THE EQUITY AND INCLUSION OF UNDERREPRESENTED POPULATIONS IN

AP COMPUTER SCIENCE PRINCIPLES

BY

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ABSTRACT

Advanced placement exams in Computer Science have been identified as having one of the largest disparities in student gender, race, and ethnicity across all College Board advance placement courses. Historically, the demographic compositions of advance placement exams AP Computer Science A and AP Computer Science AB have primarily consisted of White males. For the 2016-2017 academic year, College Board administered the first AP Computer Science Principles exam with the goal to increase diversity in computer science and appeal to marginalized populations that are often underrepresented in computing. This research provides a comprehensive analysis of the equity and inclusion of the University of Rhode Island's implementation of AP Computer Science Principles and the demographic profile of the AP Computer Science Principles exam participants at the state and national level.

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I would also like to convey my heartfelt thanks and indebtedness to Dr. Victor Fay-Wolfe for his invariable leadership, invaluable support, and the remarkable opportunity to pursue this research and academic pathway. Without his confidence in me, I would not be on the track that I am on today.

To my mother, father, brother, and girlfriend I express my deepest gratitude for their love, support, strength, and encouragement through this process and throughout my life. I feel privileged to have such a strong support group and motivation to be the best person that I can be.

DEDICATION

To my family, friends, and loved ones.

PREFACE

This thesis is written in and conforms to the standard format outlined by the University of Rhode Island. None of the chapters written in this work are currently published or have been submitted for publication.

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Chapter 1

INTRODUCTION

Section 1.1 - Preface

Sections 1.2 and 1.3 of the introduction are intended to provide the background and motivation for this research respectively, highlighting the importance and impact this research will have on student access to computer science (CS) education in Rhode Island at the primary through secondary (K-12) academic level. Section 1.3 provides a statement of problem and justification of study and section 1.4 provides the objectives of this research.

Section 1.2 – Background

The study and practice of computer science has increasingly become recognized as an important and empowering field of study that innovates technology and benefits human kind at unprecedented rates. As a result, working knowledge of computer science has become an industry standard because of the direct relationship between corporate productivity and technology [1]. To foster and encourage the study of computer science in Rhode Island, governor Gina Raimondo launched the Rhode Island state initiative Computer Science For Rhode Island (CS4RI) in 2016. At that time, Advanced Placement (AP) Computer Science was offered in only 9 public high schools and no Title I schools (i.e., schools where at least 40% of a school's students are from low-income families) [2]. Furthermore, 1% of Rhode Island high school

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students were enrolled in a computer science course. In 2014, fewer than 350 students graduated from a Rhode Island college or university with a bachelor's degree in computer science while more than 1,000 open computer science jobs existed in the state [2]. Only 72 Rhode Island public school students took the AP Computer Science A (AP CSA) exam in 2015, which consists of less than 1% of the total AP exams taken across the state [2]. Only 26 students passed with a score of 3 or higher. Of those students who earned a passing grade, 73.1% were white, and 76.9% were male compared with 68.1% white and 41.6% male ratio for all public school AP test takers [2]. In an effort to increase the number of computer scientists in the state, CS4RI was established with the goal to reduce barriers and provide quality computer science education and professional development, helping to bring CS learning opportunities to all Rhode Island schools in the future [2].

It is important to note that the objectives and goals in the CS4RI initiative mirror the motivation of the national effort to increase the number of computer science students and professionals named CS4All [3]. While these two initiatives are similar, CS4RI is a localized effort endorsed by the Rhode Island Department of Education (RIDE) to encourage computer science specifically in Rhode Island.

As part of the CS4RI initiative and with funding by the National Science Foundation (NSF), the Department of Computer Science and Statistics at the University of Rhode Island (URI) designed, implemented, and actively support several computer science courses that have been integrated into a majority of Rhode Island school districts with the intention to introduce and propagate computer science to as many students as possible while assuring ease of access to minorities and marginalized

groups [5]. To monitor grant deliverables and ensure a healthy collaboration between the K-12 educators and higher education researchers, the Rhode Island Technology Enhanced Science and Computing (RITES+C) office was tasked with collecting data on the different iterations of the University of Rhode Island's AP Computer Science Principles (AP CSP) and Introduction to Computing and Data Science (ICDS) courses [6].

Section 1.3 – Motivation

The motivation of this research deeply correlates with the motivations outlined by the CS4RI initiative. Specifically, by ensuring computer science is equitable and inclusive to all students in Rhode Island, students will be able to acquire the skills that contribute to their personal, academic, and professional success [2]. With an increase in computer science graduates in the state, businesses are more likely to invest in Rhode Island by providing a pipeline for students to transition from academia to becoming trained, talented, and integrated members of the technical workforce [2].

The motivation of this research is further rooted in the notion that diversity unlocks innovation and drives market growth [7]. We know that diverse groups allow for different perspectives and approaches to develop, causing an increase in innovation and "outside of the box" thinking. By making the field and study of computer science more diverse, we increase our chances of innovating both technology and software that have the potential to improve the human disposition.

By extending the reach of computer science to marginalized populations, expansion of the field in Rhode Island is expected to occur. This is an important and

significant outcome that has the potential to positively impact the economy and culture of Rhode Island. Currently, there is a nationwide deficiency for computer scientists in the United States. It is projected that in the year 2020 there will be over 1.4 million computer science positions available and only 400,000 candidates with qualifications that satisfy those positions [8]. This deficiency in computer scientists presents a $500,000,000,000 opportunity for students interested in the field of computer science.
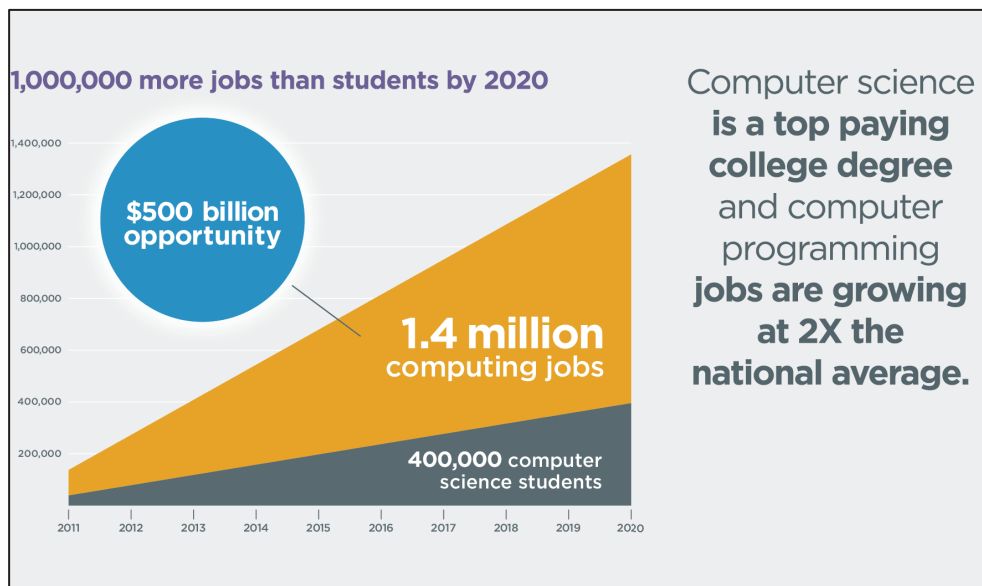
Figure 1: Computer Science Employment Outlook by 2020

Industry has the need and ability to hire young professionals, but one of the barriers preventing the satisfaction of this need is the supply of computer scientists entering the job market. By exposing the unreached populations of Rhode Island to computer science, we can drive innovation and market growth within our state and country.

Ensuring that AP Computer Science Principles encourages the equity and inclusion of under-represented populations and the expansion of the field as a whole is an important step to closing the demographic gap in computer science. Closing this gap

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further motivates this research to ensure URI's AP Computer Science Principles course is equitable and inclusive. The Department of Education released the NCES IPEDS dataset indicating that in 2015, 58.6% of students that earned a degree in computer science were White, 18% Asian, 9.1% Hispanic, and 5.2% Black. Figure 2 below illustrates the disproportional demographic state of computer science based on race and ethnicity [9].
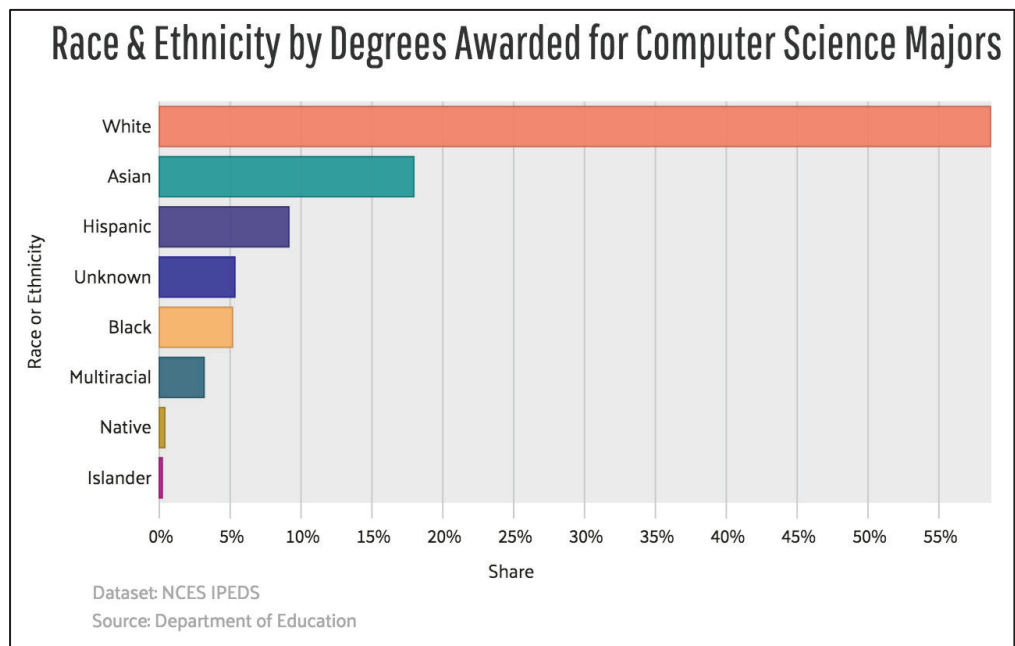
Figure 2: Race and Ethnicity by Degrees Awarded for Computer Science Major

