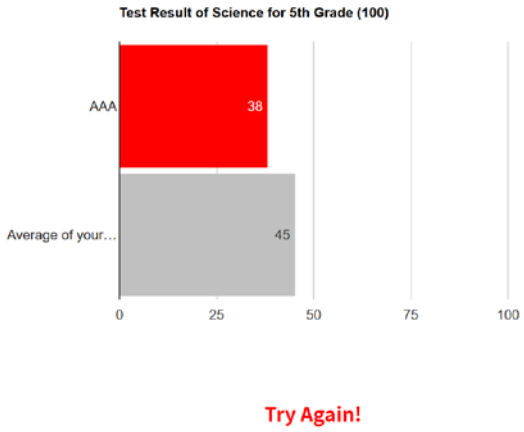

Figure 9. Evaluation Results: Bar Graph

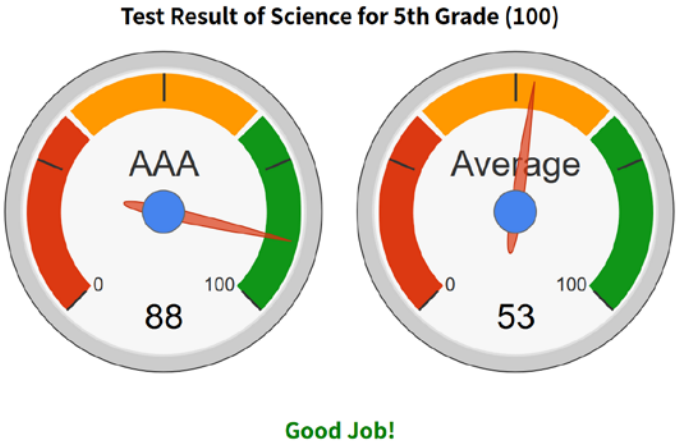

Figure 10. Evaluation Results: Dashboard

3.3. Dashboard Visualization Technique

In order to implement a learning analytics dashboard based on the preliminary survey and the survey on visualization style preferences, we needed to review and determine which platform to use. To assist developers in this situation, there is an open source project that lists the frameworks, libraries, and software associated with visualization that can be used depending on the programming language and operating system (Fabio Souto, 2017).

If the platform in which the dashboard is displayed is only a mobile operating system such as iOS or Android, developers can use the library for each operating system. If you support the Android environment, you can use Java libraries such as DecoView, MPAndroidChart, and WilliamChart. If you use iOS, you can use Objective-C and Swift libraries such as BEMSimpleLineGraph, Charts, JBChartView, and PNChart. In particular, iOS's Charts library ported to iOS version of Android's MPAndroidChart (Daniel Cohen Gindi, 2017). If you need to support two operating systems, you can consider the Charts library on iOS and the MPAndroidChart library on Android.

However, if you need to consider web environment, you can prevent duplicate development using JavaScript library. Among the mobile operating systems, Android supports WebView (Google, 2017a) and iOS does WKWebView (Apple, 2017) to show web page written in HTML. This allows you to use the same JavaScript code to configure the same dashboard for multiple operating systems. Typical visualization libraries using JavaScript include D3.js (Data-Driven Documents, 2017), Google Chart Library (Google, 2017b), and Chart.js (Chart.js, 2017).

4. Conclusion and Suggestions

In this study, we review the process by which we designed a learning analytics dashboard based on digital textbooks and online learning activities. We first sought to identify users' patterns of using online learning materials and determine their needs for a dashboard. In order to find ways to visualize our dashboard in the most intuitive and convenient manner for users possible, we also developed a number of visualization prototypes. Finally, we surveyed and reviewed the possible platforms that could be used to support our dashboard.

This report provides only an overview of how the prototypes for the dashboard we propose could be designed and produced. Once these prototypes are developed, we will need to test them in terms of efficiency, effectiveness, and usability by applying them to actual services with learning analytics systems. Then we will need to identify what improvements and changes are to be made. We also need to look for dashboard designs and applications that users actually require.

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