SAGE Game Affinity Space
Learning Metrics
Final report
COMS 6901/3998 E sec 028

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Abstract

This final report focuses on the Learning Metric feature of the SAGE (Socially Addictive Gameful Engineering) Gameful Affinity Space epic. It describes our ideas and accomplishments on the progress tracking and visualization components of SAGE, which were previously non-existent or lacking in functionality. This paper covers our contributions to both the teacher and student interfaces, which include implementation of progress bars and spider graphs at the game, quest and mission levels. We also discuss the newly created badge library and data models we constructed to store scoring and progress data. Specific user stories and objectives can be found the TFS while further documentation can be located in the SAGE wiki.

1. Introduction

While the use of games in teaching students is a relatively well-developed concept, the incorporation of technology into game-based learning has widely increased the possibilities of learning gamification and student progress assessment. [1] A 2014 report published under the U.S. Department of Education points out the growing role of data in refining learning experiences and it identifies the applications of learning analytics in tailoring instruction for students. [2] Specifically, computer-supported gameful education opens opportunities for teachers to customize learning objectives, measure student engagement, quantitatively identify challenges for individual students and provide customized feedback. From a student perspective, being able to view personal learning metrics allows a student to better gauge her level of mastery and focus her efforts on areas of weaker understanding. Integrating a defined learning metric system into game-based learning interfaces also paves the way for more unique and efficient curricula creation.

Thus in our sub-project of SAGE we concentrated our efforts on developing a robust way to track student and class progress at the 3 gamified levels (game, quest and mission) that would be sensitive to learning-objectives and Computational Thinking (CT) concepts. We also endeavored to allow students and teachers to view these metrics in an intuitive manner, namely in the form of progress bars and spider charts. Lastly we created a badge library to enhance the gameful experience for students. Later sections discuss these features in detail.

2. Related Works

2.1 Codecademy

With the rise of all kinds of computer coding languages, online teaching and instruction of programming has boomed [3]. One of the most popular of these instructional sites is Codeacademy, which walks students through the basic ideas of various web languages in an interactive way. Taking a specific look at the metrics component of the site, Codecademy provides a chart for each user that shows how many skills have been completed and how many badges he/she has earned.
In the two figures below, we can see a dashboard from a Codecademy user's point of view, displaying skills completed, how many badges earned, and a progress bar representing the percentage the user has learned of each skill.

Figure 1. Codecademy user profile

The Codecademy badge library shows a user the badges he/she has achieved and the date they were awarded the badge.

Figure 2. Codecademy badge profile

This is a good way of representing the learning progress of each user so that hey can monitor their learning paces in a right way and motivate themselves.

2.2 Gradecraft

GradeCraft is a “gamified gradebook” developed at the University of Michigan in 2012 that supports gameful courses and allows students to take a more active approach to their own learning [4]. It has recently been commercialized, yet it shares many of the same qualities and goals that we hope to achieve with the SAGE Gameful Affinity Space, the major difference being our focus on infusing computational thinking. With respect to learning metrics, GradeCraft has made rather significant accomplishments, enabling system leveling through unlocks and badges, student leaderboard participation, success prediction and teacher monitoring. Gradecraft’s versatile visualization of student performance and class data were appealing to us, which is why we used a combination of percentage bars and spider charts to represent our data. Below is an example of class data visuals through Gradecraft.

Figure 3. Gradecraft class data visualization

2.3 CyGames

The Cyberlearning through Game-based, Metaphor Enhanced Learning Objects (CyGaMEs) research project was started by Dr. Debbie Denise Reese from the Wheeling Jesuit University Center for Educational Technologies to make learning more intuitive. The project studies players (age 9-18) in the game Selene: A Lunar Construction GaME, which introduces students to concepts about the Moon's geologic [5]. While like SAGE, it combines a learning and research into one environment focused on instructional game design, CyGaMEs differs in its metaphorically enhanced approach to game-based learning.

In particular, players (who need to be registered with an access code) can earned space-themed badges awarded through Mozilla OpenBadges. During our implementation of the badge library, we looked also considered this option as it would allow us to use an api that provides many badge-related functionalities. The advantage of OpenBadges, (besides pre-implementation) is that badges can be stored separately online for each user in a Mozilla backpack. The potential disadvantage of this option is that each student would need a separate Mozilla backpack account associated with an email, and that SAGE would possibly need licensing of sorts to issue and award badges. Regardless, the themed badge series and badge library on CyGames was of much interest to us while working on SAGE's own badge system.

2.4 Khan Academy

Khan Academy's website aims to provide a personalized learning experience, mainly built on the videos which are hosted on YouTube. The website is meant to be used as a supplement to its videos, because it includes other features such as progress tracking, practice exercises, and teaching tools [6]. Part of the students' learning metrics display is shown below.

