

Socratic Seminar in a Computer Science Classroom

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ABSTRACT

This study was conducted to determine the benefit of using Socratic Seminar as an instructional strategy in Advanced Placement Computer Science. The use of Socratic Seminar has been successfully implemented in many English language or philosophy courses however there is limited research on its use in courses such as mathematics or computer science. This study examined the effectiveness of Socratic Seminar to prepare students for the free response portion of the Advanced Placement Computer Science exam. Additionally, the study measures student confidence about their ability on the exam. The study used Socratic Seminar as the method to prepare students for the AP Computer Science exam free response questions. The students were tested before, during, and after the seminar treatment to test the amount of change in their scores on the exam. Additionally, students were given a survey before and after the treatment to gauge their confidence on the AP exam. The effectiveness of the Socratic Seminar teaching style was measured by the change in student test scores as well as the change in student confidence as measured by a pre and post survey. The study results showed that students scored at or above the national average on the post-test. Student confidence on the AP exam and in Computer Science went up though there was a decrease in student desire for group work and peer tutoring.

1. INTRODUCTION

Advanced Placement (AP) Computer Science is an elective subject in which most students do not enroll. According to the College Board statistics, in 2015 48,994 students took the AP Computer Science exam representing 4,310 schools. By comparison 302,532 students took the AP Calculus exam and 195,526 students took the AP Statistic exam [3]. Part of the problem is student confidence in their ability to be successful on the exam, specifically the free response portion. Another limiting factor in students engaging with Computer Science is lack of exposure due to a lack of qualified teachers and schools offering Computer Science as a high school course of study [4].

This paper details a study focused on an alternative methods of instruction in AP Computer Science and to examine the impact on student achievement and student confidence. By exploring additional, non-traditional pedagogy within

Computer Science, it is hoped that the field will be able to build upon the research done in other fields. As a comparatively young subject, increasing knowledge around computer science pedagogy will assist in codifying computer science best practices and help build a foundation to train more qualified teachers.

The specific focus of this study was to determine the effectiveness of Socratic Seminar as an instructional method in an AP Computer Science course. Student achievement was measured by using previous AP free response questions as pre-test, midpoint test, and post-test to ascertain student growth over the course of the study. Students were also surveyed before and after the study about their confidence in passing the AP free response as well as their feelings toward group discussion as an instructional method.

2. SOCRATIC SEMINAR

Named for the method used by Socrates, the Socratic Method uses questioning and dialog to encourage participants to find the true nature of the world. Socratic Seminar is a derivation of this ancient questioning technique that follows a similar technique. In Socratic Seminar, the class begins by examining a text. This text can be a book, article, problem, or something that can focus the class discussion [2]. The students in the class then discuss the text, question each-other, and come to a group understanding by challenging and defending their understanding of the text in question.

Since the goal of Socratic seminar is to have students develop their own truth, it is inherently a discovery-based approach. There is not a set “right” answer that the students achieve, but rather the teacher facilitator guides discussion moving students toward their own truth through leading questions and cross-examination. Socratic seminar asks participants to explore, conjecture, and defend ideas about how they believe the world works. Historically this has been used to answer philosophical questions or to determine thought process or motivation of a fictional character. As a result, this technique has had much more success in classes such as English and Social Sciences and has not been implemented in math or science classrooms as frequently [1]. The limited studies that do exist have shown a positive connection to student growth and engagement in the subject

area through use of the seminar method. Researchers found students in a mathematics course had higher rates of engagement and better retention when presented with the Socratic Method in class as opposed to the more traditional methods of teaching math [8].

Documentation of existing studies of this style of teaching implemented in a computer science context are not readily available. Therefore, the results of the existing studies cannot be directly applied to computer science. Additionally, since teachers tend to teach in the manner they learned, courses like math and science, and by extension computer science, continue to be taught in a more traditional manner and the Socratic method remains tucked away in English and history classes [5].

2.1 Need for Alternative Pedagogical Methods in Computer Science

The Omaha (Nebraska) Chamber of Commerce conducted a study in 2013 that found a shortage of qualified Computer Science professionals in the state of Nebraska. The shortage is so severe that if all the Computer Science students from all the state's universities, upon graduation came to Omaha for computer science and technical jobs, there would still be a substantial shortage of Computer Science professionals [6]. This problem is worsened by the lack of Computer Science offerings across schools in the country and, where Computer Science is taught, a misrepresentation of the population where very few women and minority students take Computer Science courses [9].

