# COMMIT: A NEW WAY TO STUDY

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ABSTRACT

Commit: A new way to study

Elliot Fiske

Computer-assisted learning is older than Turing machines, and constantly evolves as technology improves. While some teachers are resistant to using technology in the classroom [17], ”e-learning” techniques are becoming more common in almost every school, from K-12 to universities [23]. As technology becomes more widespread, it becomes crucial to examine the various methodologies of computer-assisted learning and find the techniques that are most effective.

This paper explores the effectiveness of one such methodology, spaced repetition. This technique applies to homework assignments available to students online. We include an exploration of several existing apps that use this technique, and introduce our own novel app, *Polycommit. Polycommit* was developed for use with several Cal Poly classes and was deployed during the first half of the Spring 2017 quarter. With careful attention to user feedback, we created a tool that motivated students to form better study habits. While our results show only moderate improvement to student grades, this tool gives insight into how modern technology and gamification can be leveraged to create an engaging app that encourages positive study habits.

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Chapter 1

# INTRODUCTION

## 1.1 Learning Technology

Learning technology has a large problem with usability and engagement. Learning technology typically has poor UI that leads to student confusion and low rates of engagement. In addition, it does not use modern approaches to how we understand learning and motivation.

In this paper, we introduce *Commit*, a novel web-based application that uses spaced repitition and gamification elements to educational courses. For this thesis, *Commit* was deployed to a variety of classes at California Polytechnic State University to measure its effect on student engagement and learning.

### 1.1.1 Why College Classes?

*Commit* was tested with classes at California Polytechnic State University to facilitate the creation of questions and evaluation of the application. While the app would work with any level of education from K-12 to higher education, using Cal Poly classes allowed us to easily create questions for classes that we had just taken

## 1.2 Spaced Repitition

One of the key aspects of Commit is its use of spaced repitition. Spaced repitition is an idea first brought into the mainstream by Pimsleur in the 1960s. Spaced repitition is a learning technique where students reinforce learned knowledge at specific intervals, improving long-term retention and recall ability.

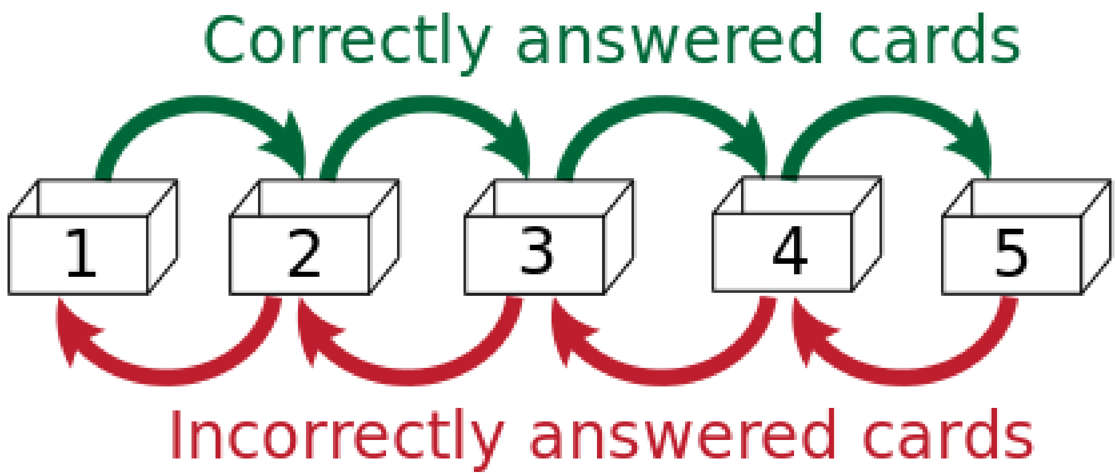


**Figure 1.1: The Leitner system. If a student answers a flashcard correctly, it is moved to a higher-numbered box that is reviewed less frequently.**

A simple example of spaced repitition is known as the Leitner system. Flashcards are organized into numbered boxes. (See **Figure 1.1**). Each successive box is reviewed less frequently. That is, a student would review Box 1 twice per day, Box 2 once per day, Box 3 every 2 days, and so on. If a card is answered correctly, it is moved to a box that is reviewed less frequently. However, if the student answers incorreclty, the card is moved to a box that is reviewed more frequently.

Thus, tougher cards are reviewed more often, and cards the student knows will be reviewed less often. However, all cards are *eventually* reviewed, and even cards that the student always answers correctly are reviewed in the long term.

There is strong evidence that this idea of "spaced repitition" enhances long-term memory and deepens understanding of subject material. [4]