Figure 4. Khan Academy learner's progress

In the Progress section, it tracks the video contents the learners have viewed and the skills they have mastered from those video contents. It breaks a student's mastery into different levels and uses a circular progress ring to display the final percentage of mastery progress for a student. Like KhanAcademy, we also created a separate tab from the main menu that leads to metrics information and visuals. While we similarly display percentage of progress in a bar (instead of a ring), we do not segment skill mastery by level. However, this is an interesting and most sophisticated implementation to consider in the future, perhaps with more feedback from field studies on what sort of statistics and graphs they would like to receive back.

Figure 5. Khan Academy badge system

Although not aimed at developing students' CT (Computational Thinking) ability, Khan Academy also has a badge system in order to motivate students to learn more materials. As shown in the figure above, various badges were created for different milestones or achievements. Like CyGames, Khan Academy also implements themed badge series, which adds to the level of gamification of the interface. Within each theme however, there are standard badges like "Just Getting Started" and "Apprentice Programmer" which we is what we added to our badge library in SAGE.

3. Implementation

3.1 Features

Our mission is to improve the student learning experience as well as teacher monitoring experience. We do that by adapting our learning metric interface to include the following features:

Progress Bars:

We allow students to view their progress at all levels of the system.We created status or progress bars that will display students' degree of completion for Quests, Parson's Puzzles and Constructionist Games. At the Quest and Constructionist game levels this degree of completion will take into account the percentage of Objectives the student has achieved and also the percentage of total VAL (Visual Assessment Language) points earned within a quest or game.

Spider Graphs:

There are a lot of ways to manage and measure students' learning processes, like progress percentage bar, progresses list in a form, or spider graphs. As for visualization, spider graphs can be a best way to visualize the whole computational thinking learning progress and display the Hairball analysis results for each game that students have completed. It can help students to easily know which specific aspects he/she is already good at and the concepts in which they still need more practice.

For each mission and each quest, we included a spider graph. And at the Student Home page, we display an aggregate spider graph that depicts the overall CT (Computational Thinking) Concept learning. So the student can monitor his own learning pace and the student can be motivated to learn more.

Badge Library:

The badge system is a reward system. Students who have completed a mission will receive the badges associated with it, and teachers can design and manage the badges in the Badge Library. In this way, the progress and achievements of students can be better visualized and students can also be better motivated to completing more missions.

3.2 Student Dashboard

A student needs to monitor his/her own progress during the learning progress. So, we use progress bars, spider graphs and badges to help them to do this. Student can see their progress on 3 levels: mission, quest and game. The implementation details can be found here: https://gudangdaya.atlassian.net/wiki/spaces/SAGE/pages/394395649/Learning+Metrics.

3.2.1 Student Metrics Tab

As a student, when he/she logs in to the system, he will see a metrics tab on the side menu to view all of his progresses.

Figure 6. Side menubar with Metrics tab

In the metrics page, we show all the student progresses according to the mission-quest-game structure.We allow students to view their progress at all levels of the system.

3.2.2 Mission Level

We created progress bars that will display students' degree of completion for the Quest and Constructionist game levels. This degree of completion will take into account the percentage of Objectives the student has achieved and also the percentage of total VAL (Visual Assessment Language) points earned within a quest or game.

When we first get into the Metrics page, we are in the mission level. On the spider graph, it shows two differently colored rings which indicates the CT (Computational Thinking) concept scores of the two quests in this "SAGE Challenge Mission". For each CT score shown on the graph, the score is a mean of all the CT concept scores of that quest, across all games in that quest.

Figure 7. Spider Graph of mission

3.2.3 Quest Level

Upon clicking on the mission link, and it then shows us the quests page like below:

Figure 8. Spider Graph and progress bar of quests

For each quest, we show the progress bars both for the Objective completed and VAL points. The percentage is derived from the calculation: total points gained divided by total points (aggregated across all games in the quest). As shown in the above picture, the student has worked on two quests: *One Foot after Another* and *AutoLoad*. Each quest has its own different progress bar of Objectives completed and VAL points, and the data is fed in from mLab.

For each quest, we also show the aggregate spider graph that contains all the CT concept score of each game. We can see that the *One foot after another* quest contains 4 games, each game shows different CT concept scores. While quest *Autoload* only contains one game.

3.2.3 Game Level

Then we enter the game page of *One foot After Another*. The picture shown below also contains progress bars and a spider graph of each game. The progress bars depicts the points the student achieved for this game, the spider graph shows how the student performs in each of the 7 CT concepts for the game.

Figure 9. Spider Graph and progress bar of games

By having full accessibility to their progress, students will be more motivated and engaged to complete quests and focus on areas of weaker understanding. Each game will also link to the scratch game so that they can start to play the game easily after seeing their progress.

3.2.4 Badges Earned

Besides progress bars and spider graphs,, we also include the badge reward system. Student will be more motivated when he/she earns a badge.

When the student navigates into the Metrics page, a bar of the badges earned will be shown on the top of the screen. When you move your mouse over the badge picture, you will get the badge description shown on the right side.