In the course of their work with the Los Angeles Unified School District, Jane Margolis and researchers from UCLA found that minority students could be interested in Computer Science through the use of culturally relevant problems and more inclusive language [9]. Through this research, the Exploring Computer Science (ECS) curriculum has been taught in Los Angeles, New York, and is required of all students in Chicago, in addition to countless other schools that have used this curriculum to bring Computer Science to their schools.

A variety of teaching approaches allow for inclusivity in Computer Science classrooms. Traditional methods that cater to traditional Computer Science students are not as effective at bringing non-traditional computer science students into the field. Socratic seminar has been shown to be an effective teaching method across all gender, racial, and socio-economic divisions in English Language Arts and Social Science courses [5].

2.2 Socratic Seminar in CS Classes

Computer Science education has long been a boys' club and only available to the most affluent schools [2]. Even among students who self-select to take the AP Computer Science course, only 33% of those students take the AP Exam at the end of the semester to get college credit, compared to 68%

of students in AP Calculus [11]. Not only are most students not taking Computer Science in high school, the majority of students who do take Computer Science do not participate in the AP exam. This speaks to the issue of self-confidence among potential test-takers. The premise of this action research study is that by preparing for the AP exam using an alternative instructional method, it is hoped that students will not only perform better on the exam, but they will have greater confidence in their abilities, leading to a higher percentage of students taking the exam.

By exploring alternative methods of teaching Computer Science, it is hoped that pedagogy can be found that support all learners in a way that is currently missing from Computer Science education. Socratic seminar has the potential to be a methodology that changes the dynamic of the Computer Science classroom itself from one that is closed and isolating to one that is open, vibrant, and full of discussion of ideas.

3. METHODOLOGY

3.1 Demographic Data and Information

This study was conducted in a section of AP Computer Science class, offered as an elective to students grades 10 to 12. The cumulative focus of this class is the AP Exam which is given in two parts, a multiple choice section and a free response section. Students frequently elect to opt out of the exam for fear of failing the free response section. This study's goal was to determine if preparing for the AP Exam through use of Socratic Seminar would increase student confidence and achievement on the free response section of the AP Computer Science Exam.

According to the Nebraska Department of Education's *State of the Schools Report* (2015), Omaha Public Schools served 51,928 students during the 2014-2015 school year [10]. The district includes students from many different ethnic and socio-economic backgrounds. The majority, 73.3 percent, of students in the district receive free/reduced price lunch. This statistic indicates that many students in the Omaha Public Schools come from low-income households. Omaha North is a magnet school for Science, Technology, Engineering, and Mathematics (STEM). As a magnet, the school has a lower percentage of free/reduced price lunch students, 65.3 percent, than the district and also has a higher percentage of white students, 40.7 percent at North compared to 30.1 percent as a district.

The study was performed as part of the class in Omaha North's only AP Computer Science class. AP Computer Science is an elective course and has prerequisites of completing the Computer Science Principles course, a full-year course, as well as successfully passing Geometry with a grade of C or better both semesters.

Eighteen students participated in the study on use of Socratic Seminar as a tool for teaching Computer Science. Limiting the applicability of the study, all 18 students were male. Further separating the subjects of the study from the

population of the school, while African-American students make up 46.3 percent of North's population, only one of the eighteen students in AP Computer Science was African-American thus demonstrating that the students in this study do not reflect the demographics of North High School as a whole.

3.2 Research Design

The Action Research was conducted over an eight-week period during the spring semester of the 2015-16 school year. The preparation for the study began in January with implementation starting just after the spring break recess in March.

3.2.1 Phase One

A passive research consent letter was drafted and sent to the parents of the student-participants in the study. The consent letter was distributed before the spring break recess and discussed with parents at parent-teacher conferences which took place on the day prior to spring break.