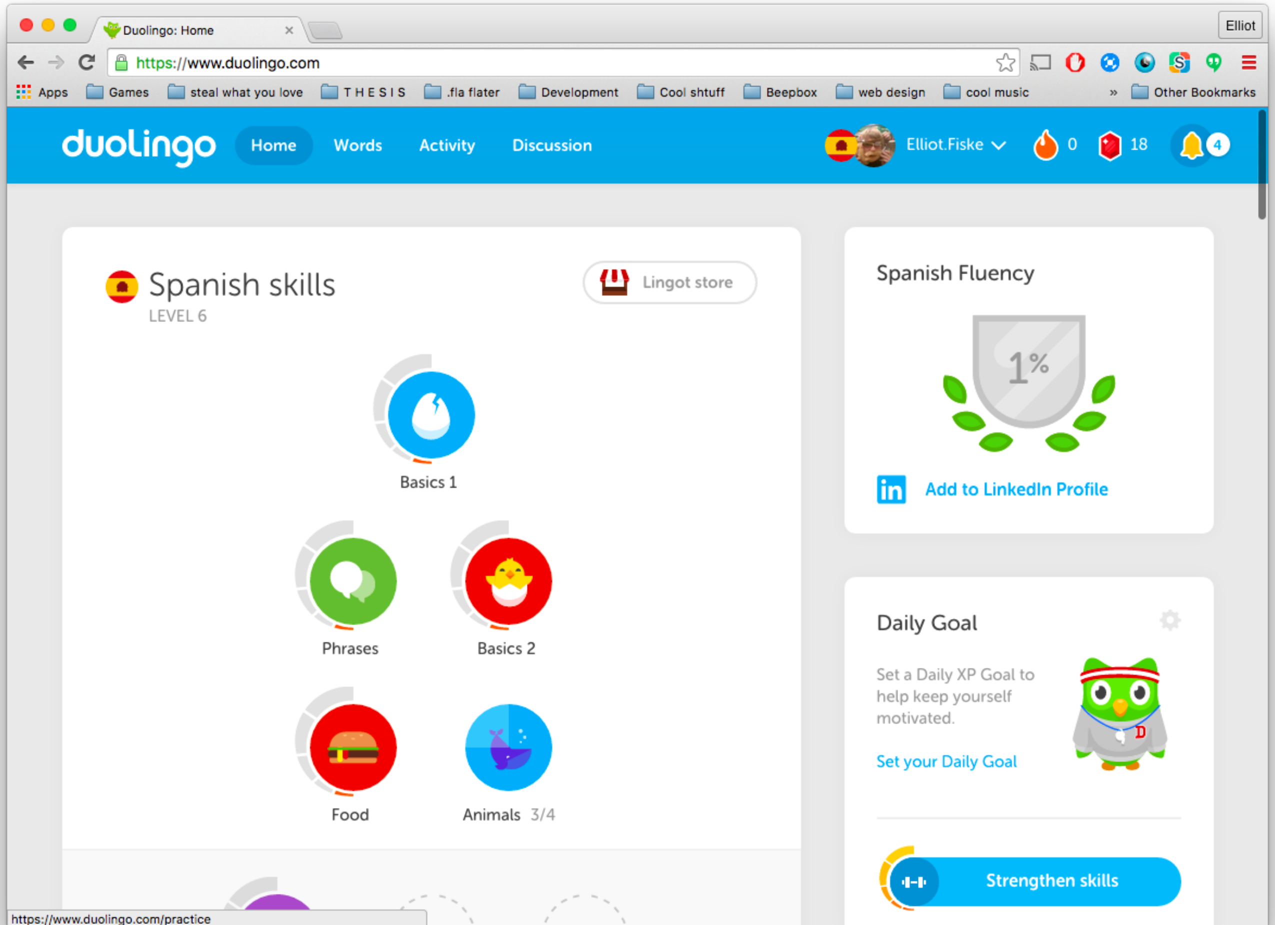


**Figure 1.2: The Duolingo interface. Notice the gamification elements and the encouragement to reach a "daily goal."**

## 1.3 Spaced Repitition Apps

### 1.3.1 Duolingo

Several recent apps and products make use of spaced repitition to allow user to easily gain long-term recall of languages, class content, or any other information that needs to be learned. One such app is Duolingo (See **Figure 1.2**); in Duolingo, users learn a language by repeating small tasks every day.

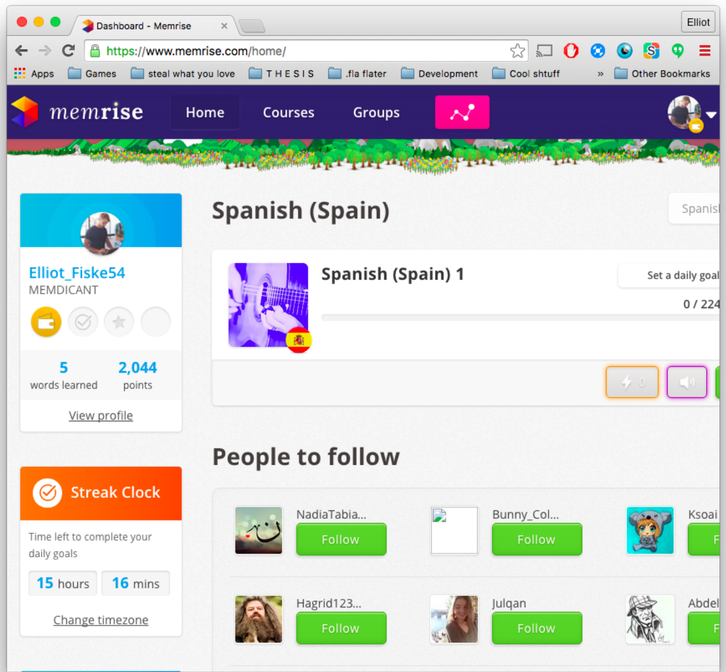


**Figure 1.3: Screenshot of the Memrise interface. Note the gamification elements, the social aspect, and the "Streak" clock encouraging consistent use of the app.**

The app encourages users to spend a small amount of time each day studying useful words and phrases, rather than cramming in a lot of knowledge at once. It encourages this behavior through the use of gamification. Each user earns "experience" in a language, eventually leveling up. Users connect their Facebook accounts and can see their friends' levels and accomplishments, adding a social element to the app.

### 1.3.2 Memrise

Memrise (See **Figure 1.3**)is a web app that has very similar function to *Commit.* Memrise takes a series of flashcard-based questions and answers and automatically creates a "study plan" where the application breaks up flash cards and uses spaced repitition to encode the information in the user's long-term memory. Memrise also uses gamification and social elements, as users earn points for every correct answer and can see their friends' scores.

Interesting to note is that users can input any data they choose into Memrise to receive a custom study-guide. This would allow students to easily learn flashcards if they took the time to input them into the app.

Both of these applications heavily emphasize language learning, since the process of learning a language can easily be broken down into a series of small words and phrases, and re-emphasized using the process of spaced repitition. However, Commit is scoped specifically to one class, allowing students to easily learn and retain class content without the commitment of adding their own flashcards.

### 1.4 Gamification

The *Commit* app is structured to incentivize students to enjoy using it. The primary incentive for experimental participants was the chance at winning a $20 Amazon gift card. However, in order to actually obtain this reward the participants would have to engage with the app's systems.

One powerful technique used by Commit is the idea of variable rewards scheduling. Variable rewards scheduling is based off of the idea that it's boring to always receive the same reward for performing the same action. It's far more exciting and engaging to not know what reward you'll receive; several studies affirm that variable reward scheduling leads to more willingness to perform a desired target action [3].

In order to earn entries into the $20 gift card raffle, participants are required to earn a certain number of **points.** These points are earned through answering questions. However, far more points are earned if the user returns to the app every day. In addition, "bonus rewards" will be awarded at random intervals to engage users more. The expectation that today may be the "bonus reward" day leads to greater user engagement with the system.

In general, users reported that they enjoyed the gamification sections and the potential to earn rewards. Through the study in general, we note that users showed higher rates of engagement and improvements in test scores over the control group that did not use the app.

Chapter 2

# BACKGROUND

## 2.1 Early Computing

### 2.1.1 Pressey and Skinner

Learning applications have been used since the early days of computing. BF Skinner [18] explained how computers could be used to facilitate learning. When Dr. Skinner wrote his paper, computers were used largely simply to test students about simple pieces of information. However, Dr. Skinner believed that computers could actually be used as teaching devices in and of themselves. Skinner argued that the main advantages of computers as teachers were that students are encouraged ”to take an active role in the educational process,” and notes that the practice of using automation dates back even to the 1920’s with Sidney L. Pressey’s automated testing machines. One huge advantage that Pressey noted with automated learning is that students learn at their own pace; one of the toughest challenges teachers face, according to Pressey, is that some students will fall behind while others feel bored because they already understand most of the material being taught. While Pressey’s automated teaching methods eventually succumbed to the fact that technology at the time wasn’t up to the task of automating education. Instead, Skinner was able to use the technology of his time to more effectively bring computers to the field of education.

