# SAGE Learning Metrics
# Project Proposal
# COMS 6901/3998 E sec 028

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# Abstract

This is the proposal for the Gameful Affinity Space development in SAGE project. We are aiming at the Learning Metrics feature, which includes eleven user stories arising from previous work. We have divided the necessary implementation needed into four sections in this proposal, namely Student Interface, Spider Graphs, Teacher Interface, Badge System.


# 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.

The SAGE (Social Addictive Gameful Engineering) project has efforts underway in creating a collaborative game-based learning and assessment system with a goal of introducing computational thinking into students at an early age. Computational thinking, as first defined by Jeanette Wing in 2006, refers to cross-discipline analytical skills that are applicable in “problem solving, designing systems, and understanding human behavior,” and it draws elements from the field of computer science. [3] While this skill is fundamental and important to nearly every subject area, it is difficult to measure a student’s ability in computational thinking through the traditional school grading systems because it is inherently encompassed by other subjects. Besides providing a interactive and enjoyable environment in which students and teachers personalize learning experiences, the potential of SAGE to gather data on learning experiences and adapt this data to improve curricula educational practices is enormous, and should not be left in the background.

In our sub-project, we propose to focus our efforts on developing the learning metrics feature of the SAGE Gameful Affinity Space, formerly known as the Dashboard. Our aim is to devise a robust system of measuring student progress within the SAGE learning interface that is sensitive to learning objectives and game difficulty, and consequently allow students and teachers to view these metrics in an intuitive manner. We plan to continue work done by previous researchers on the Gameful Affinity Space by addressing the lack of progress monitoring ability at the Mission, Quest and Constructionist Game levels. We also wish to increase the gamification and social aspects of the interface through addressing the Learning Metrics feature by creating a game-fully competitive Student Leaderboard and a Badge rewards system.

# 2. Related Works

### 2.1 Codeacademy

The computer code is the language that is surging. the Teaching of online instruction in programming and web construction is booming[4]. The frenziest start-up in those sites is codecademy. It walks all the students through the basic ideas of various web languages in a reactive way. For each web user, it also gives a chart that shows how many skills that has been completed and how many badges the user has earned. From what is shown below, we can see that it shows how many skills completed, how many badges earned, and a progress bar that shows the percentage the user has learned of each skill.

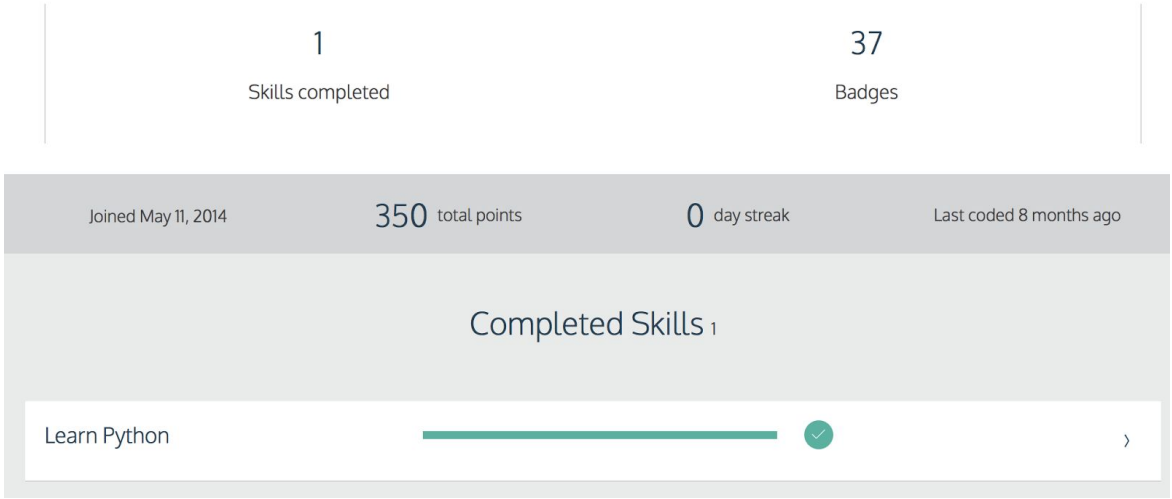


Figure 1. Codecademy user profile

For the badge library, we can see the badge achievements that the user has got and at what time the user got the achievement.