3.2.2 Phase Two

This portion of the study was conducted immediately after the spring break holiday. Students were given a pre-survey to gauge their confidence in their ability to pass the AP Free Response exam. Additionally, students were given a pre-test of the AP Computer Science exam consisting of the 2014 free response exam. Students were also introduced to Socratic Seminar. Norms and procedures for seminar were discussed and the grading rubric for seminar participation was shared with students.

3.2.3 Phase Three

During this phase, the action research began. Students were given a problem from previous AP free response questions to examine. The class was led in discussion by either the instructor or one of the students. The discussion followed the Socratic Seminar methodology in which different methods of solving the problem were discussed and argued. The merits of each method were discussed as a class and in the end a general consensus was reached on a way to solve the particular problem.

3.2.4 Phase Four

In the final phase of the research, post-tests and post-surveys were administered to measure test scores and gauge student confidence. Post-tests were compared to pre- and mid-tests and post- and pre-surveys were compared to evaluate the results of the Socratic Seminar as an instructional effective method.

3.3 Data Collection Methods

3.3.1 Pre-survey

Prior to the research, students were asked to complete a pre-survey indicating their self-confidence in Computer Science. Specifically, students were asked about their

confidence with regard to the free response section of the AP Computer Science exam.

3.3.2 Pre-test

Prior to the research, students were given the free response section of the AP Computer Science exam from 2014. This exam has an accompanying scoring rubric and a breakdown of how students scored nationally on the exam when it was administered in 2014. This exam served as a baseline to measure student knowledge before the action research was performed.

3.3.3 Mid-test

After four weeks of the eight-week study, a mid-point test was administered to measure growth in achievement. For this test, the free response question from 2013 was used and was graded using the AP scoring rubric with student scores measured against the national scores of the original test administered in 2013.

3.3.4 Post-test

After the eight-week study was completed, a final post-test was administered. As with the pre-test and mid-point test, a prior years' AP exam was used along with the accompanying scoring guide and the details of student scoring nation-wide.

3.3.5 Post-survey

At the end of the eight-week study, another survey was given to gauge student confidence. This survey was the same as the pre-survey with additional questions about the Socratic Seminar method itself.

4. FINDINGS

4.1 Student Survey Results

The 18 students were surveyed at the beginning and at the end of the trial. The questions allowed for five responses ranging from strongly disagree to strongly agree. The results were coded with numerical values 1 to 5 and the results were averaged. After the trial, the survey showed positive growth in areas related to student personal confidence as shown in Table 1. Students were more confident in their ability to be successful both in the class and on the AP exam.

Table 1. Student confidence in individual ability

<i>Q: I could pass the Free Response portion of the AP Computer Science Exam.</i>		
Pre-Survey	Post-Survey	Change
3.58	3.78	.20
<i>Q: I am confident I can produce high-quality Computer Science work.</i>		
Pre-Survey	Post-Survey	Change
3.47	3.89	.42

As depicted in Table 2, there was negative relationship to how students saw both their abilities to help peers as well as

their ability to learn from peers, indicating that as their personal confidence grew, they had become less sure of their abilities to be taught by and learn from their peers. This is an interesting finding as the Socratic Method relies heavily on student interaction. This raises a question of the effectiveness of the method as students begin to doubt the utility of their classmates and peers.

Table 2. Student confidence in group ability

Q: I am confident I can help my peers.		
Pre-Survey	Post-Survey	Change
4.05	3.61	-.44
Q: I am able to learn from my peers.		
Pre-Survey	Post-Survey	Change
4.32	4.06	-.26

4.2 AP Exam Pre-Test

Prior to the study, students were given the 2014 AP Computer Science Free Response questions. Since the original test focused on the Grid World case study which was removed from the required materials in 2015, the question about Grid World was omitted from the exam. For consistency, each of the free response exams had one question omitted.

Each of the AP free response questions have a maximum of 9 points. A rubric is used to determine the number of points awarded including partial credit. The rubric used to grade the students in the study was the same rubric used to grade the exam nationally and is used to ensure consistency of grading.