### 2.1.2 Skinner Boxes and Operant Conditioning

Of course, BF Skinner is famous for his creation of the ”Skinner Box,” [19] a device that gave simple reinforcement to animals or humans in the lab in order to slowly shape their behavior, through a process known as operant conditioning. When a subject performed well according to the test, they would receive a quick reward, while if they strayed from the purpose of the test, they would not receive a reward.

### 2.1.3 Variable Ratio Reinforcement Scheduling

This method is combined with other interesting motivational techniques such as variable rewards scheduling [5] [6], where rewards are not actually doled out on a regular basis exactly according to the behavior of the test subject. Instead, rewards are handed out semi-randomly, varying in quantity and quality, while still mostly rewarding the desired behavior that the researcher is trying to condition. This causes the test subject to become conditioned much faster (See **Figure 2.1**).

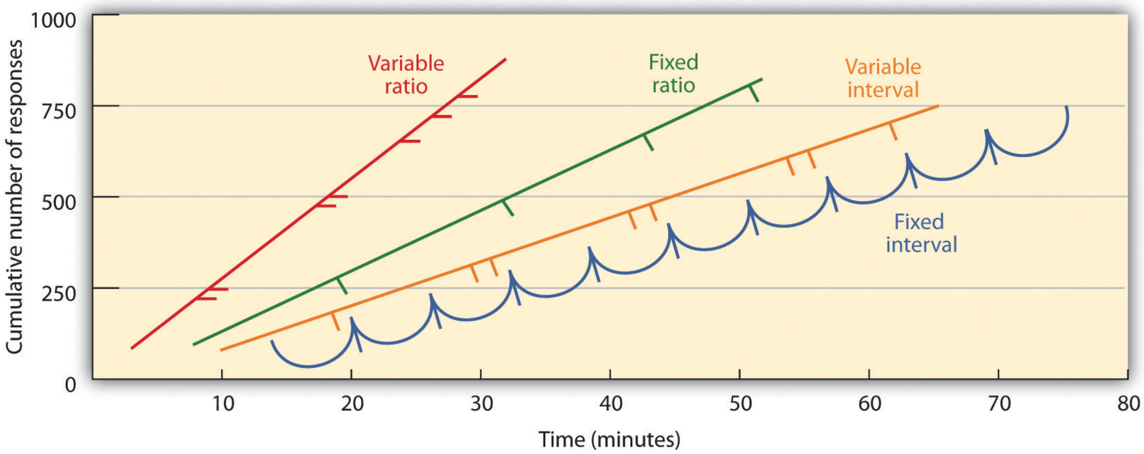


**Figure 2.1: Variable ratio rewards scheduling. Note that as rewards are spaced out randomly, the desired behavior appears much more quickly.**

[6]

## 2.2 Duolingo

As mentioned previously in the introduction, Duolingo is an app that already uses several of the processes that we are describing. Duolingo has been shown to be very effective for learning new languages, even perhaps more effective than typical classes. However, the effectiveness of Duolingo is mostly contingent on the motivation of the student. If the student is going to a foreign country soon, Duolingo is the most effective since there is a significant time pressure and pressure to learn the language in order to fit in at whatever country the student is planning to go to [20]. If, however, the student is simply learning another language for fun, there will be significantly less benefit to them. We must consider this as we develop our educational software; apparently the nature of the student's motivation and their reason for wanting to learn the subject material plays heavily into wheter or not they will be successful in using the app.

### 2.3 Habits

The study on Duolingo notes how difficult it is to actually get people to use the app. It is extremely hard to change people's habits, taking a lot of time and effort on the user's part to effectively change their behavior. One such strategy around this is to connect one desired "habit" behavior to an existing habit [10]. For instance, test subjects in the study by Dr. Lally determined that it was easiest to condition subjects to perform some action by instructing them to perform it right after eating breakfast in the morning. By using the powerful force behind an existing habit, it is possible to "reprogram" your behavior such that a new habit is formed with the new desired behavior.

For instance, if a subject wants to make a habit of cleaning their room, they can make a habit of picking up one piece of clothing after coming home from work for the day. In this way, the habit is driven forward by the regular schedule of coming home at a regular time each day. By associating one behavior with an existing behavior, it is possible to rewire a subject's brain to complete the second behavior far more often.

### 2.3.1 New Psychological Theories

It's interesting to note that the advent of "apps" and habit-forming application has created an essentially new field in psychology [15]. In a study, Dr. Renfree argues that the behavior modifications seen in apps like Lift and Memrise actually represent new advances into how habit-forming psychology operates.

Unfortunately, most of these new effects are actually negative. For instance, Dr. Renfree notes that oftentimes the new habits generated by these apps are "fragile," since they are so dependent on a tight dopamine-based reinforcement loop. As soon as the loop is broken, the brain "loses interest" and the new information is deprioritized. This will be an interesting consideration as we develop our application. We want to ensure that the habits and knowledge developed by our app is not simply impermanent, and that it won't be simply "pushed out" by new information.

Chapter 3

# RELATED WORK

## 3.1 Habit Formation

### 3.1.1 Habit Formation and User Interface

Previous work has been done to tie habit formation with online user interfaces [8]. In this book, Dr. Jeff Johnson describes how psychology ties into user interface design. He cites that familiar user interfaces lead to less mental stress, encouraging users to come back to your application repeatedly since it seems familiar and less stressful to them. We desire users to consistently use our application every day, so we must keep this in mind.

### 3.1.2 Memrise

As mentioned before, Memrise is an excellent example of habit formation. In one paper, researchers gauged the ability of students to memorise simple Latin phrases in a classroom setting. They found that Memrise is an effective tool

## 3.2 Gamification

Gamification in the classroom has several other examples that can be compared to our application.

### 3.2.1 Classcraft

Classcraft is an intriguing example of gamification in education (See **Figure 3.1**). In Classcraft, students choose a "role" and go on the equivalent of a World of Warcraft raid with their fellow classmates. Classcraft is interesting in that it promotes co-operation and a variety of skills, so that students can assist each other where they might not have a certain skill.

Classcraft takes the typical elements of an RPG and converts them into an experience that supplements a typical classroom experience.


**Figure 3.1: Classcraft user interface. Note the student's health and mana pool, as well as the list of other students in the classroom.**

[6]

Interesting to note is the emphasis Classcraft puts on integration with existing technologies such as Google Classroom. In order for this application to be widely adopted, it is definitely necessary to have the experience of the teacher go extremely smoothly. Thus, if an application ties directly in with existing technology that the teacher is already familiar with, it will be much more readily adopted by the educational community. It's important to value the teacher's time with this application, so it is necessary to make the UI recognizable, familiar and easy to work with, as well as integrating it with existing tools and perhaps even modeling the user interface after tools that many teachers will already be familiar with.

### 3.2.2 Classcraft Study

A study was done on the effectiveness of Classcraft as well as "ludicization" in the classroom in general [16]. Their study ran primarily in France, as this is the home country of the Classcraft company and application.