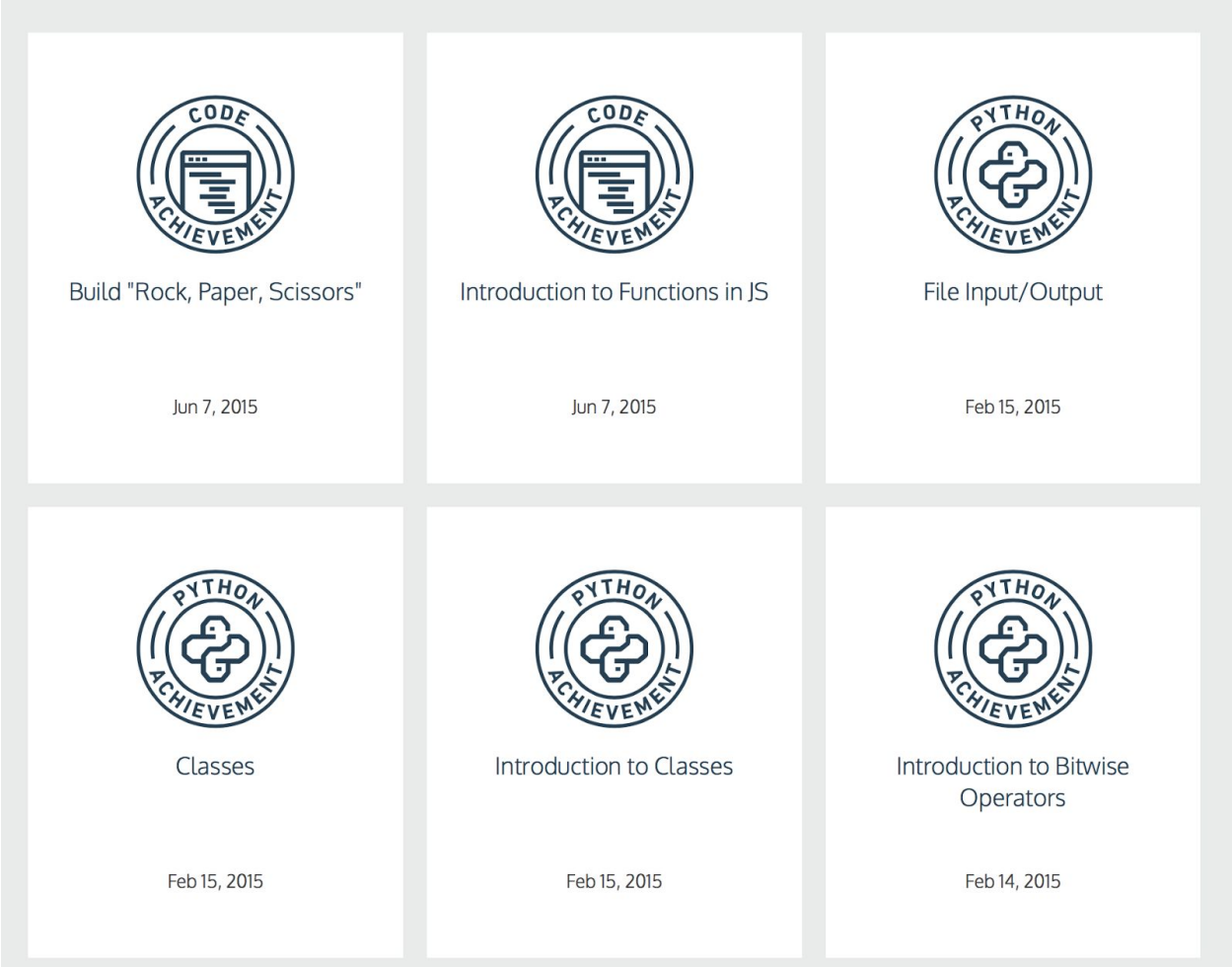


Figure 2. Codecademy badge profile

This is a good way of showing the learning progress of each user so that they 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 [5]. 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 should also be considered as we make advances with the Affinity Space. Below is an example of class data visuals:

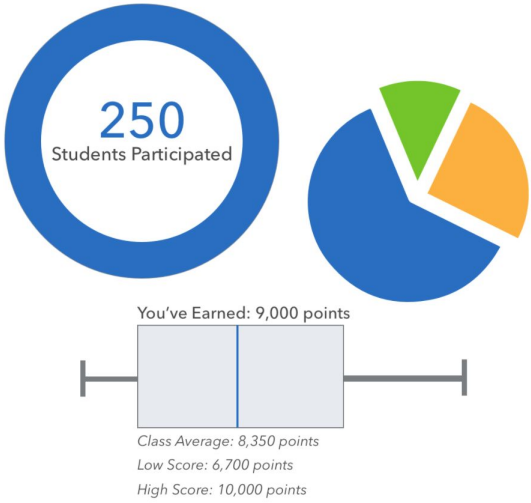


Figure 3. Gradecraft class data visualization

### 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 [6]. 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.

### 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.[7] Part of the students' learning metrics demonstration is shown below.

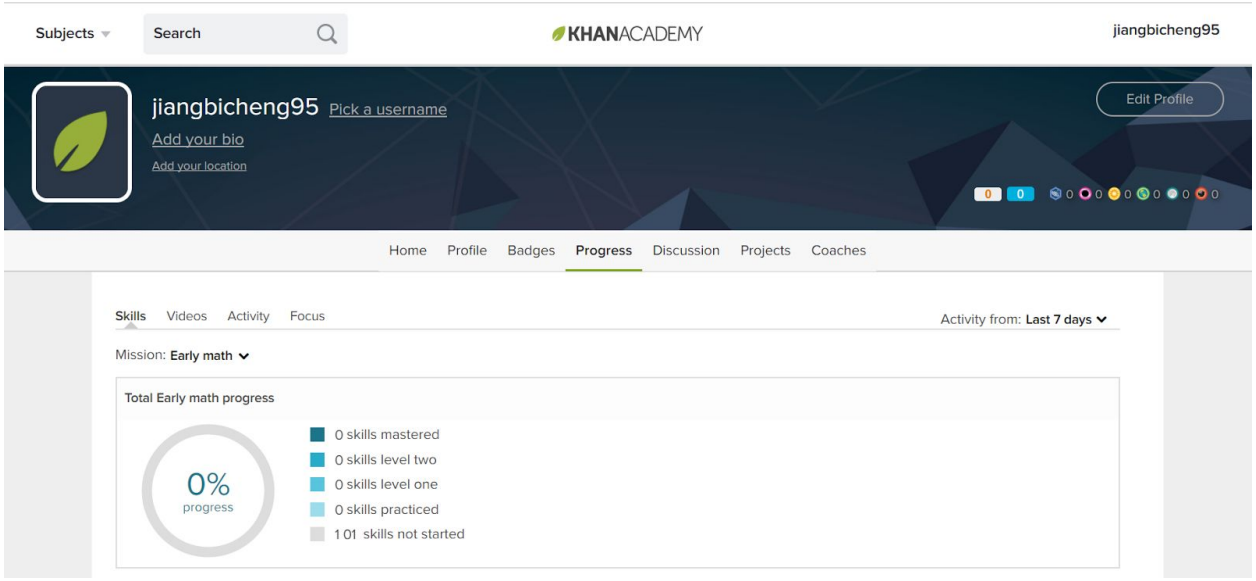


Figure 4. Khan Academy learner's progress

In the Progress section, it tracks the video contents the learners have views and the skills they have mastered from those video contents. However, these statistic data do not reflect the students' computational thinking ability, since after all Khan Academy is not a website aimed mainly for introducing computational thinking to students.