In the pre-test, students performed below the national average. The class had been taught all of the material on the AP exam, but there had been no instruction on how to take the free response portion of the exam

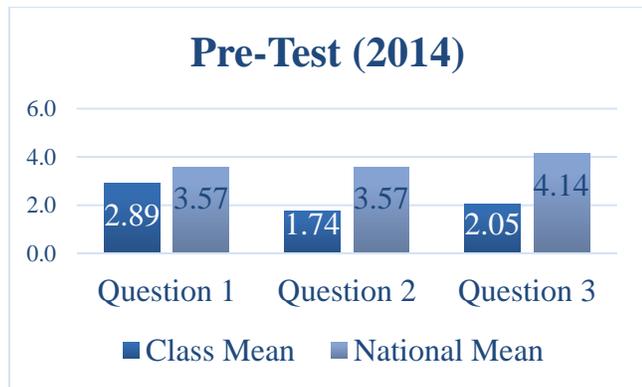


Figure 1. Pre-Test results compared to national average.

4.3 AP Exam Mid-point Test

After four weeks of the study, students were given another three-question AP Free Response Exam, this time from the 2013 edition of the exam. The students still were below the national average on two of the three questions. This may be due to their relative inexperience with the exam though this was an improvement from the pre-exam.

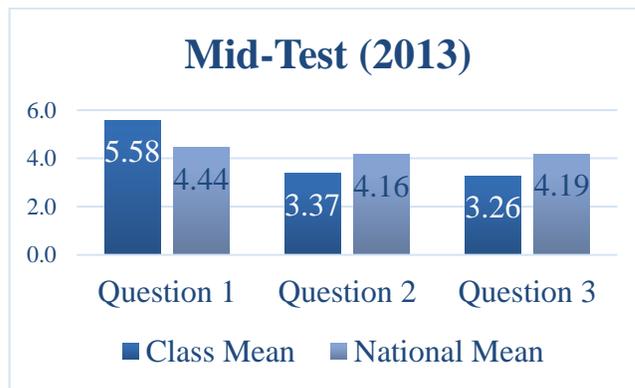


Figure 2. Mid-Test results compared to national average.

4.4 AP Exam Post-Test

After eight weeks of the study, students were given a final three-question AP Free Response Exam, this time from the 2015 edition of the exam. The students still were below the national average on two of the three questions and performed only slightly below the national average on the third question. However, class means improved from the beginning to the end of the study.

The questions between all three exams were different but they are similar in their content and the underlying themes they are trying to address. It is not the case, however, that the first question in each of the three exams is evaluating the same idea or theme.

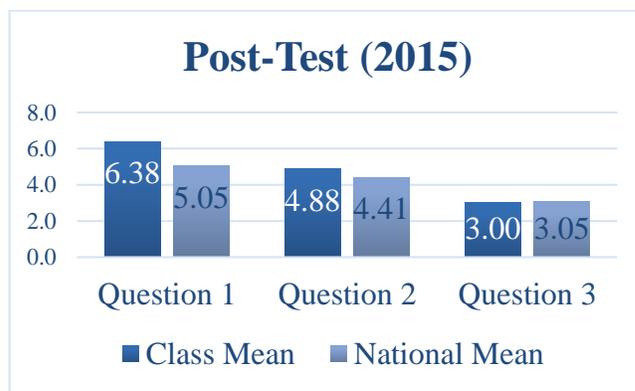


Figure 3. Post-Test results compared to national average.

5. CONCLUSION AND DISCUSSION

Over the course of the study, gains were made when the class mean was compared to the national mean. This relationship can be partly attributed to the additional practice the students received both through taking the sample AP Free Response Exams and through the examples used in Socratic Seminar. Without conducting a study of a class participating in seminar versus a class not participating in seminar, it is difficult to know how much value the seminar added. This is an area that could warrant additional study.

5.1 Student Achievement

Given that the students in the post-test scored at or above the national average for the actual AP exam on two of the three items, it would appear that student achievement benefitted or at least was not harmed by the Socratic Seminar. There was positive progression across the Pre, Mid, and Post-Tests suggesting that student proficiency increased during the eight-week implementation.

The students also developed methods of describing the problems that improved over the course of the study. Initially, students had difficulty with the vocabulary of arrays, strings, and other common java objects. Through the discussion and by requiring students to verbalize their ideas, there was a noticeable difference on the pre to post-test with regard to their use of vocabulary and ability to understand the written problem.