One interesting aspect is that the study primarily focused on

### 3.2.3 Gamification in Other Educational Areas

So far, we have considered gamification in the classroom mostly in the context of STEM or language fields. While gamification does lend itself towards these subjects, as math problems and science problems can be easily generated by an algorithm, there have also been steps to gamify aspects of classes around liberal arts and the humanities [21].

This study by Dr. Wagner approaces a music class the same way Classcraft approaches subjects not focused on the humanity. It highlights the idea of a "flow" where a student is fully immersed in the educational process and is fully engaged with the learning process, and notes that it is far easier to attain this "flow" state when the student is learning in the context of a video game.

Chapter 4

# EXPERIMENT

We carried out an experiment at California Polytechnic State University to test the efficacy of habit-based educational software. We created a web-based application called *Polycommit* that was connected to 4 college classes: **Introduction to Computer Networks**, **Introduction to Computer Graphics**, **Introduction to Computer Networks**, **Introduction to Operating Systems**, and **Linear Analysis I**. These classes were selected because they covered subject matter that was easy to convert to online quizzes. For instance, one staple Linear Analysis problem is to find the determinant of a matrix (often a whole number), which is easy to input into an online form. In addition, I had taken these classes in recent quarters and was familiar with the course content.

We presented Polycommit to each of the courses in the first 2 weeks of class. Students voluntarily signed up through a website hosted at https://polycommit.com/, where they were able to log in with one click through the main Cal Poly portal. This lets students easily access the website, while also guaranteeing that only Cal Poly students can sign up for the program.

## 4.1 UI Overview

### 4.1.1 Home Scren

Upon logging in, students click "Enroll" for the classes they wish to participate in. Upon enrolling, the classes are listed under the "Enrolled Classes" section (**Figure 4.1**). This page also lists the two main "scores" that students earn by answering questions: **Commitment** and **Points**.

Commitment is a numerical value that represents how many *unique* days a student has answered a question on the website. Students could earn up to 1% extra credit on their final grade in the class by getting 15 Commitment.

Points are earned by answering questions. More points are awarded for correct answers, and bonus points are awarded based on the user's current Commitment. All participants in the experiment were placed in a raffle for $20 Amazon gift cards. Additional entries into the raffle were awarded by earning more points.

### 4.1.2 Course Screen

Each course page has a list of challenges (**Figure 4.2**) that are open to the student. Challenges are organized into **Weeks**. If a student has completed all the challenges in a week, the week is displayed with a green check mark and does not expand. If there are open challenges in a week, the week is displayed in yellow with an "alert" icon, indicating that the student has an available challenge. This UI imparts a sense of urgency to the user, since they could potentially lose opportunities to earn Commitment by not answering a question in a . Each challenge also lists the date it was opened, and the number of points awarded if the challenge is already completed.

Finally, the Course page lists the student's points and Commitment for the course, along with a tooltip that explains what "Commitment" is. This information is repeated from the Home page, since it is the most relevant information for the user, and it is inherently satisfying to watch your points and Commitment rise as you complete challenges.

### 4.1.3 Challenge Screen

The challenge screen is where students see the content of a challenge and input their answers. A challenge can either be Multiple Choice, Short Answer, or Numerical. An example of a simple Multiple Choice challenge is at **Figure 4.3**.

At the bottom of the Challenge screen is a link to submit feedback about a question. Through this link, students are brought to a Google form where they can provide feedback about a particular question. The feedback form is viewable at **Figure 4.4**.

Once the challenge is closed, students can see a list of their previous attempts along with the correct answer to the problem. Certain problems have their answers hidden; for instance, all Linear Analysis problems don't show their answers because many challenges on *Polycommit* are directly from the assigned homework. Hiding the correct answer prevents students from quickly inputting a wrong answer to see the homework solutions. Additionally, if a question has received feedback as being confusing, an "Explanation" field provides detailed context about the answer the problem and potential pitfalls (See **Figure 4.5**).

### 4.1.4 Toasts

*Polycommit* uses "toasts" to convey temporary, state-based information to the user. For instance, when the user answers a question, they get immediate feedback in the form of a pop-up toast. Positive information, such as a correct answer, is styled with a green background and a check mark. Negative information, such as an incorrect answer or a server error, is bright red with an alert symbol that commands the user's attention. Examples of each are at **Figure 4.6**.

## 4.2 Technology

All the code for *Polycommit* is available here: https://github.com/elliotfiske/commitment

*Polycommit* has its origins in a Summer 2016 section of Dynamic Web Development (CPE 437), taught by Dr. Clint Staley. The base code and overall code architecture remain, as well as some of the platforms used. The app runs on a M*EAN stack. It uses Node.js as a backend, with Express as a routing service and MySQL as a database. In addition, Sequelize is used to easily interface with the database from Javascript. Angular.js is used as a frontend framework, supplemented by Bootstrap for reactive layout.

Node.js and Javascript lends itself well to quick, iterative development. As a dynamically typed language with easily nestable functions, it is easy to quickly make sweeping changes based on user feedback. However, since Javascript is an interpreted language, potential errors that a compiler could have caught may make it through to the live site. Because of this, it was extremely important to regularly run the backend code through comprehensive unit tests.

#### 4.2.1 Test-First Methodology

All of the backend server code is thoroughly covered by various test cases. I used the service *Postman* to maintain a suite of tests that ensured all the data involved in *Polycommit* was both available and secure. *Postman* allows developers to run a series of web requests against a server, and verify that the correct response or error code is returned (See **Figure ??**). For instance, one test suite logs in as a student and attempts to complete a challenge, create a class, and query the information of another student. Only the first request should complete successfully; the student's unprivileged account should not be able to create classes or see other students' data.

Writing test cases for new server functionality *before* beginning development allowed me to see edge cases before they arose, and allowed for the satisfaction of seeing the tests pass as I completed each feature. In addition, it protected the privacy of students' answers and scores.

## 4.3 User Feedback

Throughout the duration of the experiment, I received a large amount of excellent feedback about the usability of *Polycommit*. At the bottom of each page is a