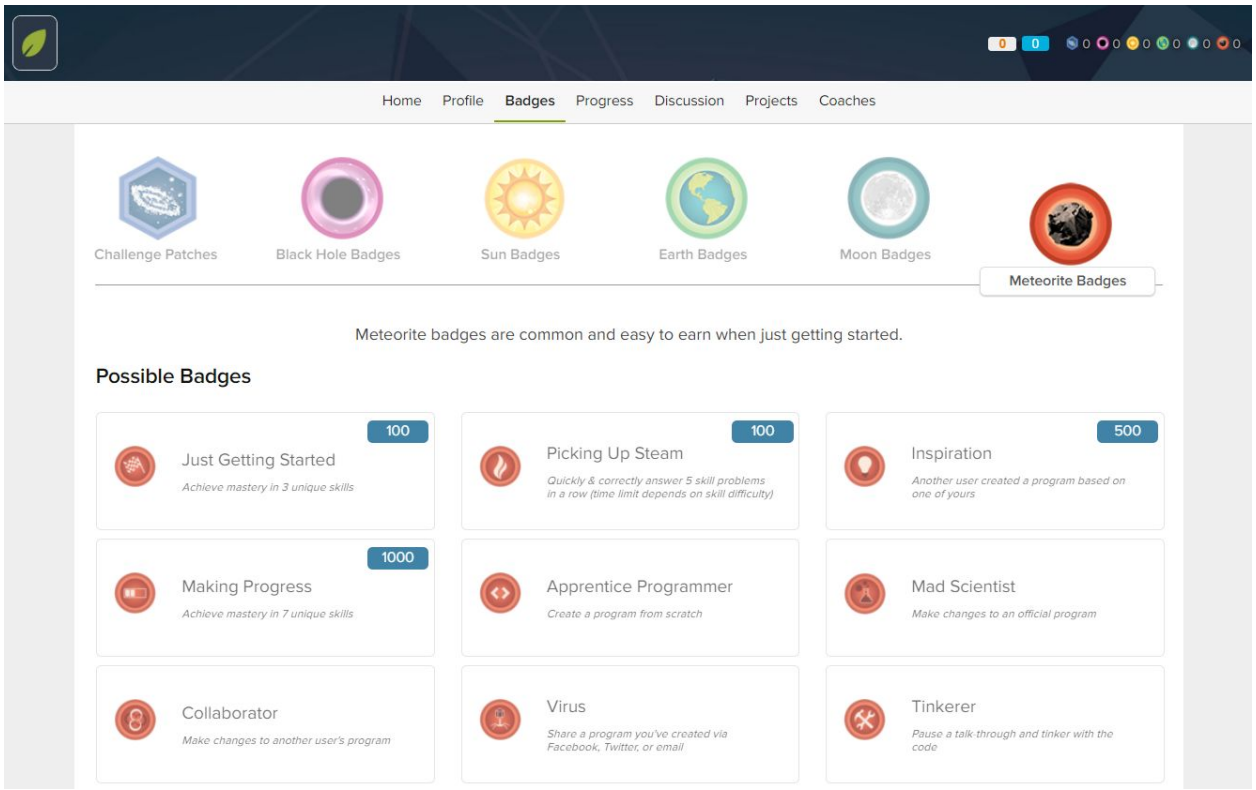


Figure 5. Khan Academy badge system

Although not aimed at developing students' CT ability, Khan Academy also has a badge system in order to motivate students learning more materials. As shown in the figure above, various badges were created for different milestones or achievements. Badge system is indeed a good feature in the gameful affinity space showing the students' learning progress.

# 3. Proposals

### 3.1 Student Interface:

Our mission is to improve the student learning experience by adapting our learning metric interface to include the following capabilities:

1. Allow students to view their progress at all levels of the system. We plan to create 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 points earned within a quest or game. At the Parson's Puzzle level, a score will be displayed reflecting the student's performance relative to the best possible performance for the puzzle. By having full accessibility to their progress, students will be more motivated and engaged to complete quests and focus on areas of weaker understanding.