Even within the leading race and ethnicity groups identified in Figure 2, a clear gap can be observed in the gender breakdown of these groups in Figure 3.
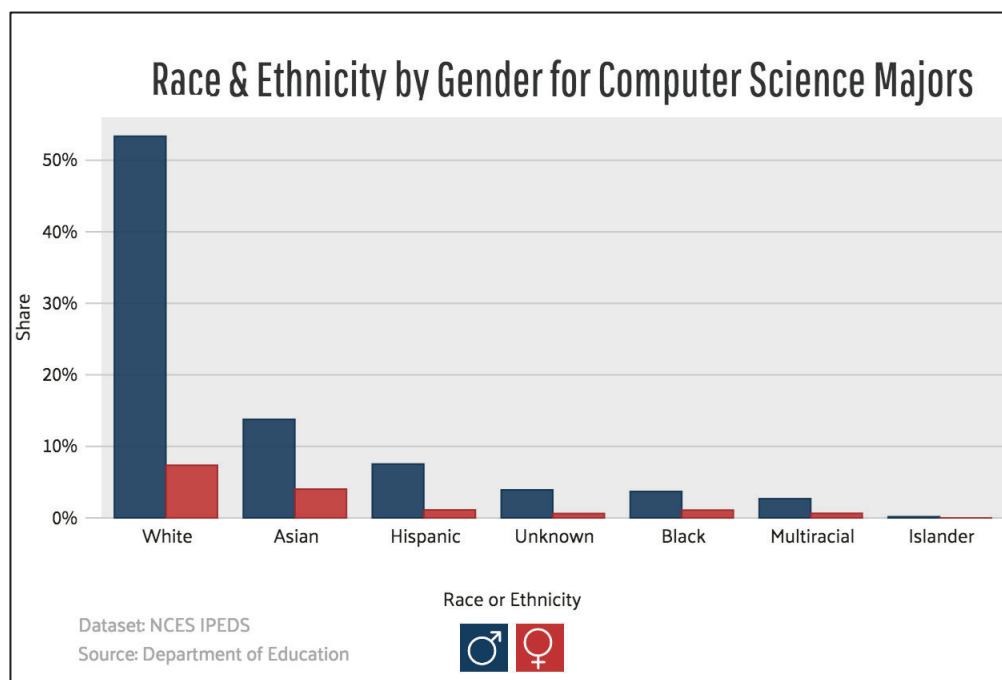
Figure 3: Race and Ethnicity by Gender for Computer Science Majors

A motivation of this research is to reach these underrepresented populations and diversify the field of study.

Section 1.4 – Research Objectives

While the objectives during the design and implementation process of the AP Computer Science Principles course were clearly defined to encourage the equity and inclusion of marginalized groups, no mechanisms existed to identify where AP CSP currently stands in terms of equity and inclusion. The intention of this research is to establish a base line of how inclusive AP CSP is and what the diversity landscape in AP CSP looks like. Another objective of this research is to collect and aggregate data about URI's AP Computer Science Principles course and determine it's equity and inclusion by comparing the demographic distribution of each class and comparing it against the demographic distribution of the school. The overall goal is to achieve a classroom demographic distribution that it is proportional to the demographic

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breakdown of the school but the goal of this research is to determine where AP CSP stands in this process. This metric for equity and inclusion can be further scaled in the future to determine equity in computer science courses to compare school to district distributions, district to state distributions, and state to national distributions.

Chapter 2

REVIEW OF LITERATURE

Section 2.1 – Diversity in Computer Science

Diversity in Computer Science has been a subject of interest since the early 1990's and has increasingly become a topic of focus in research, academia, and industry. Organizations like Google, Code.org, and the National Center For Women And Information Technology (NCWIT) have been at the forefront of identifying barriers and implementing solutions to help close the diversity gap that exists in computer science. Women, Black, and Hispanic populations have been identified in particular as groups that have considerable structural and social barriers that inhibit their participation in computer science [10]. Within each group, different factors exist that contribute to their lack of participation. To further contribute to these barriers, a lack of comprehensive data on the factors that perpetuate the underrepresentation of these groups in computer science exists [10].

Underrepresented populations in computer science face structural challenges that impact their access to computer science, creating a disparity in opportunities to learn [10]. How students are introduced to computer science greatly contributes to their participation in the field. That is, most students that learn computer science are exposed to it in school [10]. If computer science classes are offered in some school districts and not others, a clear disparity in opportunity is created. Black students (47%) are less likely than White students (58%) to have classes dedicated to computer science at the

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school they attend [10]. Because White students are more likely to be in a school where computer science classes are offered, exposure to computer science for White students is greater. In addition to access to computer science classes, access to technology proves to be another factor that inhibits equal opportunity in computer science. Black and Hispanic students are less likely than White students to use a computer at home at least most days of the week [10]. Figure 4 and Figure 5 demonstrate the difference in usage and access to computers, tablets, and cellphones.
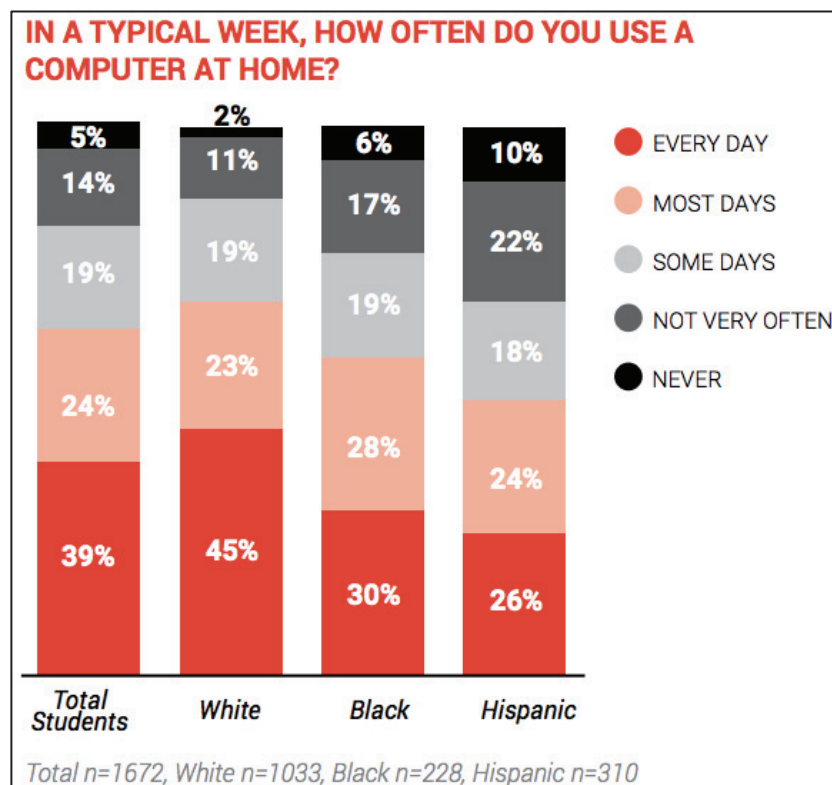
Figure 4: Computer Usage by Race and Ethnicity
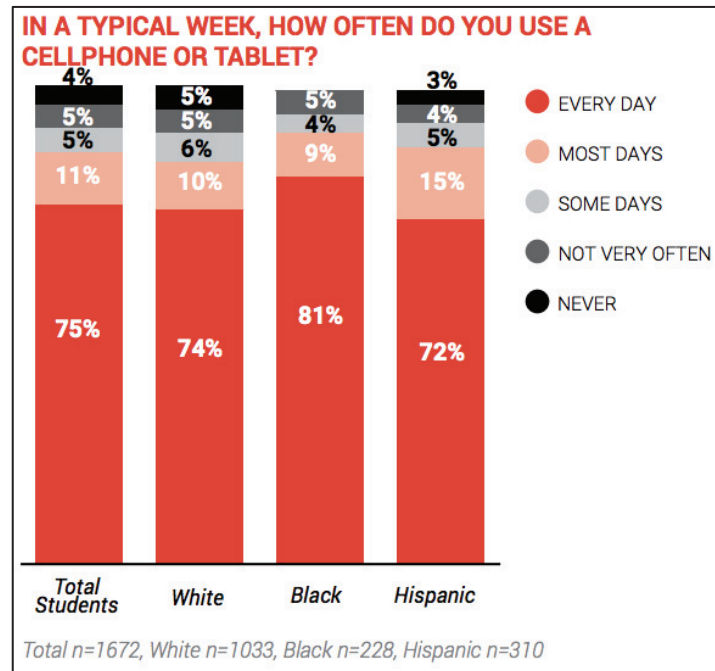
Figure 5: Cellphone and Tablet Usage by Race and Ethnicity

Research suggests that students who use computers less at home are less confident in their ability to learn computer science [10]. Here, computer time and availability impacts a student's confidence level in computer science, creating a gap in computer science for groups who do not have regular access to computers or are not encouraged to use technology. Over the course of a two-year study conducted by Gallup and commissioned by Google, teachers at the seventh grade through twelfth grade levels are more likely than parents to say that a lack of exposure is a major reason why women, racial, and ethnic minorities are underrepresented in the computer science field [10]. An observation that can be reached from this conclusion is that students demonstrate interest in the field of computer science and that facilitating student access to computer science would help bridge the diversity gap that exists. Of

the structural barriers that exist, exposure seems to contribute the most to a lack of participation.