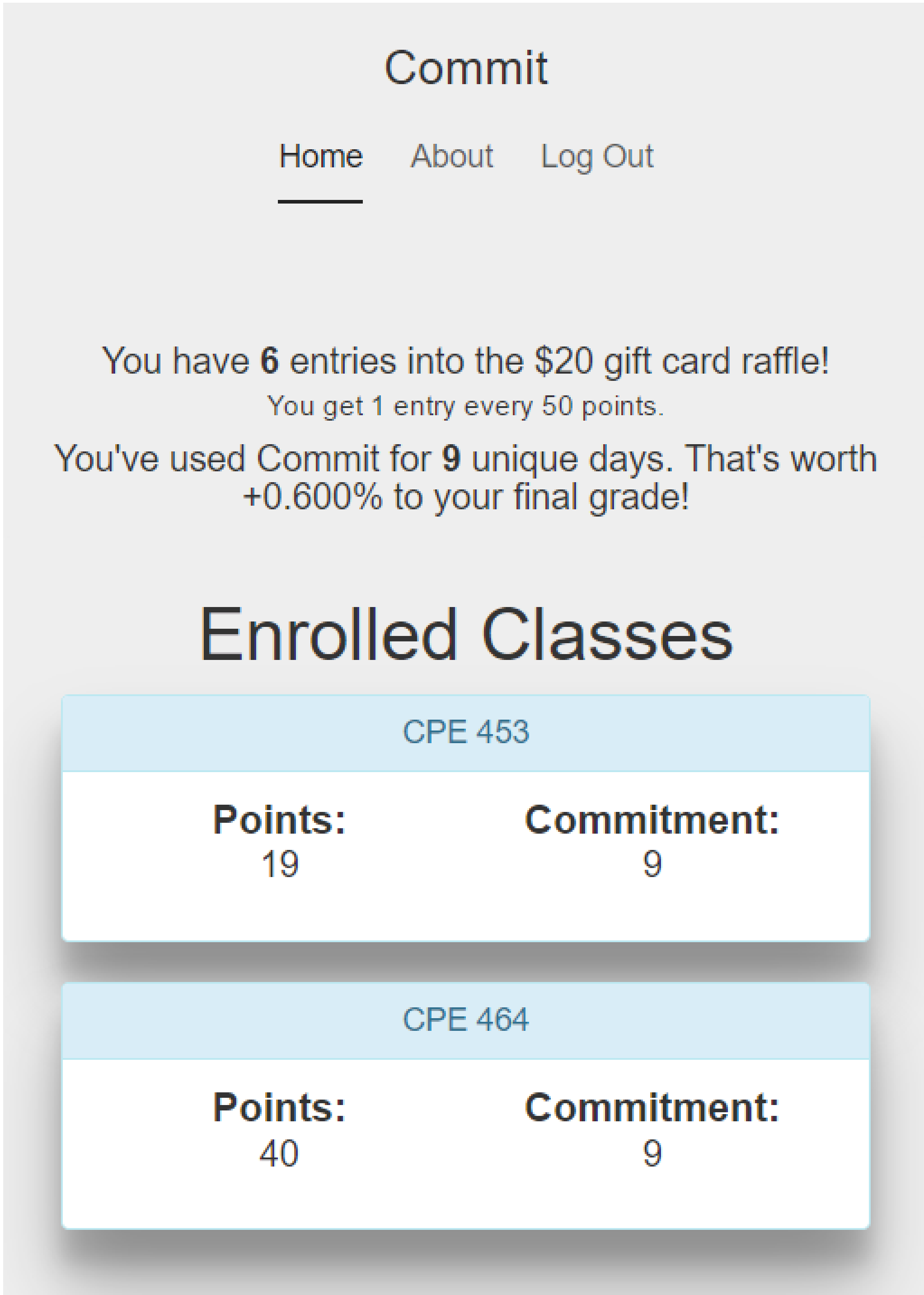


**Figure 4.1: The "Home" screen for Polycommit. Students can see their current progress and can click on a course to answer challenges.**

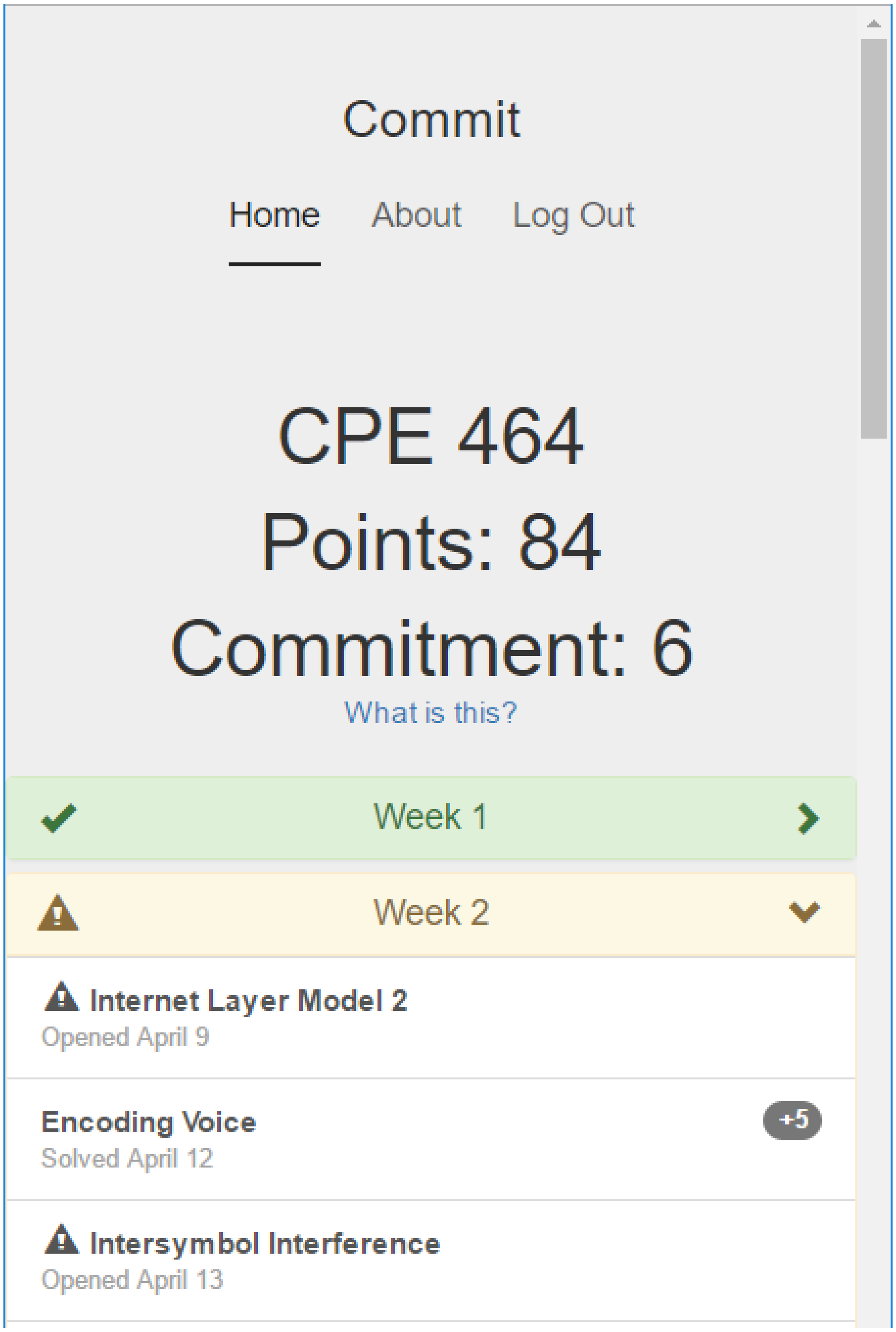


Figure 4.2: The "Course" screen for Polycommit. Students can see their current Points and Commitment and can see a list of challenges organized by date.