Figure 10. Badges earned of that student

All of the badge information and the picture of the badge is retrieved from mLab. In this case, we retrieve the information of this student and their badges from the mLab, then display it on the metrics page of this student.The technical details can be seen here:
https://gudangdaya.atlassian.net/wiki/spaces/SAGE/pages/396591105/Badge+library

3.3 Teacher dashboard

On the teacher side, there is an overview page to monitor the students' progress on per-Mission CT Concept learning in spider graphs. The basic format of the spider graph is the same as it is on the student interface. First, for each mission, there will be a composite spider graph of the CT Concept scores of each student. Second, it shows the average overall student performance on that mission. With the composite spider graph showing all the students in the class, the teacher will be able to identify struggling and high-performing students.

When logged into SAGE with an instructor's account, the web application will be directed to the teacher interface.

3.3.1 Teacher Metrics Page

The main purpose of this webpage is to provide easy access to tracking the progress and behaviors of students in the class rosters of the instructor.

Figure 11. Instructor Metrics Page of SAGE Affinity Space

Above is the current Teacher Metrics Monitoring interface. The current webpage has two functions, one is to show the CT scores of all the students in the roster of the corresponding instructor, and the other is to show the average CT scores of all the students in each different missions that this instructor has assigned to the class. The CT scores in both functions are demonstrated in Spider-graphs.

Figure 12. Composite CT Scores in a mission of 2 enrolled sttudents

Figure 13. Average CT Scores of an assigned Mission for across the same class of 2 enrolled students

3.3.2 Badge Creation

Besides the Metrics pages for the instructor to monitor the students' behavior, the instructor can also create badges in our badge libraries through the dashboard libraries page.

Figure 14. Instructor Dashboard Mission Management Page

Since badges are very likely to be closely related to the quests, we put the badge creation in the quest creation page. In the page, the instructor can input badge name, badge description, badge image URL and issuer name. Then when he clicks upload, the badges will be posted into the mLab.

Figure 15. Instructor Dashboard Badge creation interface

Then he can navigate to Badges Library in the libraries page to see the badge he created.

Figure 16. Instructor Dashboard Libraries Page

Figure 17. Instructor Dashboard Badge Library Page

In the Badge Library page, it displays all the badges created so far, with the badge name as well as the descriptions. This page will connect to the database collection in mLab to retrieve the badges.

4. Architecture

The Gameful Affinity Space is formerly known as SAGE Dashboard, which is a web space that envelopes the Scratch Editor and enables students and teachers to interact with the rest of the SAGE ecosystem. Our work focuses on the Learning Metrics feature.

Figure 18. Affinity Space Architecture Model

The technical architecture of Gameful Affinity Space is demonstrated in the figure above. There are two servers running in Node.js. One is SAGE front-end Server which controls the learning metrics demonstration and the other is Assessment Server which controls the evaluation of students' behavior in the Missions/Quests/Games using Hairball and data storage and retrieval between the front-end and MongoDB database. For the Learning Metrics feature, we worked on both servers in Node.js and also the front-end page in AngularJS. The data for objectives completed and student scores etc. are stored in the mLab database, and our calculations are generated in the servers.

Figure 19. Mission Quest Game architecture model

The above diagram displays the 3 level mission-quest-game structure and the metric display method at each level. The diagram is meant to summarize the metrics included across all levels of the student interface.

5. Future Work

5.1 Implementing Material framework

The front-end framework we use now for our metrics pages is still in BootStrap. Some groups working on other features have already begun moving to implementation in the Material angular framework, and work to standardize the UI across groups and

features of the Gameful Affinity Space would likely make field studies more coherent and aesthetically appealing.

5.2 Badgr.io API

We have currently completed a self-constructed Badge Library design and implementation, but the library does not contain as many features as some other existing online badge systems like OpenBadges. During our work, we looked into many badge system APIs including OpenBadge Mozilla Backpack, Credley and ultimately we discovered the Badgr API which provides an easy access to the OpenBadge system, similar to Mozilla Backpacks. We have figured out how to connect to the Badgr API using XmlHTTP with an authentication token. We are still unsure of the viability of connecting to badge APIs as an option, because most such apis require students to have an online account created with an email to receive a badge. However the option may be worth considering when maintaining our own badge library becomes too cumbersome.

5.3 Further Gamification

Some terminologies we use now like “VAL points” do not sound quite gameful. As further progress is made with the Affinity Space, it may be meaningful to transition from developer terminology to more student/teacher friendly phrases. One such move we made this semester was to start using mission-quest-game levels rather than learning path and courses. Furthermore, it may be of value to consider learning metrics in conjunction with the programming detection behavior and intelligent hinting features with regards to giving students feedback along with their scores. This feedback should be encouraging and constructive and help the student (and teachers) to better understand what the statistics or metrics displayed actually mean.

6. Conclusion

The implementation of the features we have described in this report is relevant and necessary for the upcoming field studies with students and classes. By enabling students and teachers to monitor student progress, we hope to gain quantitative feedback on the efficiency and viability of various learning approaches in computational thinking. Creating and storing learning metrics will lay the foundation for potential future work on predicting learning success or failure, as well as on student-specific learning profiles. We strive to measure and infuse the computational thinking that is fundamental to problem-solving across fields into the common curricula for younger students.

References

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