While structural barriers inhibit diversity in computer science, social barriers also exist that contribute to attitudes and perceptions of computer science that prevent a more diversified field of study and practice. To support this contention, research indicates that female students are less likely than male students to be aware of computer science learning opportunities on the Internet, in their community, to say they have ever learned computer science, and to say they are very interested in learning computer science [10]. This finding leads to an important observation that contributes to the lack of diversity in computer science for students. In schools where some structural barriers have been eliminated, women are still less likely to be aware of and learn computer science in school or independently. Gallup's two-year study found that of the women that participated, 16% were interested in learning computer science compared to the 34% of males who expressed interest in learning computer science [10]. The difference in interest level is graphically represented below in Figure 6.
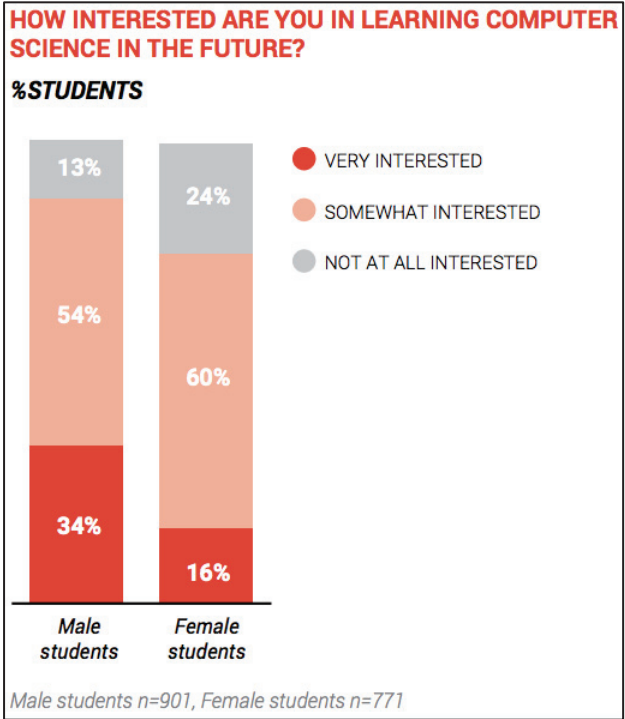
Figure 6: Interest in Learning Computer Science by Gender

In addition to comparatively low levels of interest in computer science, 48% of women felt confident they could learn computer science compared to 65% of males who also felt confident [10].

HOW CONFIDENT ARE YOU THAT YOU COULD LEARN COMPUTER SCIENCE IF YOU WANTED TO?

%STUDENTS

- ● VERY CONFIDENT
- ● SOMEWHAT CONFIDENT
- ● NOT VERY CONFIDENT

	Male students	Female students
Not very confident	6%	8%
Somewhat confident	29%	45%
Very confident	65%	48%

Male students n=901, Female students n=771
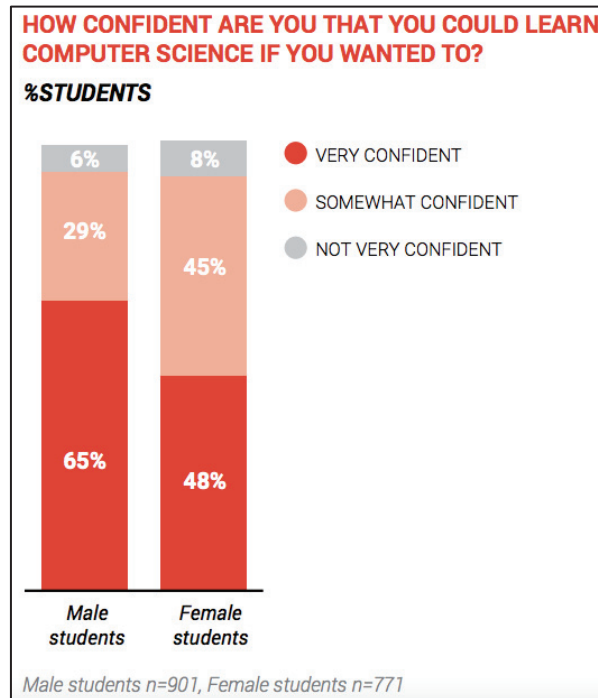
Figure 7: Confidence in Learning Computer Science by Gender

The disparity between female and male percentages in confidence and interest demonstrate a social difference in attitude towards computer science that impact female participation. A parent, teacher, or authoritative figure can foster this difference in confidence and attitude towards the field of study explicitly or implicitly. For example, males are much more likely to be told by a parent or teacher that they would be good at computer science [10]. This single difference in verbal affirmation can have serious implications for women participation in diversifying the field of computer science.

In 2014, Google conducted a study titled "Women Who Choose CS" to identify and understand factors that influence young women's decisions to peruse degrees in computer science. This study yielded 91 statistically relevant factors with the potential to influence a woman's decision to pursue a degree in Computer Science [11]. Once determined, the study identified the significance and rank order of the influences, rather than just ask what influences exist. In doing so, influences that contribute greatly to a

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woman's decision to pursue a degree in computer science could be better targeted to increase the number of women computer science degree holders [11]. "Women Who Choose CS" found social encouragement, self-perception, academic exposure, and career perception to be the top four influential factors leading to the pursuit of a computer science degree [11]. These findings can be used to help develop effective, research-based strategies to encourage women participation and retention in the CS field.

Social encouragement from family and peers comprises 28.1% of the explainable factors that contribute to a young woman's decision to pursue a computer science degree [11]. While encouragement from family (17%) and peers (11%) hold a majority of weight in terms of social encouragement, it's important to note that incentive programs at the college level further contribute to a young women's interest in the field. Below, we see the relationship between students that were encouraged to take computer science, and those who were not. Figure 8 and Figure 9 highlight the importance of social encouragement from family.
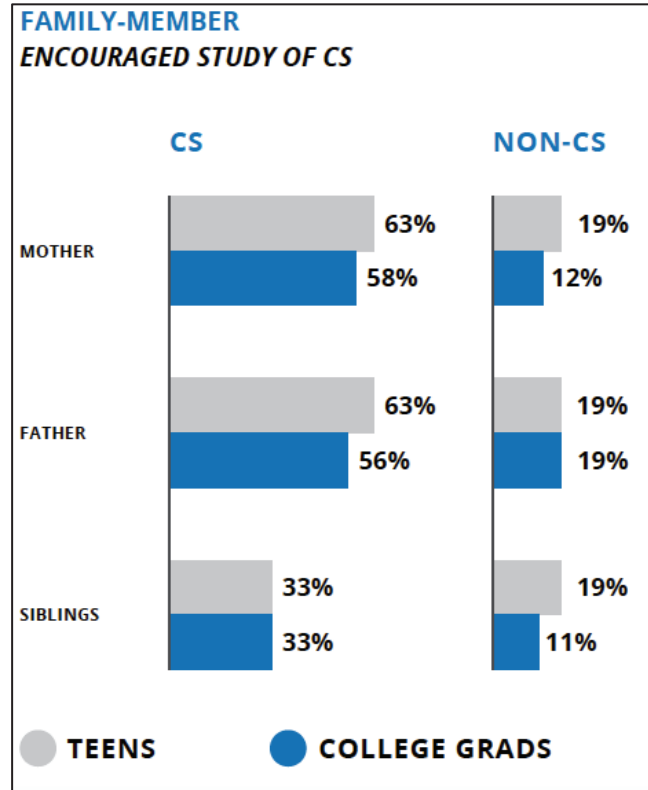
Figure 8: Family Encouragement in Computer Science
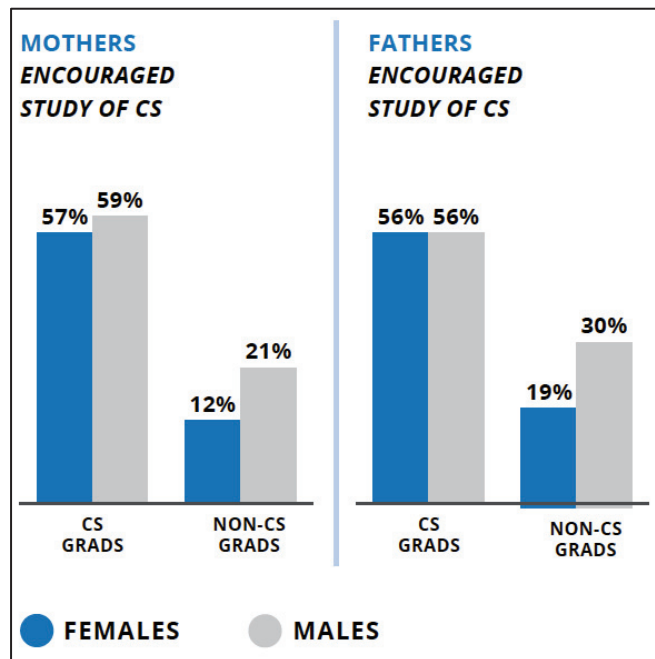
Figure 9: Parental Encouragement in Computer Science

Figure 8 and Figure 9 capture the importance between social encouragement and participation in computer science. It is also important to note that encouragement from a parent increased participation in computer science regardless of the parent's occupation or technical knowledge [11].