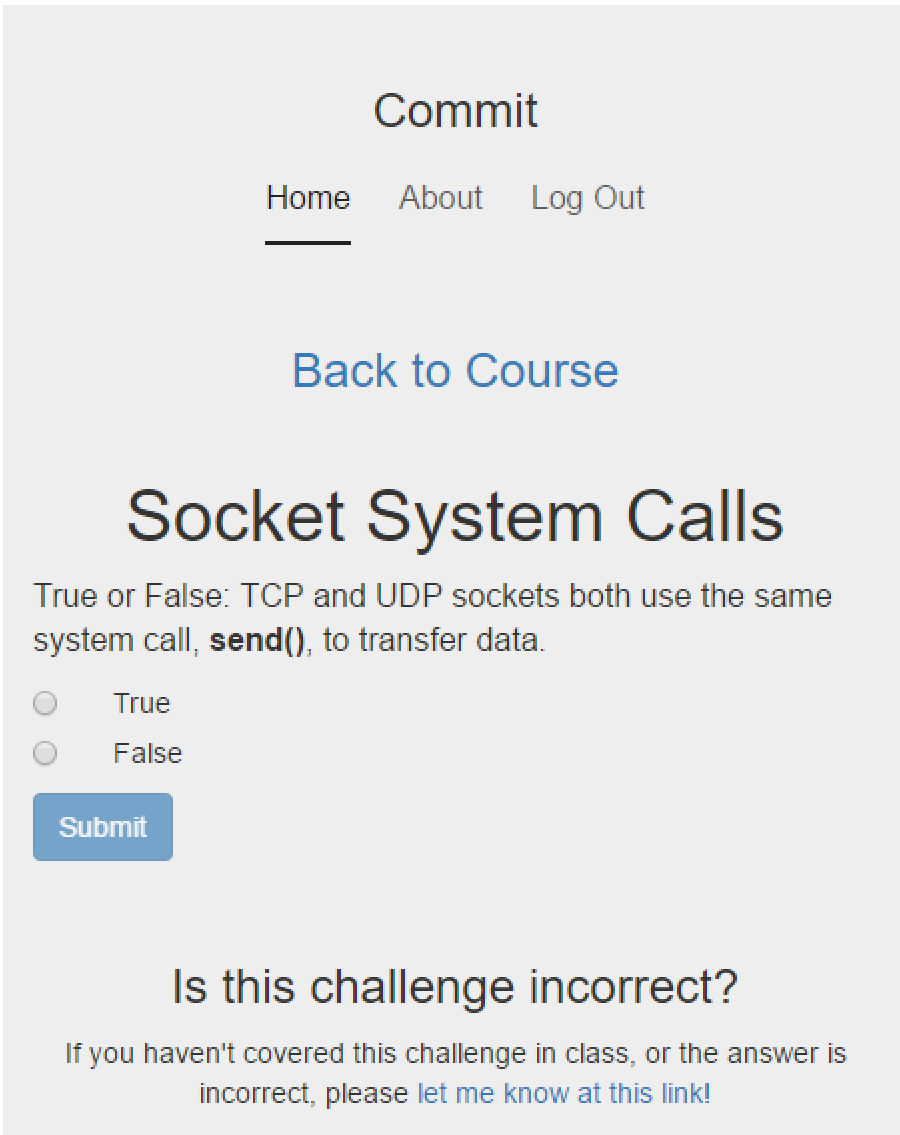


**Figure 4.3: The "Challenge" screen for Polycommit. Students see the content of the challenge and can enter their answers. At the bottom is a link where students can give feedback on a challenge.**

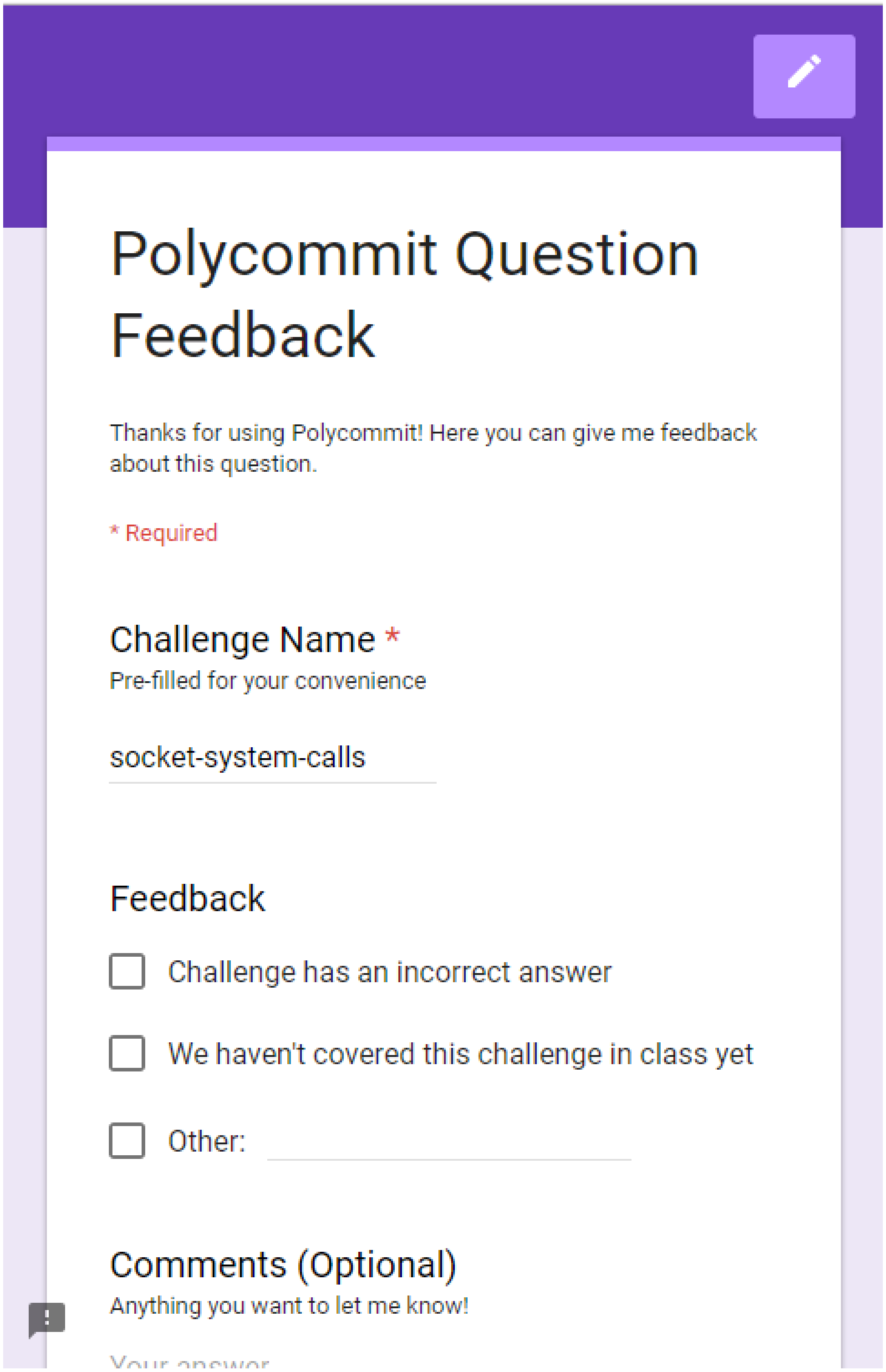


**Figure 4.4: The Feedback form for questions. The id for the question is automatically filled in. The student can optionally enter their email address (off-screen) if they want to be contacted when the challenge is fixed.**