2. Rank and order quests by difficulty level. Students will be able to see all Quests and their corresponding difficulty levels in a Quest Page, separate from their home page. We plan to implement three levels of difficulty which will be based on the lowest score in the Parson's puzzle preceding the game. The purpose of this feature is to allow students to gauge their own learning mastery and advancement by choosing difficulty levels they feel ready to challenge.

3. Display a leaderboard on which students can game-fully compete with their classmates or peers. The leaderboard will be ranked by CT score which is calculated from aggregate Hairball Analyses on all the games completed by a student. The purpose of the leaderboard is to encourage students to interact and to motivate them to participate in a fun and enjoyable way.

### 3.2 Spider Graphs

Manually grading Scratch program is very time-consuming, so we use Hairball plugin to help instructors inspect the implementation of Scratch programs in each games that students have completed[8].

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 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 which concept they still need more practice.

For each mission and each quest, we are going to put a spider graph on its page. And at the Student Home page, there will be an aggregate spider graph that depicts the overall CT Concept learning. So then the student can monitor his own learning pace and that the student can be motivated to learn more.

Our thought is to show each mission’s spider graph while moving the mouse over the mission button, then the graph will appear at the place for it. In each quest, there will also be a spider graph to show all the CT Concept scores.

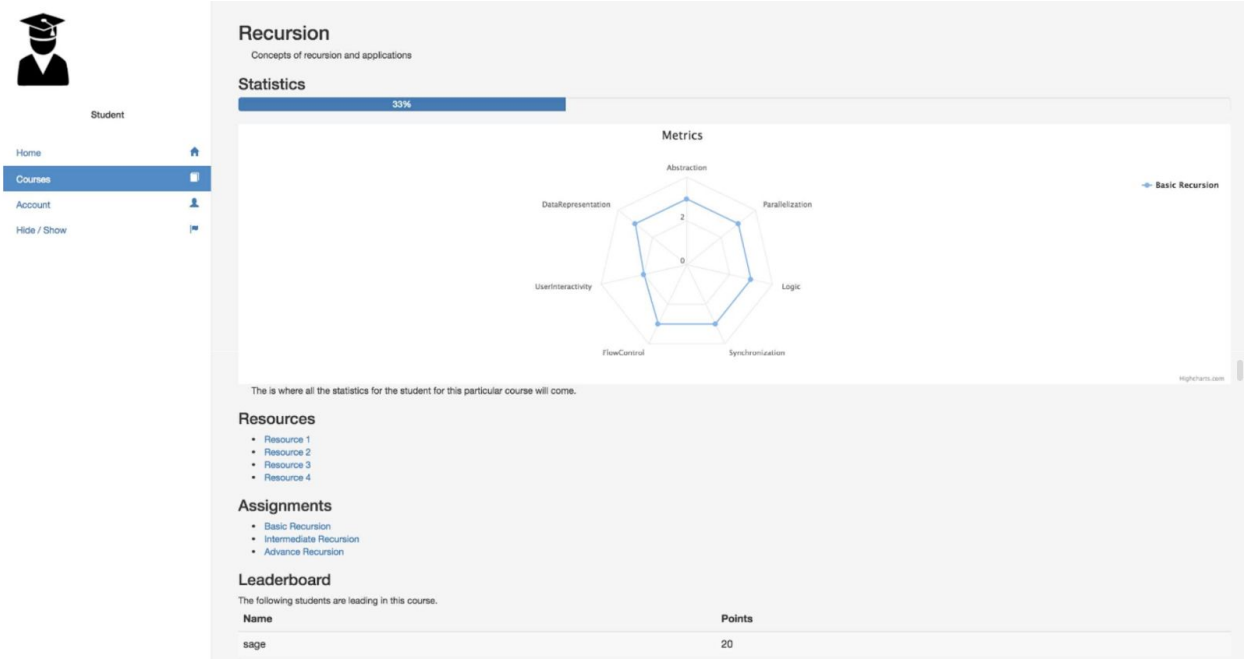


Figure 6. Spider Graph with CT Concept Score

On the teacher side, there will be an overview page to monitor the students' progress on per-Mission and per-Quest CT Concept learning in spider graphs. The basic format of the spider graph will be the same as what on the student side. First, for each mission, there will be a spider graph of the aggregated CT Concept score of all students. Second, there should be several buttons for each mission to show each CT Concept scores per-Quest. At last, there will be another bar chart to show all the students progress, so that the teacher will be able to identify struggling and high-performing students.