Along with social encouragement, self-perception accounts for 17.1% of explainable factors that were identified that contribute to young women's participation in computer science [11]. Specifically, self-perception in this context describes interests and personal aptitudes. A positive self-perception in mathematics and sciences boosts confidence and promotes internal encouragement. Interest in puzzles, problem solving, and tinkering seemed to correlate with a high interest in computer science. Figure 10 and Figure 11 illustrate women who indicated they like math, theoretical concepts, and understanding how things work gravitated towards computer science.
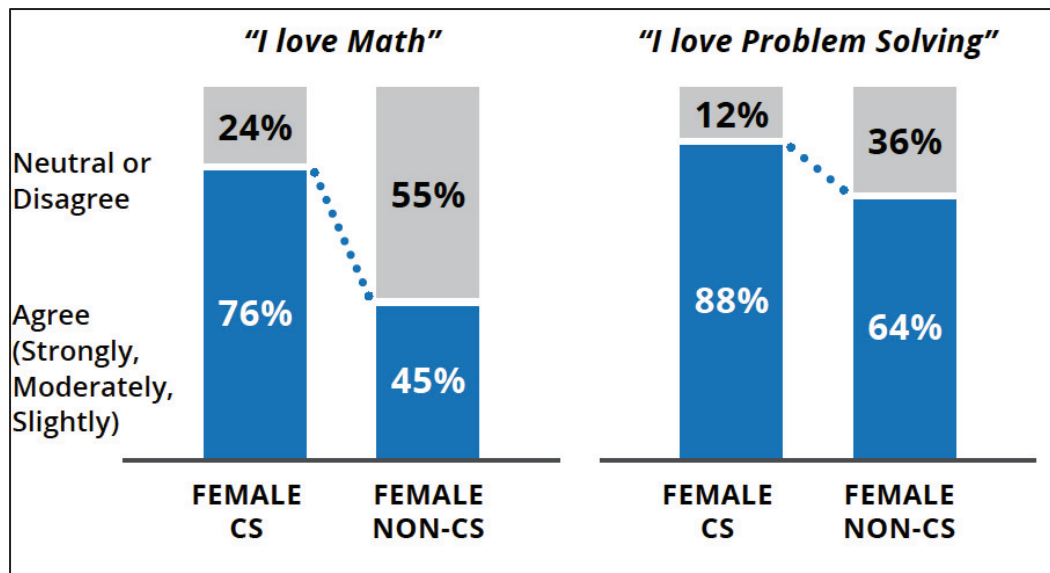
Figure 10: Self-perception in Math and Woman in Computer Science
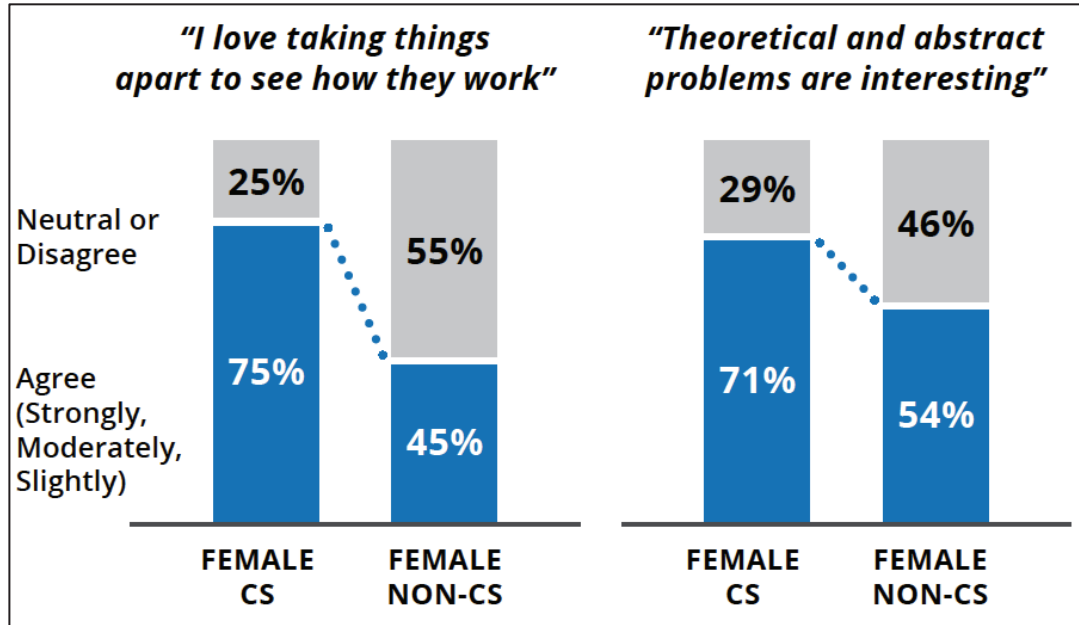
Figure 11: Theoretical Problems and Women in Computer Science

Academic Exposure, a critical element to this research, accounts for 22.4% of the explainable factors influencing the decision to pursue a computer science degree [11]. If offered and advertised equitably in schools, an increase in diversity in computer science is expected. In general, those who have taken the AP CSA exam are 46% more likely to indicate interest in a computer science major [11]. This increase in interest is particularly true for women who take the AP computer science exam. It is important to note that while academic exposure to computer science increase the chance that women will pursue computer science in the future, it has been demonstrated that any expose to computer science increases the likelihood of female participation in the field. While exposure in school is important, after school clubs and workshops unaffiliated with school also contribute to women expressing interest in computer science [11].

A clear understanding of what computer science is and the different career paths computer science can take prove to be a social barrier that requires a hands-on approach to increase awareness. This negative career perception of computer science

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prevents women engagement. Popular media contributes to this negative perception of computer science, suggesting that only a narrow set of applications can be applied to the field.

Section 2.2 – Efforts to Mitigate Diversity Gap

While equity and inclusion are not where they should be, steps in the right direction are being taken to bridge the diversity gap in computer science. In 2016, Brown University published "Pathways to Diversity and Inclusion: An Action Plan for Brown University's Department of Computer Science", outlining specific action items they intend to implement in the coming years to increase diversity and promote inclusion in computer science in higher education. Data collection, community input, education and training, communication and dissemination, community support, and outreach are a few of the proposed strategies Brown plans on implementing to increase diversity in CS [12].

To better understand the diversity at Brown's computer science department, first creating a snapshot of their diversity profile was needed. A department-wide survey was distributed to CS students to collect data on the current diversity and inclusivity climate at Brown [12]. With this data, a baseline was established to determine future diversity goals and benchmarks. Brown encouraged community input and participation in their conversations about diversity and inclusion. They did this by holding regular town hall meetings to discuss diversity and inclusion, opening the topic of diversity to anyone in the community with the hopes to encourage external participation and awareness [12]. To further continue community conversation, student

advocate office hours are held regularly and logged for students to come with any questions or concerns pertaining to diversity. A feedback system was also implemented, allowing students to report anonymously any behaviors or experiences they encountered that made their environment more or less inclusive [12].

Education and training are important tools used to bridge the gap in diversity in CS. Brown is leveraging education to provide information and context to those who are unaware of the gender and demographic disparity in computer science by creating diversity lecture series and inviting predominant computer scientists to speak about diversity in computer science [12]. Coupled with this lecture series, workshops are being developed and offered to the Brown community focusing on important topics like social identity and how unconscious bias can create hostile environments for students in marginalized populations [12]. Existing diversity training modules for staff, faculty, and teaching assistants are also being modified to include computer science as a topic of interest and awareness, increasing the reach and depth of both education and training on important concepts and history in computer science equity.

Along with education and training, ensuring support mechanisms are in place for individuals within minority groups become an important aspect of empowerment and encouragement in the field. Making sure that people have a space to talk, express their concerns, and share about their experiences becomes a powerful tool for closing the diversity gap in computer science. This type of community support model can be done through student-led diversity groups, student networking, and community based activities and discussions [12]. Having mechanisms that allow support from peers and

administration while a member of the computer science community in academia or industry allows for the security and expansion of marginalized groups.

Research suggests that the recruitment, hiring, and retention of at risk populations such as women, Blacks, and Hispanics plays a pivotal role in diversifying the field [13]. Students belonging to marginalized groups tend to feel more accepted and preform better in environments where individuals in authoritative positions are diverse [14]. Increasing the number of women, Black, and Hispanic teachers at the K-12 level could result in an increase in participation from these groups, effectively minimizing the diversity gap. While college and university enrollment from these groups are increasing, bachelor degree graduates are still predominantly White. Taking a subset from this group of college graduates, a disproportion amount of teacher-track graduates are White. Figure 12 highlights this disparity.
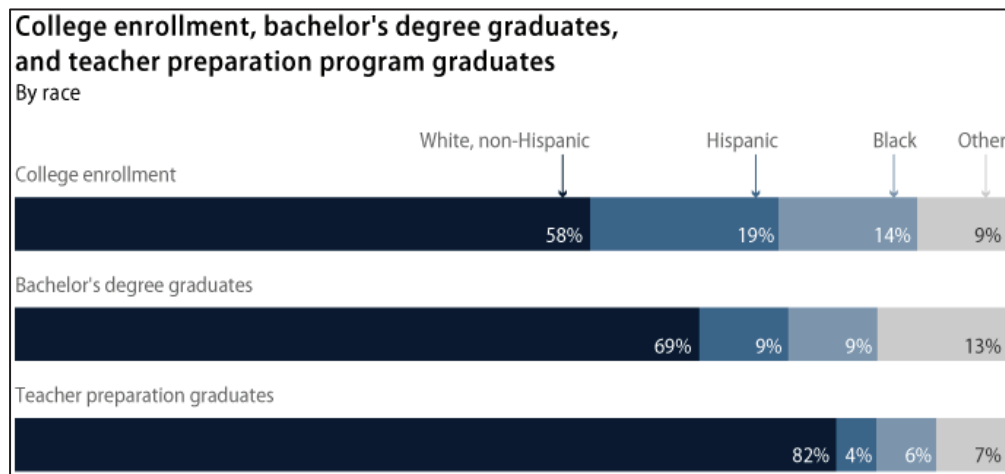
Figure 12: Demographic of Teacher Track Graduates

It's important to note that while these strategies and models are being implemented at Brown University, they can be duplicated throughout higher education and different municipalities. If done throughout Rhode Island, diversity is expected to

increase in the computer science community helping minimize the equity gap that currently exists.

With these strategies being implemented in academia and local communities, industry also plays in important role in ensuring equity and diversity in the field. Because the end goal of most college graduates is to enter industry, ensuring that a stable pipeline and incentive program is in place to allow the transition from student to industry professional for underrepresented populations plays a critical role in their participation [11]. Because the responsibility to encourage more individuals at risk of not participating in computer science falls on the industry employing these groups, many technology and computer science companies are at the forefront of creating progressive workplace polices encouraging the equity and inclusion of these groups [15]. Policies that promote a healthy work-life balance and competitive maternity leave and child care options are just a few examples of technology companies appealing to women and marginalized groups. Facebook, Google, Apple, and SAS all provide extended paid leave for new parents, male and female, in addition to stipends to be used as "baby cash" for unexpected expenses for new families [15].

In addition to maternity benefit programs and stipends, college tuition assistance and industry-track pipelines exist for minorities that satisfy program criteria. To name a few, Microsoft's BAM (Blacks at Microsoft) program is a "company-sponsored employee network dedicated to supporting the continued growth and development of black employees at Microsoft Corporation. This year, BAM will award two $5,000 scholarships to outstanding high-school seniors who are interested in pursuing careers in technology. The scholarships are renewable, so winners who

continue to meet the criteria can receive an annual $5,000 award for up to four years"
[16]. Society of Hispanic Professional Engineers (SHPE) Foundation also plays an
important role in targeting Hispanic populations to bridge the disparities in STEM
degrees between Hispanics and their non-Hispanic counterparts [17]. For the 2017-
2018 academic year SHPE provided approximately $250,000 in scholarships and plan
to increase this number for the 2018-2019 academic year [17]. Companies and
organizations implementing programs and policies that help bridge the diversity gap
and increase equity in computer science play a critically important role in creating a
more diversified field.