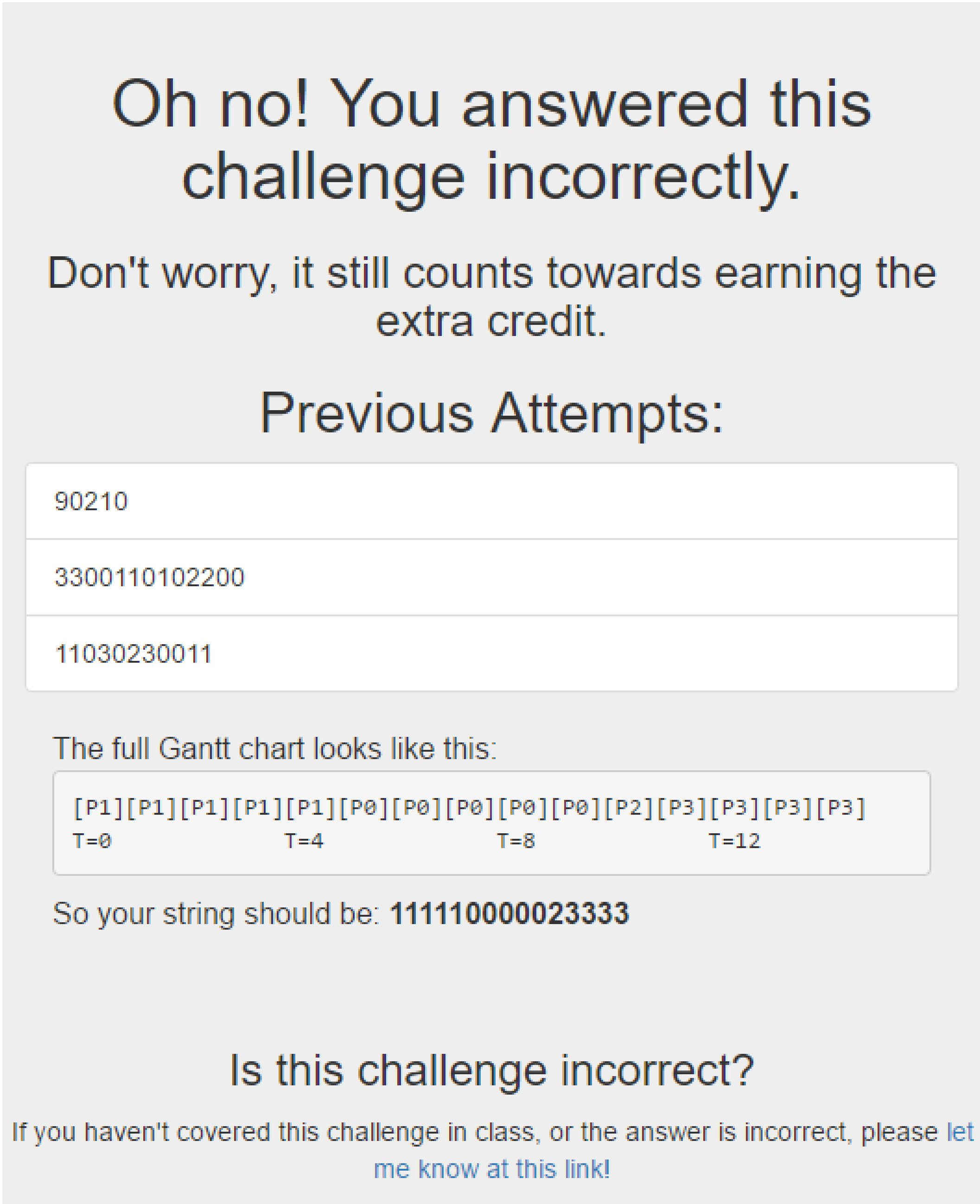


**Figure 4.5: The view of a challenge once it has been answered incorrectly. The main message assures the user that it still counts for Commitment. A full explanation of the problem is under the list of the user's attempts.**

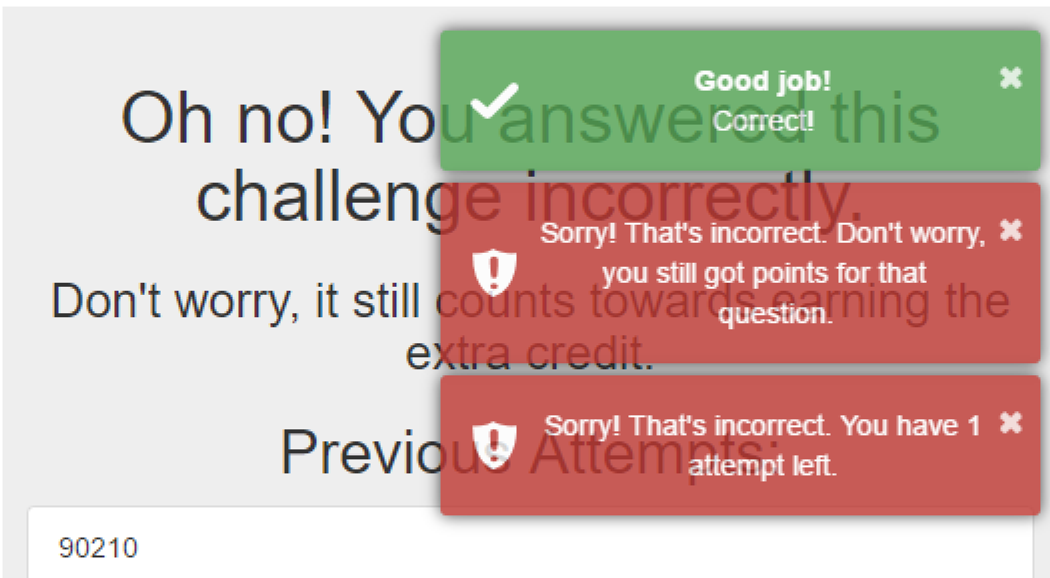


Figure 4.6: Three examples of "toast" notifications. These provide useful state-based information, such as whether a challenge was answered correctly. They also can provide feedback if an error occurred, such as a challenge not submitting due to poor network connectivity.