### 3.3 Teacher Interface

When logged into SAGE with an instructor's account, the web application will be directed to the teacher interface. The main purpose of this webpage is to provide easy access to tracking the progress and behaviors of students in the Quests.

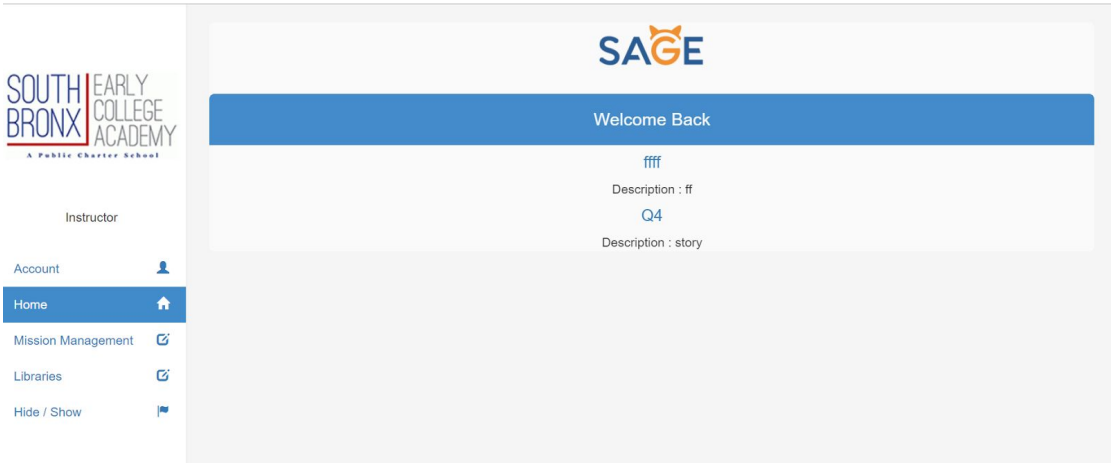


Figure 7. Instructor Homepage of SAGE Affinity Space

Above is the current Teacher Mission Monitoring interface. The current webpage is not well organised. The new structure Mission/Quest/Game should be adapted, rather than simply displaying all the Quests results in the Home space, so that the teachers can select any of their Missions and see a representation of their enrolled students on a per-Class basis and easily navigate into a Mission to view progress of comprised Quests.

### 3.4 Badge System

The badge system is a rewarding 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.