Section 2.3 – AP Computer Science A and AP Computer Science AB

The AP Computer Science A and AP Computer Science AB (AP CS AB)
exams offered by College Board are advance placement exams that were first offered
in 1984 with the goal to introduce students to computer science with fundamental
topics that include problem solving, design strategies and methodologies, organization
of data (data structures), approaches of processing data (algorithms), analysis of
potential solutions, and the ethical and social implications of computing [18]. AP
Computer Science AB, while similar in nature and design to AP CSA, covered all of
the content in AP CSA but offered a more in-depth review in algorithms, data
structures, and data abstraction [20]. While productive in it's motivation, "…the
Advanced Placement exam in Computer Science has the worst gender diversity across
all courses, with 78 percent participation by men and 22 percent by women.
Participation by students of color is 13 percent" [19]. AP Computer Science AB was

discontinued due to a lack of enrollment after the 2008-2009 academic year. This left

AP CSA to be the only AP computer science exam offered by the College Board until

AP Computer Science Principles exam was offered for the 2016-2017 academic year.

Figure 13 shows the disparity in exam participation between underrepresented

minorities (URM) and non-URM groups for AP Computer Science A between 2007

and 2017.
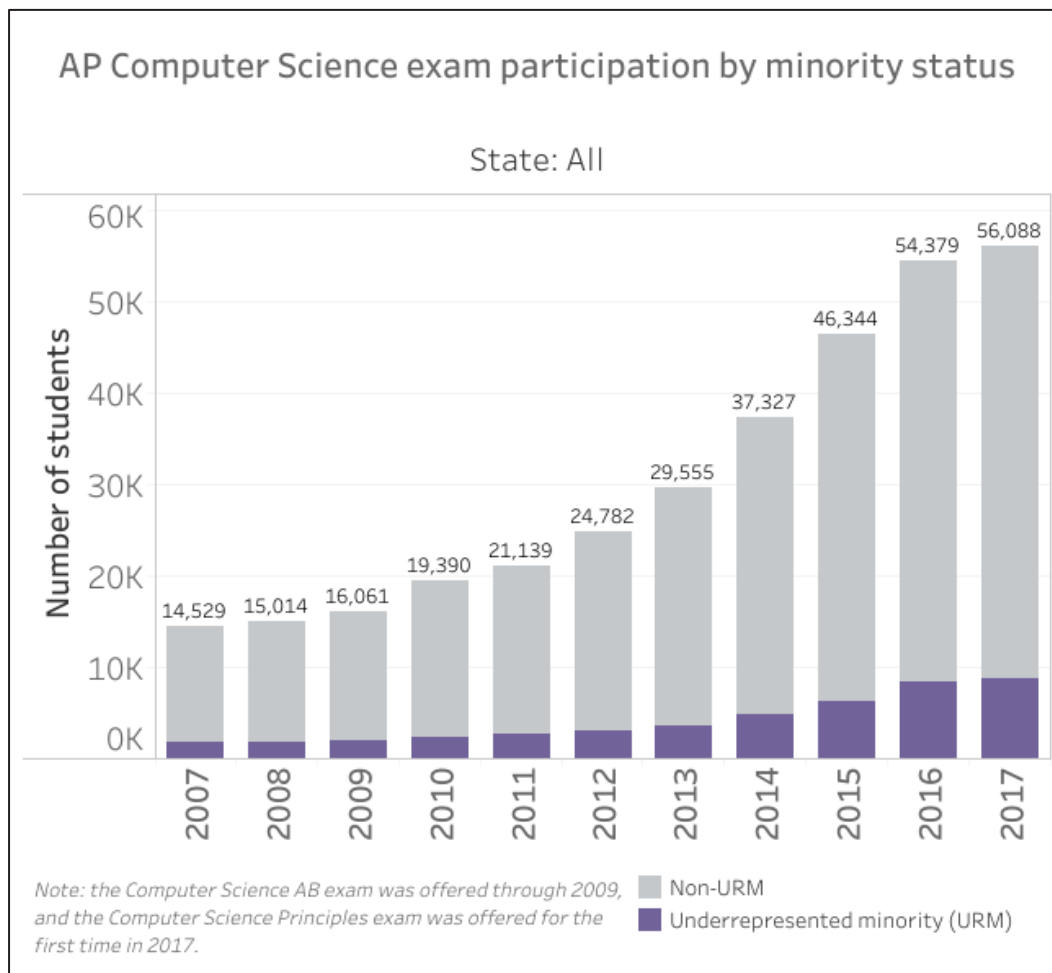
Figure 13: AP CSA Underrepresented Minority – All

Clearly, a drastic difference in participation between Non-URM and URM

exists for AP Computer Science A. Figure 13 is describing the total number of students

that have taken the AP CSA by year. Figure 14 illustrates the disparity in participation in AP CSA in Rhode Island between 2007 and 2017.
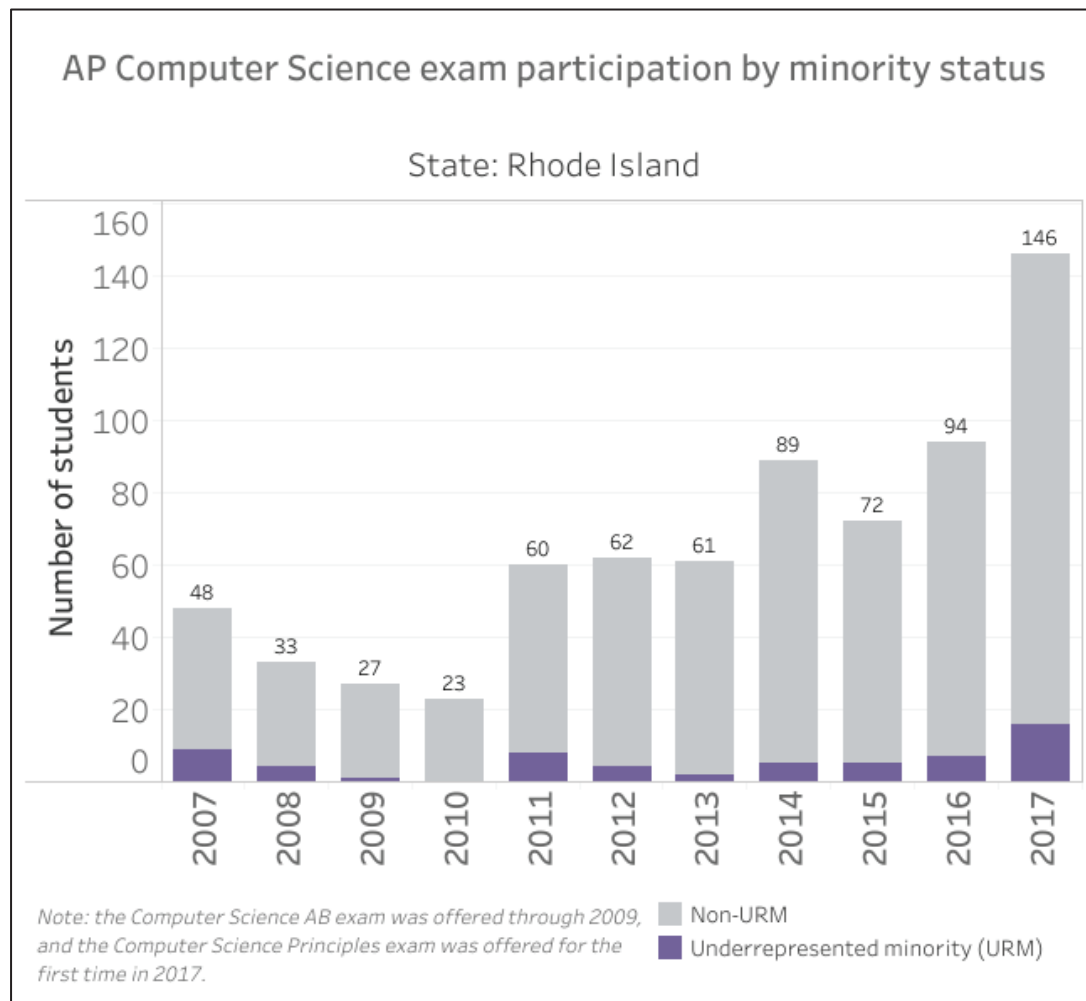
Figure 14: AP CSA Underrepresented Minority – Rhode Island

For Rhode Island AP CSA test takers, we see a less stable distribution between Non-URM and URM students. Unfortunately, this disproportional trend carries over when comparing genders. Below, Figure 15 compares gender participation across all AP CSA test takers and Figure 16 compares gender participation across all AP CSA test takers exclusively in Rhode Island.

