Evaluating the effectiveness of the Section Leader program on CS-151 student performance at Willamette University

A Project Proposal

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1 Background and Motivation

Introductory computer science courses have long wrestled with several impactful problems. On the one hand, computer science education can not offer the salaries and benefits of the modern commercial tech-world, and thus attracting driven and skilled faculty is difficult. Yet the demand for basic programming skills, both from students and industry, has never been higher. To compound this mismatch of faculty and student numbers, students entering introductory computer science courses often have immense differences in computing backgrounds, existing technical skills, and mathematical sophistication, each of which complicate teaching what are often large classes. Furthermore, computer science as a field continues to struggle with aspects of diversity which can make it difficult for students, especially for under-represented demographics, to envision a future for themselves in the field.

In an attempt to address some of these issues, the Section Leader program was started at Willamette University in the Fall of 2020, and distributes introductory programming students across a small cadre of selected and highly competent student leaders. These leaders are current undergraduate students who have taken and excelled in the CS 151 course. They might be computer science or data science majors, but it is not required. These leaders meet with 7-10 students weekly for 1 hour to go over example problems and tutorials related directly to current class assignments. Additionally, the section leaders serve as individual tutors to their students, meeting with them outside of section hours, as necessary or requested, to help troubleshoot or explain more difficult concepts. To date approximately 20 students have been hired and served as section leaders, with most continuing to serve repeatedly until their graduation.

Despite being four years into the program and the program being a seeming success, a more formal study of the effectiveness of the program on Willamette CS-151 students has not yet been compiled. This project seeks to answer the question "*How has the Section Leader program at Willamette University impacted student performance and participation in the CS-151*

course?". Of particular interest is how student participation in the Section Leader program has helped student grades, student equality, and student engagement in the course material.

2 Data Sources

I am in a fortunate position where I have been helping to organize or run the Section Leader program since its inception, and also regularly teach at least one of the CS-151 lecture sections. As such, I already have a large collection of data that will prove useful to this study. That includes:

- Section attendance information for all students. Any student in CS-151 on a given semester was assigned a section leader, and section leaders keep attendance on what students attend each week. This will be used to determine what students really participated in the program for the purposes of comparison. While not a perfect metric, since there are a variety of reasons a student might not show up to their section meetings, it should still allow us to look for benefits offered by the program.
- Student grades. For my own classes, I have all student scores, both per assignment and overall. Since 2022, the section leaders have been scoring the major class projects, and thus I also have ready information about how students performed on each project. To extend the data, I will also reach out to other faculty who have taught the CS-151 course over the same duration to ask for anonymized overall course grades for students. By linking this data to the section attendance data, the hope is to look for a clear separation in scores between those that attend the small sections, and those that do not.
- Student classroom attendance. The hope is that the Section Leader program boosts student engagement overall, and one area that might show is in classroom attendance. Because classroom attendance does play a small role in my overall course grade (which will unfortunately be an obfuscating factor), I have attendance data for all of my own students. Many of the other faculty also track attendance, and thus I should be able to get overall classroom attendance metrics for other course sections as well.

All the data can be linked or joined on unique students, and overall should provide a decent base upon which to build out analysis and conclusions. There are absolutely some privacy concerns which I will address in a below section, but they should be surmountable.

3 Methodology

As part of our methodology we are tasked with showcasing several methods and skill sets, which I will highlight below.

3.1 Statistical Thinking

There are several relationships that we are looking for, particularly between section attendance and class grades, and section attendance and lecture attendance. While this is an observational study, and we will be able to make no claims of causality, we can still look for statistical trends between these values. If we are working with percentages, we can at least look at correlation coefficients, and proceed further with linear regression of the trends seem linear. It may very well be the case though that we need to threshold the data into two groups: students that regularly attend section and those that do not. In that situation, we could then use a t-test to compare the average scores of the two groups, with our uncertainty being summarized by a confidence interval.

3.2 Data Visualization

The most obvious visuals would involve a scatter-plot of section attendance vs either course grade or course attendance to demonstrate correlations or any sort of linear trend. Should grouping be necessary, either for privacy or noise reasons, a comparison with two box-plots and error bars would seem the logical direction to go. As a control, there will probably need to be a visual (and analysis) comparing the course grade to the course attendance to try to disassociate how much that correlation might be reflected in the section attendance correlations.

3.3 Data Engineering

Most of the data engineering will already happen within the data collection stage. All data I already possess is embedded within relational database tables, but would probably be selected out and placed in its own database for the purposes of this project and analysis. Data coming from other faculty would then be added directly. Data will be accessed for analysis purposes in Python using SQLAlchemy to connect directly to the database.

3.4 Machine Learning

As an alternative way to gauge the strength of correlations between section attendance and our observable metrics, at least one machine learning model will be trained to attempt to predict student class scores given section attendance. This will probably work best with actual percentage data, and thus may require some decisions around the ethics of identifiable students. Should this not prove tractable, a reduced version may be trained around predicting whether a student passed a class given a section attendance score. Ostensibly, a strong relationship should result in a model that is fairly accurate in these predictions, given the simplicity of the model, whereas a weaker relationship would result in a predictive model that performs poorly. Unfortunately, even pulling from the past several years and multiple faculty, the data set may

remain somewhat small (likely less than 250 individuals), and so large amount of noise in the data may effectively limit or handicap most ML models.

3.5 Data Ethics

Student scores are private between students and the faculty that granted them. According to FERPA, sharing of such scores is generally only allowed on a "need to know" basis, which this type of study would not qualify for. As such, any scores coming from other faculty would need to be anonymized, with those faculty setting up the necessary links between student attendance, score, and section attendance. This should be possible and would largely make the data non-personally identifiable. Should it be needed though, an extra step could be taken to only work with letter grades, instead of percentages. This should effectively make it impossible to personally identify particular data points, but doing so throws away the extra resolution that percentages would yield. Whether sure a sacrifice is necessary will need to be investigated, but some variant of the analysis can exist regardless.