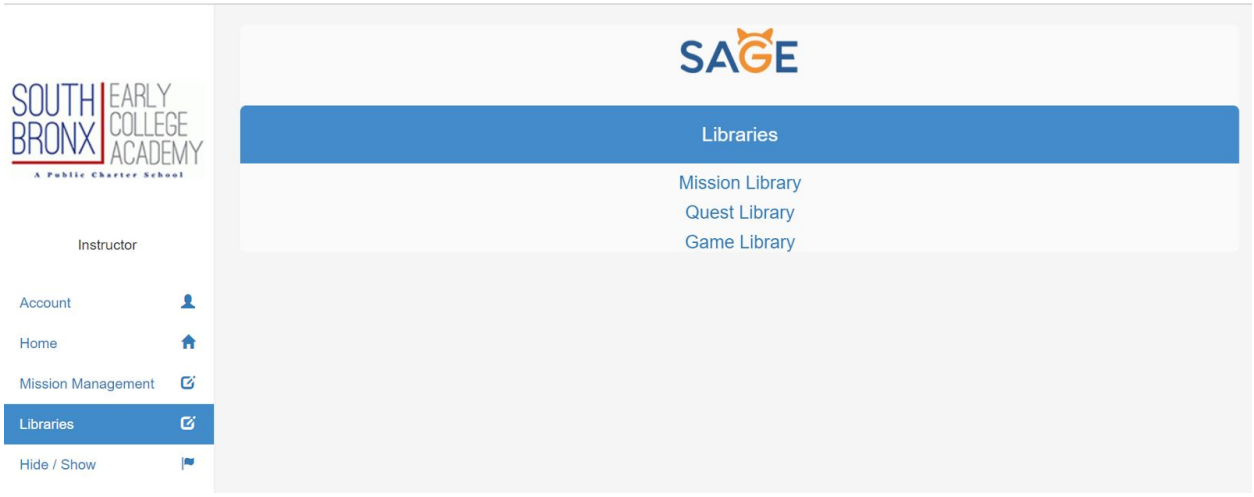


Figure 8. Instructor Libraries

There is almost no implementation in the Badge System yet. For the instructor, there is already a Library section with Missions, Quests and Games management in the Teacher's Dashboard now as shown above, so we have to add one more Badge management into this Library section, where teachers can manipulate the Badges in the database and associate them with different Missions.

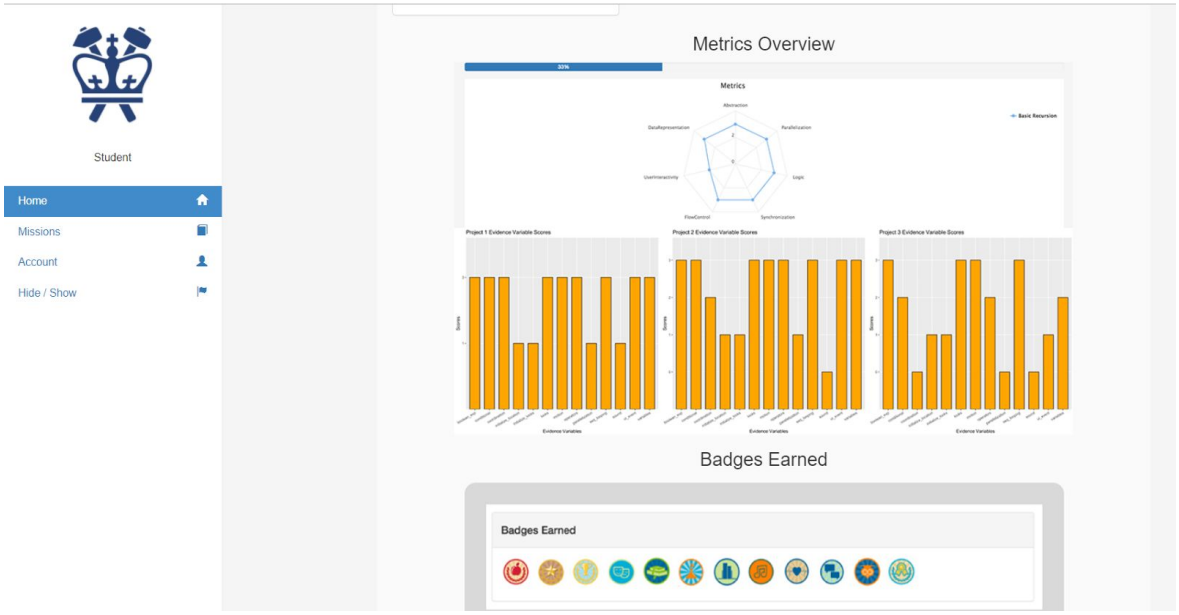


Figure 9. Purely visual implementation of current Affinity Space learning metrics

For the students, there is a spot left for displaying the badges earned in the student's homepage, as shown on the figure above. However, there is need for a seperate Completed Mission section where all the completed Missions and the comprised Quests of the students can be easily tracked and badges associated to them can also be better displayed in a way of earning history.