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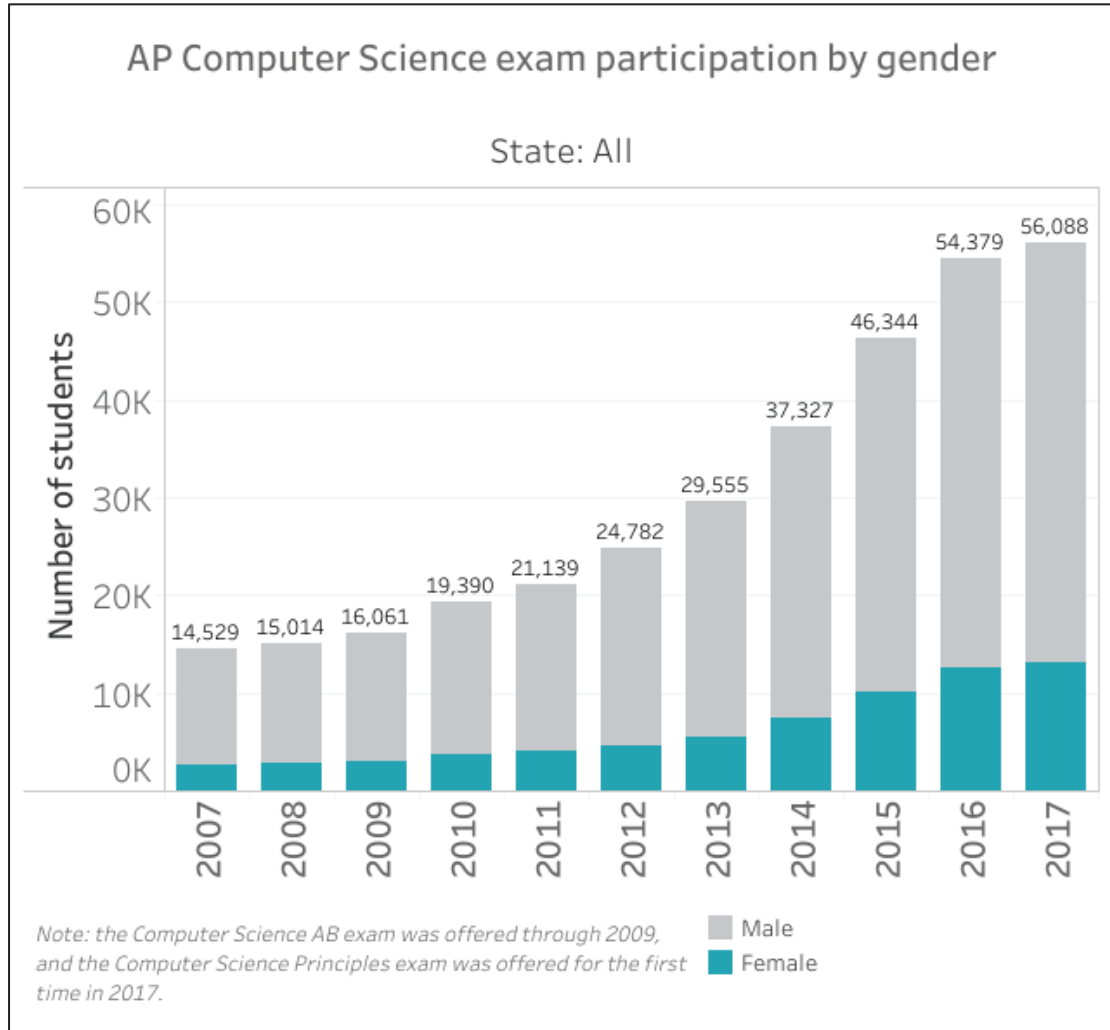
Figure 15: AP CSA Gender – All
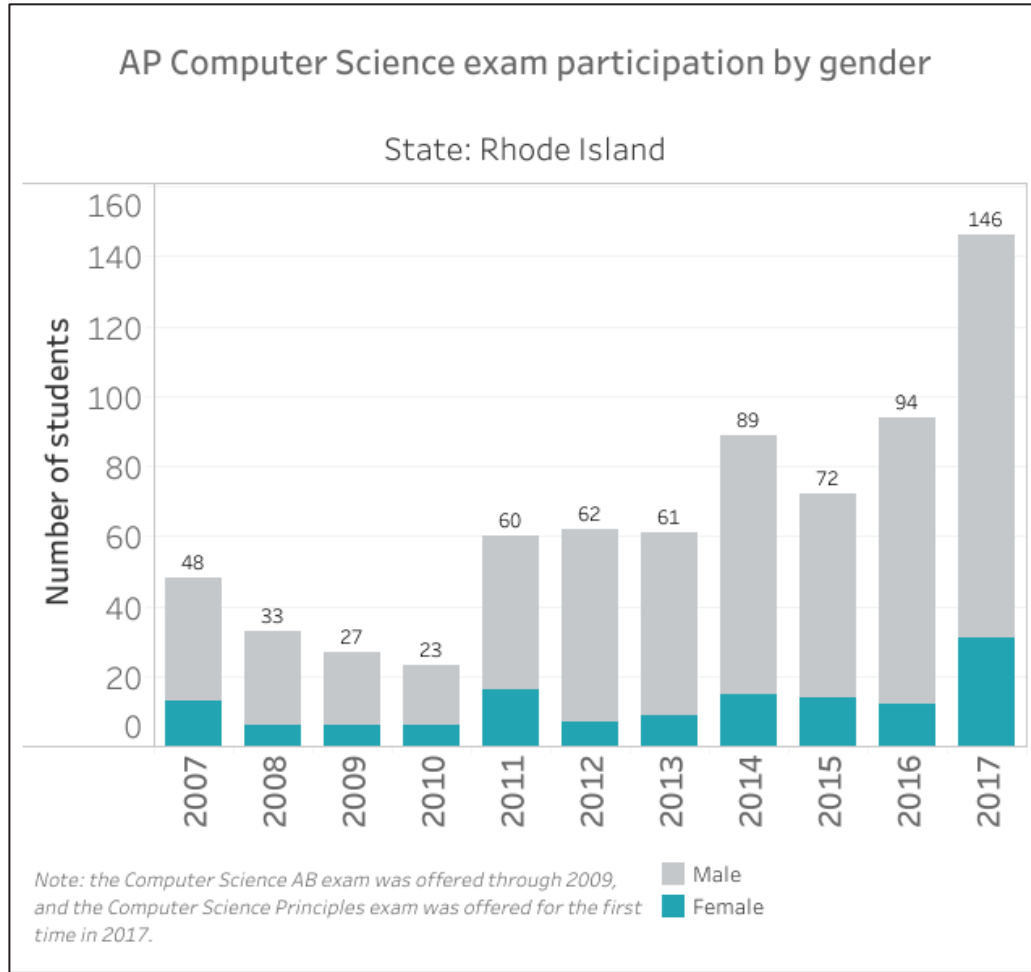
Figure 16: AP CSA Gender – Rhode Island

It is important to note that the AP Computer Science A course follows a conventional style of teaching and assessment with a specific focus on Java programming and object oriented programming concepts [22].

Section 2.4 – AP Computer Science Principles

The first AP Computer Science Principles exam was offered in 2017 for the 2016-2017 academic year. Before then, AP Computer Science A was the only AP computer science course students could take to receive college credit. The arrival of AP Computer Science Principles posed an exciting opportunity for the encouragement and

recruitment of URM populations in the United States. While considered a complementary course to AP CSA, the Computer Science Principles coursework and assessment take a less conventional approach to teaching computer science by discussing computational thinking, working with big data, and using an artifact based portfolio in addition to the AP exam as assessments for the course [22]. "To appeal to a broader audience, including those often underrepresented in computing, this course emphasizes the vital impact advances in computing have on people and society" [22]. Interestingly, College Board does not require a specific programming language to be taught in AP CSP. Because a driving motivation of the course is to broaden participation in computer science, teachers are allowed to develop their own AP Computer Science Principles material "centered around computing concepts in the curriculum framework that support the creation of exciting and relevant computational artifacts" [22]. This is drastically different from the pre-packaged Java labs and assignments that are integrated into AP CSA, allowing for a more tailored approach to CS education. As a result, teachers are enabled to target student strengths and learning styles by providing multiple ways to present concepts and assessment in their classroom.

Specifically, the AP CSP curriculum consists of "Big Ideas" that include creativity, abstraction, data and information, algorithms, programming, the Internet, and global impact [22]. Along with these computer science concepts, computational thinking practices exist requiring the student to learn and preform in the classroom. These computational thinking practices include developing computational artifacts, abstracting, computing, analyzing problems and artifacts, communication, and

collaborating [22]. Within the AP Computer Science Principles course and exam description, it's important to observe specific educational psychology jargon and concepts are used to encourage access and reach in education. When listing specific performance tasks for the AP CSP curriculum, specific works like "explore" and "create" are intentionally used, following the Universal Design for Learning (UDL) model in education. This suggests that when the AP CSP curriculum was designed, important elements of the UDL model were considered to meet the needs of the widest range of students by reducing the number of barriers to learn [23].

When considering the equity and inclusion of AP Computer Science Principles test takers in Rhode Island, the national and state data for the AP Computer Science Principles and AP Computer Science A exams can be used. Because results for AP Computer Science Principles exam are only available for the 2016-2017 academic year, it's difficult to say with certainty that AP Computer Science Principles is more equitable and accessible than AP CSA. However, comparisons in diversity and equity can certainty be made. Below, Figure 17 and Figure 18 demonstrate the comparison between underrepresented minority and non-URM students that took the AP CSP exam and the gender distribution for the AP CSP exam, respectively.
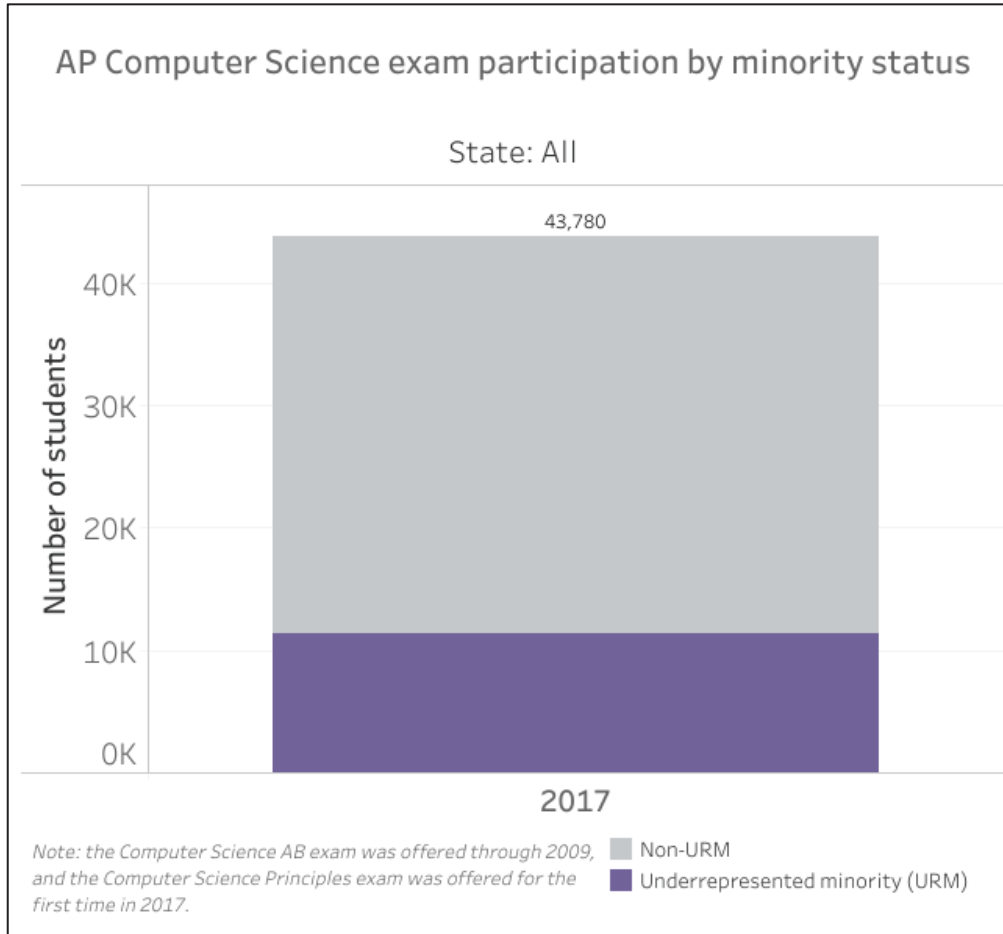
Figure 17: AP CSP Underrepresented Minority – All

At a national level, 43,780 students took the AP CSP exam. Of those students, 11,417 are considered URM and 32,363 are non-URM [21]. This means that approximately 74% of students who took the AP CSP exam were not classified as an underrepresented minority and 26% were. Compared with the demographic distribution for the AP CSA exam for the 2016-2017 academic year, 84% (47,332 students) of students who took the AP CSA exam were not classified as an underrepresented minority and 16% (8,756 students) out of a total of 56,088 test takers were. This proves that for the 2016-2017 academic year, the AP CSP exam was more balanced in URM and non-URM students than AP CSA [21].