Chapter 5

# VALIDATION

## 5.1 Results

The experiment was carried out across the first half of the Spring 2017 quarter at Cal Poly. 130 students signed up across 4 classes. By the end of the experiment, just over 3200 answers had been submitted to the application.

Currently, we only have access to exam data from Introduction to Operating Systems. The exams were held completely through an online quiz form, making it easy to analyze the resulting data. Data collection for the rest of the classes is ongoing.

### 5.1.1 Limitations

Certain restrictions were necessary in order to run this experiment. Most importantly, according to Cal Poly's human research regulations, studies about educational tools must be offered to all participants in a class. Thus, there was no true "control group" since any student could opt-in or opt-out of using the application.

### 5.1.2 Overall Data

First, consider the relationship between a student's overall score on the midterm and their Commitment (**Figure 5.1**). No student that actively used the app (more than 10 Commitment) got less than 30/50 as a final score. This supports the idea that students benefit from consistent repetition over a longer period of time.

Next, consider the mean of all midterm scores between students that didn't answer

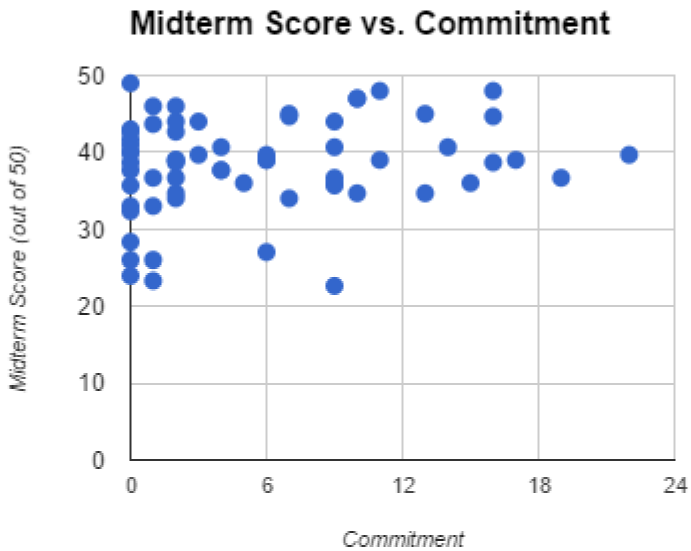


**Figure 5.1: Graph of Commitment versus the student's score on the midterm.**

*any* questions vs. the ones that did. Students that didn't answer any questions in the app scored slightly higher on average than the students that didn't.

| | Users | Non-users |
|---|---|---|
| Midterm Average | 39.37 | 36.27 |
| Population Size | 43 | 21 |

### 5.1.3 Individual Questions

Certain questions on the midterm matched closely with the content of the questions that were repeated on Polycommit. We can match scores

## 5.2 Conclusion and Future Work

After we have collected the data from the remaining classes, we can get a more in-depth understanding of how using *Polycommit* affected student understanding of the course material and test scores.

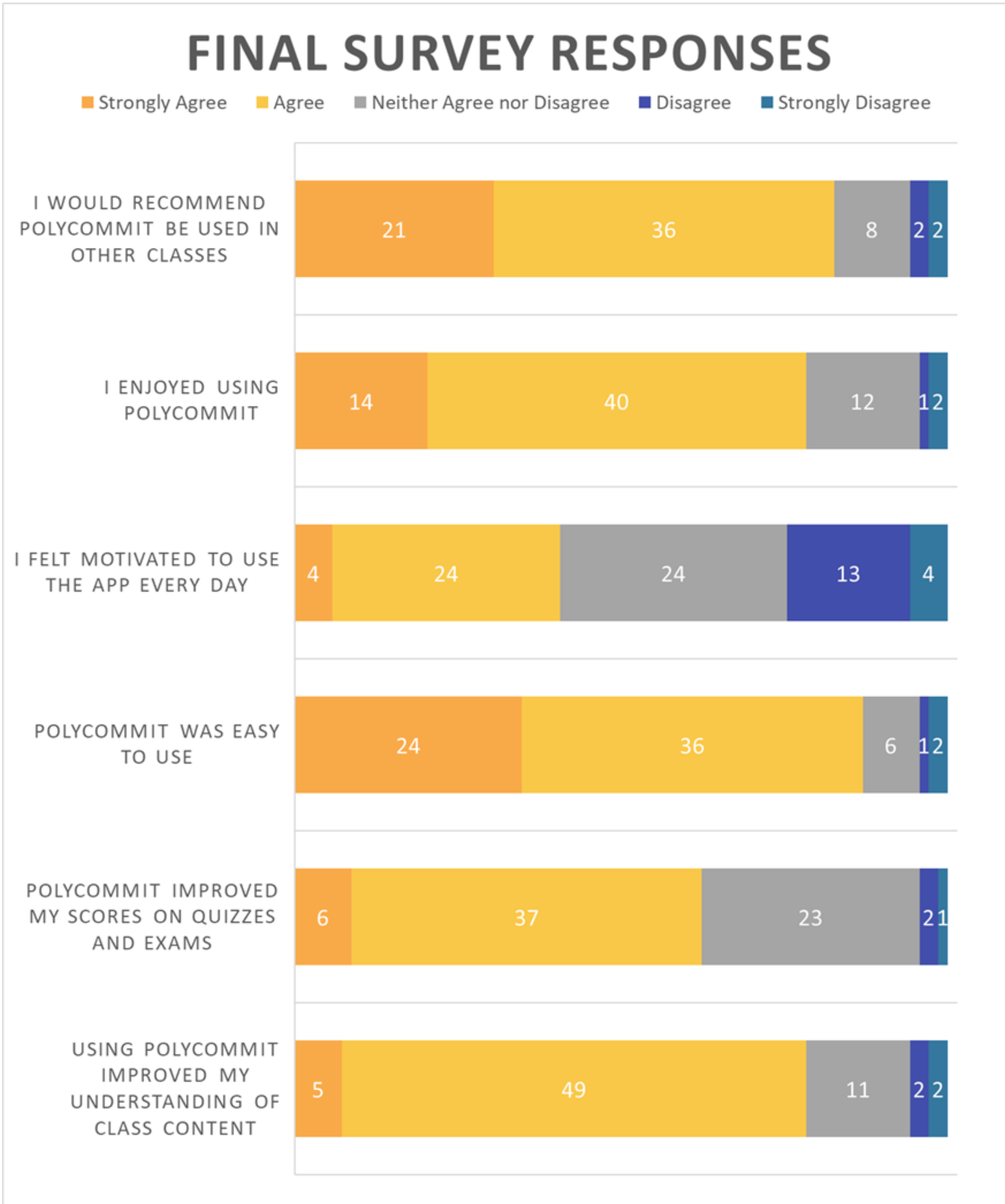


**Figure 5.2: Survey responses from users of Polycommit.**

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