# 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 will focus on the Learning Metrics feature.

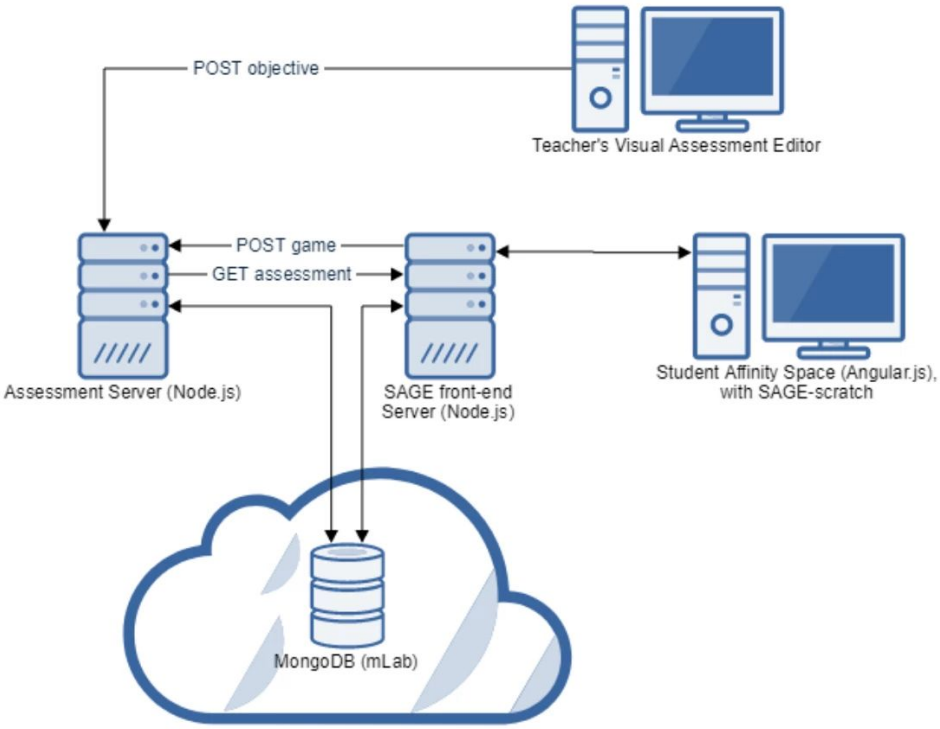


Figure 10. Affinity Space architecture model

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 should work on both servers in Node.js and also the front-end page in AngularJS.

# 5. Timeline

| Sprint Number | Milestone | Sprint End Date |
|---|---|---|
| 0 | Environment Setup | 2/15/2018 |
| 1 | Student Quest Difficulty level, Student quest Hairball analyses | 3/1/2018 |
| 2 | Student Quest Progress, Student Parson's Progress, Student Constructionist Game Progress | 3/15/2018 |
| 3 | Student CT Concept Aggregate Spider graphs, Teacher Spider Graphs | 3/29/2018 |
| 4 | Teacher Mission Monitoring, | 4/12/2018 |
| 5 | Badge Library, badge Earned | 4/26/2018 |

# 6. Conclusion

The implementation of the sections we have described in this proposal is relevant and necessary for future research that may involve field studies with students. By enabling students and teachers to monitor student progress, we hope to gain quantitative feedback on the efficiency and viability of various learning approaches. 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.

# Reference

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[2] Bienkowski, Marie, Mingyu Feng, and Barbara Means. "Enhancing teaching and learning through educational data mining and learning analytics: An issue brief." *US Department of Education, Office of Educational Technology* 1 (2012): 1-57.

[3] Wing, Jeannette M. "Computational thinking." *Communications of the ACM* 49, no. 3 (2006): 33-35.

[4] Wortham, Jenna. "A surge in learning the language of the internet." New York Times 27 (2012).

[5] Reese, Debbie Denise. "CyGaMEs: A full-service instructional design model harnessing game-based technologies for learning and assessment." In *The next generation of distance education*, pp. 157-170. Springer, Boston, MA, 2012.

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[8] Boe, Bryce, et al. "Hairball: Lint-inspired static analysis of scratch projects." Proceeding of the 44th ACM technical symposium on Computer science education. ACM, 2013.