29
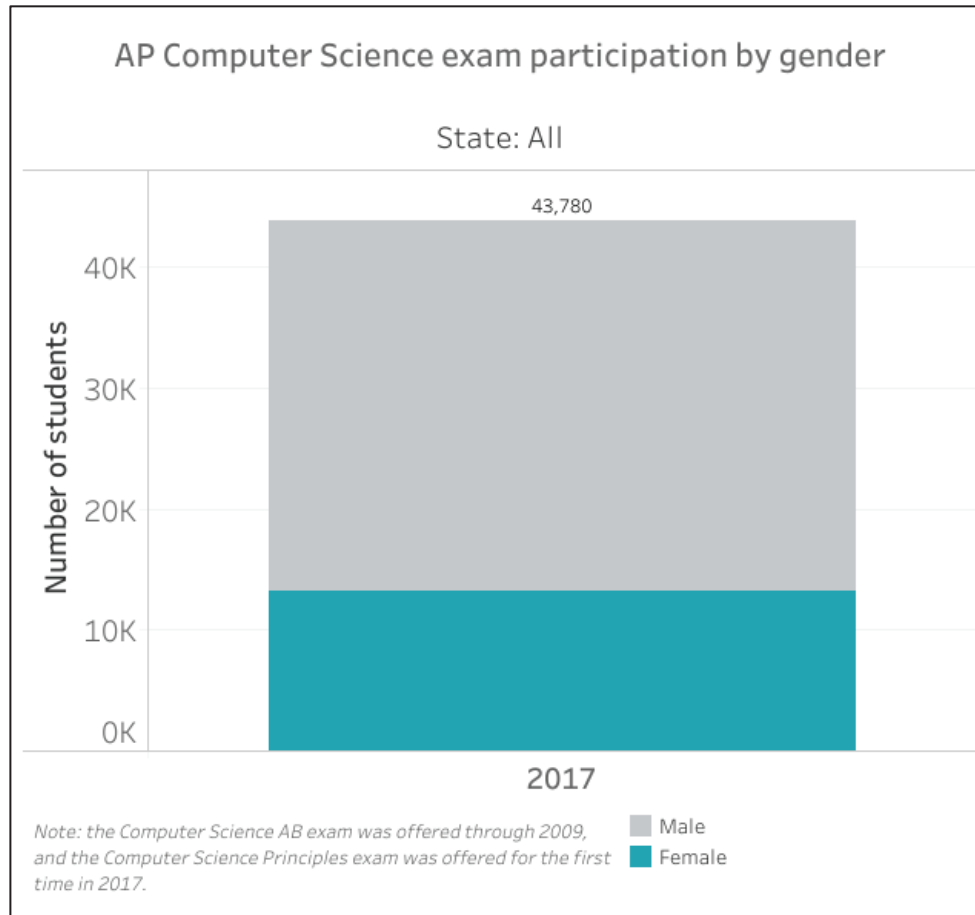
Figure 18: AP CSP Gender – All

Of the 43,780 students that took the AP CSP exam, approximately 70% (30,608 students) were male and approximately 30% (13,172 students) were female. Gender distribution for AP CSP is also better when comparing against AP CSA's gender breakdown. Of the 56,088 students that took the AP CSA, approximately 77% (42,921 students) of the test takers were male and approximately 13% (13,167 students) of test takers were female. For both diversity and gender equity at the national level, AP Computer Science Principles outperformed AP Computer Science A. Respectively, Figure 19 and Figure 20 describe the demographic breakdown of AP CSP in diversity and gender specifically for Rhode Island.

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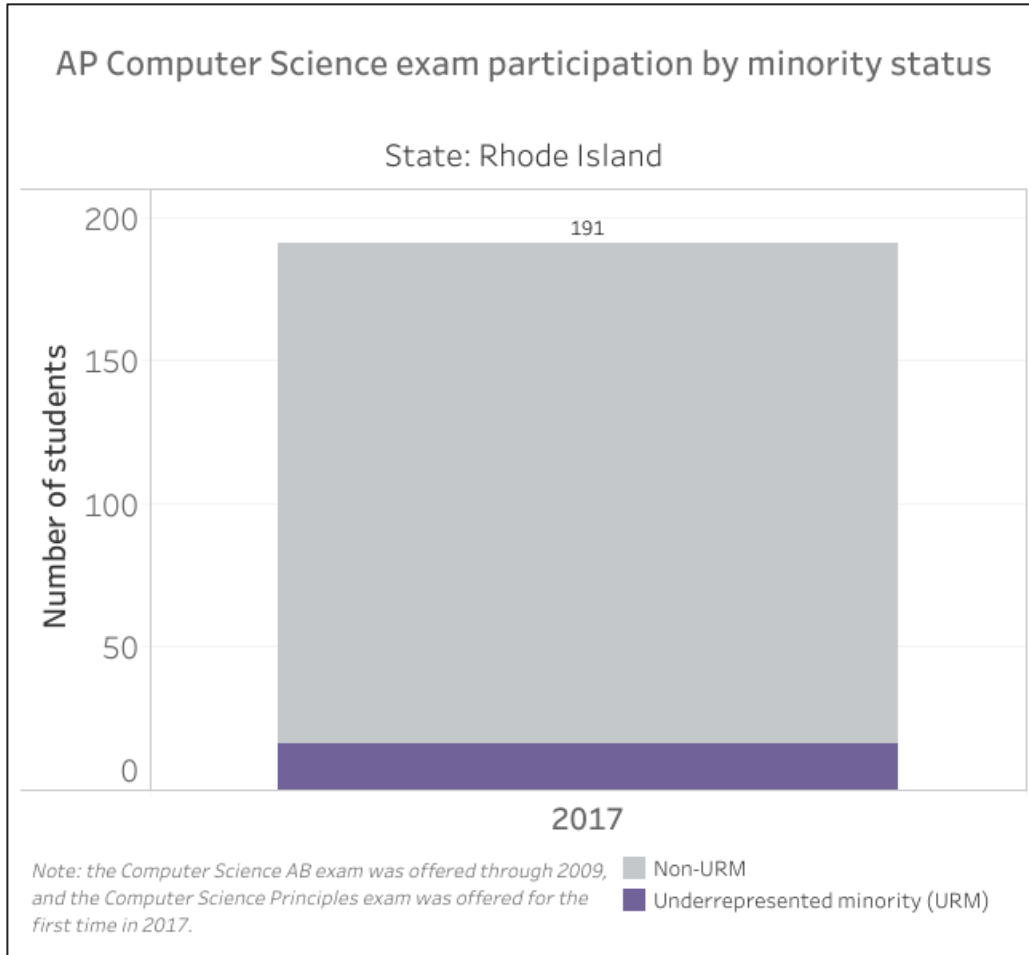
Figure 19: AP CSP Underrepresented Minority – Rhode Island

In Rhode Island, approximately 92% (175 students) of AP CSP test takers were identified as non-URM, leaving only 8% (16 students) of test takers as URM. These statistics reveal that the ratio for AP CSP test takers in Rhode Island is less diverse than the national ratio. That is, Rhode Island only had 8% of AP CSP test takes identifying as underrepresented minorities for the 2016-2017 exam compared to the 26% of URM students at the national level.
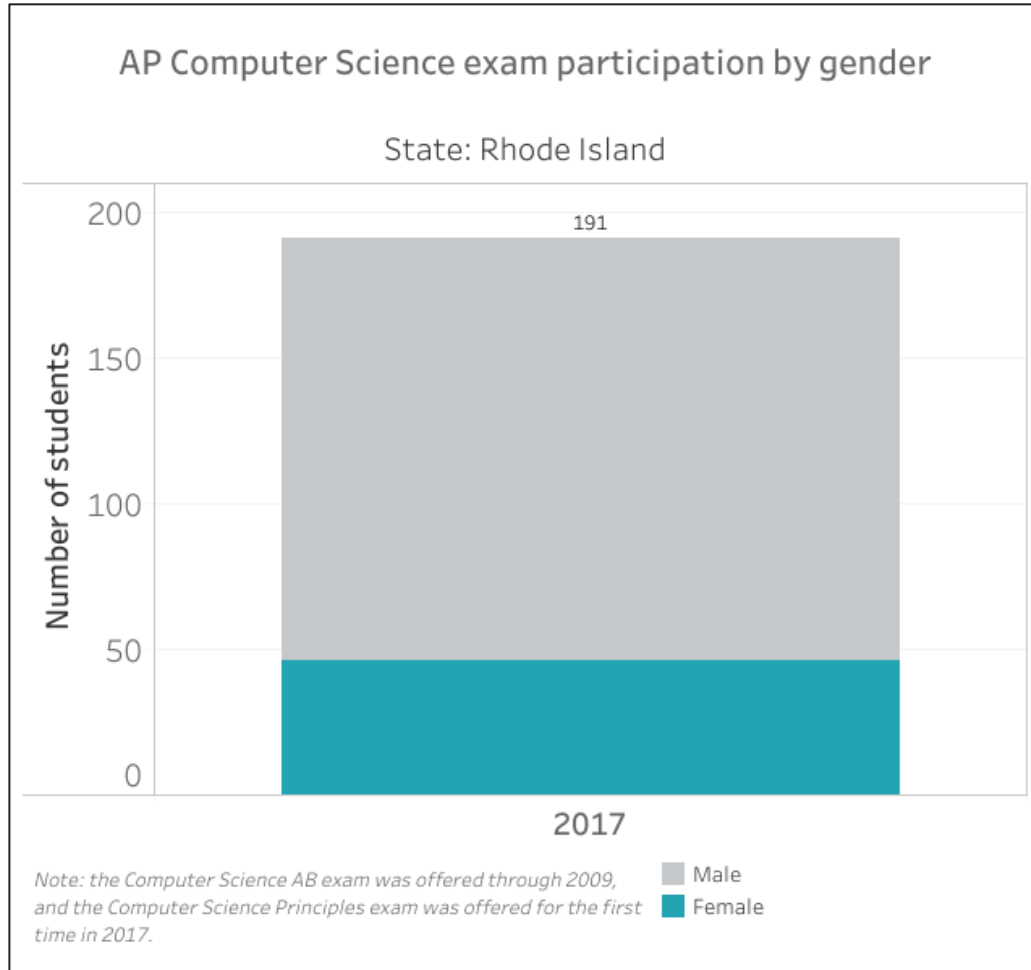
Figure 20: AP CSP Gender – Rhode Island