5.2 Student Engagement

Prior to the Socratic Seminar methodology, there was little interaction in the classroom beyond students engaging with their immediate neighbors. The process of seminar required all students to engage both with the text (Free Response Question) and their classmates. Not all students enjoyed this engagement and some did not participate or participated very little in discussion. Other students engaged in discussion to the point that the moderator took steps to include others over these students.

During the study, it was found that smaller groups provided opportunities for more students to participate rather than being dominated by a few students. This was experienced when the Socratic Seminar used the inner-outer circles technique where half the students were participating in discussion while the other half was only listening. Seminar was also implemented in small groups of about five students while the rest of the class worked on other assignments, not engaged in the discussion. In this configuration, students were more likely to participate though without moderation the discussion was still likely to be dominated by a few students.

5.3 Student Confidence

The results of the student survey were contrary to the assumptions of the researcher prior to the study. Students reported an increase in their confidence to create high-quality computer science work and to succeed on the AP exam. At the same time, they reported less confidence both in their abilities to teach their peers and to learn from their

peers. This result may indicate that students had previously been overestimating or underestimating their peers. Either assuming that they were much more advanced or much less advanced and that they could either learn from or teach them quite easily. By engaging in discussion as a class, perhaps students saw their peers as much more on-par with their own knowledge.

Computer Science is currently a subject only taught in some schools. It is also an area that struggles with Imposter Syndrome wherein students believe they are not as capable as their peers [7]. As students are exposed to the knowledge of their peers, they are more able to adjust their own evaluation of other students in the class and perhaps themselves.

5.4 Further Study

The results indicate the need for further study to validate and isolate the effects of Socratic Seminar both on student confidence and student achievement. While the participants of this study increased in achievement as compared to the mean, not all students saw the level of growth indicated by the class average. For further study, a control group not receiving the Socratic Seminar, but instead a more traditional preparation for the AP Computer Science exam, could be utilized. Additionally, a focus group of students could be further interviewed to determine attitudes and perceptions about the effectiveness of Socratic seminar.

The AP Free Response questions were chosen because of their well-defined rubrics and large body of existing and available data regarding past student performance. A wider range of problems and a focus on more open-ended questions would benefit future studies. These questions can explore more of the aspects of computer science as a field and could also lead to a more inclusive perception of what computer science is and whom it affects. The AP exam questions may not be the best source of materials for Socratic seminar. Further study using different texts would be a good supplement to this study and could isolate the Socratic seminar treatment from the other confounding variables affecting student achievement.

5.5 Action Plan

Over the course of the study, several questions arose for potential follow-up study. The first relates to the value of Socratic Seminar versus the benefit of the increased exposure to the AP materials. During the study, it was difficult to separate the treatment of the Socratic Seminar which used AP texts as an integrated part and the increased exposure to the AP questions as a method of preparation. A follow-up case study could look at two concurrent classes wherein one received the Socratic treatment while another had the exposure to AP exam questions without the Socratic Seminar. This could eliminate the exposure as a possible confounding variable. Further, other primary texts in Computer Science may have a more meaningful impact on student achievement when used in Socratic seminar. More study could use non-AP exam questions in seminar to assess the benefits of the Socratic treatment separate of the

potential limitations of the AP exam questions. For example, questions could be focused on moral and ethical dilemmas in Computer Science, the implications of code that makes a life or death decision in the scenario of self-driving cars for example. These topics are more aligned with current standards in Socratic Seminar as they are non-binary in the answer and better suited for discussion with multiple points of view.

Another change that the study would enhance the study is extended time for incorporating the Socratic Seminar into a longer duration of time in the class. While the process worked fairly well, students would have benefited from having more time to acclimate to Socratic Seminar, develop norms and expectations. By using the Socratic Seminar for an extended time, perhaps a semester of class, students would be able to get beyond the novelty and into the deeper learning aspects of Socratic Seminar.

Socratic Seminar is being effectively administered by many teachers in English and Social Sciences. Collaboration on Seminar with teachers currently implementing this form of pedagogy would be beneficial to further understanding the process and refining the expectations for students in an AP Computer Science context.

6. ACKNOWLEDGEMENTS

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