Comparing the Rhode Island gender breakdown to the national gender breakdown, Rhode Island AP Computer Science Principles test takers prove to be less equitable in gender. Specifically, approximately 76% (145 students) of AP CSP test takers in Rhode Island were male compared to the 70% (30,608 students) of male test takers across the country.

In summary, AP Computer Science Principles is more equitable and diverse than AP Computer Science A in both race and gender for the 2016-2017 academic year. However, when comparing equity and diversity ratios for AP Computer Science Principles between test takers across the United States and Rhode Island, Rhode Island

underperforms in both metrics with a delta of 18% in diversity and 6% in gender equity.

Section 2.5 – Effective Classroom Instructional Strategies

A great deal of research and literature exists regarding effective classroom instructional strategies that encourage diversity, equity, and accessibility to curriculum content [24]. Because there is some freedom in instruction for the AP Computer Science Principles course, research-based approaches can be taken to address the specific needs of a more diverse population of students.

The Universal Design of Learning is a research-based model or framework that can be used in education with the ultimate goal of ensuing the diverse educational needs of all students are met [23]. There are a several factors that need to be considered to ensure that a true UDL environment is being implemented. Some of these factors include increasing accessibility, isolating potential barriers and identifying students' learning preferences, aptitudes, and areas of improvement. However, the Universal Design for Learning is supported by three principles that encourage a universal access to learning. Representation, action and expression, and engagement are the three principles drive the concepts of access for all in the UDL model [23].

Representation focuses on how the content and material are being presented to the students. Because all students learn differently and have different learning preferences, multiple representations of information help ensure that the content is playing to each student's strength, instead of a select few [23]. Using different

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scenarios instead of one explanation also helps activate prior knowledge for students that might connect with the content differently.

Action and expression relates to how the students interact with the given information and how they convey their understanding of it. Constraining how assignments are completed automatically puts those who are not strong in that format at a disadvantage [23]. Therefore, allowing students to submit assignments or express their understanding of concepts in a range of ways removes barriers that might affect student performance, attitude, and perceptions. An example of this includes allowing the use of computers, audio, video, and oral presentations like in AP Computer Science Principles instead of strictly pen and paper assignments, which more closely follows the AP Computer Science A format.

Engagement challenges the strict student lecture relationship that is used in traditional classrooms. To encourage engagement with the material, discussing real world applications and allowing for open discussion can be used. Providing the ability to collaborate and communicate with follow students helps strengthen the student's involvement and engagement in the material. Models like the flipped classroom also challenge the traditional classroom format, providing some freedom in how students are allowed to learn.

It's important to note that AP Computer Science Principles is more adaptable to implemented UDL and other researched based frameworks, encouraging the enrollment and success of a more diverse range of students [23].

Chapter 3

METHODOLOGY

Section 3.1 – Outreach, Enrollment and Professional Development

To study the equity and inclusion of the University of Rhode Island's AP

Computer Science Principles course, ensuring a representative number of K-12

teachers were teaching AP CSP became the major source and bottleneck of data that

was required and used in this study. Because 2016-2017 was the first academic year

AP Computer Science Principles ran, developing AP CSP curriculum, spreading

awareness, and encouraging participation became an important part of this research.

The Department of Computer Science and Statistics at the University of Rhode Island

was tasked with developing AP CSP curriculum and assessment material while the

RITES+C office was tasked with contacting district leaders, principles, and teachers to

spread awareness of AP CSP. The participation of this research began in the

communication, canvasing, and documentation phase of this process. This required a

close and functional relationship with the RITES+C office and access to participant

data.

Having a strong distribution of teachers from a diverse set of districts willing to

participate in URI's AP CSP professional development [1](PD) and continue on to

implement AP CSP in their school for the following year became a specific goal of the

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[1] Professional Development is a formal training offered to teachers for continuing
education hours or credit that might be required by their school or district. It also
serves as a content specific training opportunity that allows teachers to
implement and teach new courses in their school [25].

Computer Science Department and RITES+C office. It's important to note that not all teachers that took URI's AP CSP PD taught AP Computer Science principles after the training. Because of this, having a strong understanding of which teachers and schools implementing AP CSP became an important aspect of the data collection process.

Section 3.2 – Data Collection

Once the enrollment process and professional development process came to a close, a series of surveys were distributed at the beginning and end of the 2016-2017 and 2017-2018 academic years to all AP CSP classrooms that taught AP CSP the school year after taking the summer PD. Non-identifying student demographic information such as the student's school name, grade, gender, race most closely identified with, location the survey was taken, and if a family member or close friend is involved in computer science was collected. From this data, an understanding of the class demographic distribution and population size was determined.

URI's AP Computer Science Principles students were not the only population data was collected on. The teaches who went through the URI professional development were also surveyed on what improvements they felt could be made to the training program and their comfort level with curriculum material. For future professional development iterations, this data will be used to modify and improve the training experience for teachers based on teacher recommendation.

This data collection process took place for both the 2016-2017 and 2017-2018 years. Communication with teachers and district leaders throughout the data collection period was necessary to ensure both teachers and students were confortable with the

AP CSP material and data collection process. At the beginning of each academic year, research agreement and media release forums were distributed and signed by all teachers in this study. Proper Institutional Review Board (IRB) training, certifications, and approval were also completed and acquired to ensure a reliable and ethical data collection process involving human subjects took place.

Aside from the survey data collected in the University of Rhode Island AP Computer Science Principles class, demographic information at the school level was collected and compare against the class level distribution. This data is publicly available through the Rhode Island Department of Education website and database. To acquire this data, a simple query to the RIDE database specifying the school, district, and enrollment year was needed. Once the demographic status at the class and school level was collected, a comparison between the class demographic distributions and school demographic distributions was made.

Section 3.3 – Curriculum and PD Analysis

Most of the available data on equity and inclusion in computer science is purely quantitative, limiting the scope of analysis that can be made on the subject. To gauge the proficiency of broadening participation strategies (BPC) in both AP CSP curriculum and professional development, a rubric developed by the Rhode Island Department of Education was used. With this rubric, a better understanding of how equitable and inclusive AP CSP curriculum and professional development is could be obtained.

The broadening participation rubric used to evaluate AP CSP contains different criteria related to how BPC manifests itself in AP CSP curriculum and professional development. The presence of these BPC qualities are evaluated with the following rankings: (1) Emerging: Evidence suggests no serious effort has been applied to this goal (2) Approaching: Evidence suggests some effort has been applied toward this goal (3) Developing: Evidence suggests appropriate or adequate meeting of goal (4) Mature: Strong evidence of meeting or exceeding goal. For each broadening participation criterion, a ranking is assigned with supporting evidence to justify the given ranking. The rubric for this curriculum analysis can be found in the appendices. It's important to note that the rankings given to each criterion was evaluated and approved by a content expert. The resulting rankings can be seen below in Table 1.

AP CSP Curriculum	AP CSP Professional Development
Mature – 4	Mature – 1
Developing – 4	Developing – 4
Approaching – 0	Approaching – 3
Emerging – 0	Emerging – 0

Table 1 – AP CSP Curriculum and PD Evaluation

Notably, AP Computer Science Principles curriculum meets or exceeds more broadening participation criteria than URI's AP CSP professional development. Because College Board is responsible for developing the AP CSP curriculum framework with the explicit goal of including broadening participation qualities, notions of BPC are reflected throughout the concepts and learning objectives covered

in AP CSP. This is not necessarily the case for the professional development workshops that educators went through at the University of Rhode Island. The professional development model used was developed based on teacher feedback requesting more individual time to learn the material than in-person instruction. This lack of face-to-face contact limited the amount of time that could be spend discussing the different type of broadening participation strategies that could be implemented in teacher classrooms. Because of this limitation, most of the face-to-face time spend with educations was content focused.

Chapter 4

FINDINGS

Section 4.1 – 2016-2017 University of Rhode Island AP CSP and School Data

For the first iteration of the AP Computer Science Principles course in 2016-2017, 12 schools implemented the University of Rhode Island's curriculum. Table 2 contains the list of schools where data was collected.

Schools
Juanita Sanchez Educational Complex
Classical High School, Providence
Westerly High School
East Greenwich High School
Cranston Area Career Technical Center
Woonsocket High School
North Smithfield High School
Mount Pleasant High School
MET-East Bay / FabNewport
Narragansett High School
Chariho Regional High School
Smithfield High School

Table 2: 2016-2017 AP CSP Schools

From these schools, a total of 135 students submitted surveys indicating that they were enrolled in AP Computer Science Principles. It's important to consider that some classroom barriers such as attendance and computer availability might have impacted the survey return count. That is, just because 135 students completed the enrollment survey does not mean that exactly 135 students were enrolled in URI's AP Computer Science Principles course.

Of these respondents, 104 reported that they self-identify as male, 30 self-identified as female, and 1 student omitted gender identification. For the 2016-2017 academic year, 77% of students taking URI's AP CSP course were male and 22% female. This distribution is illustrated in Figure 21.
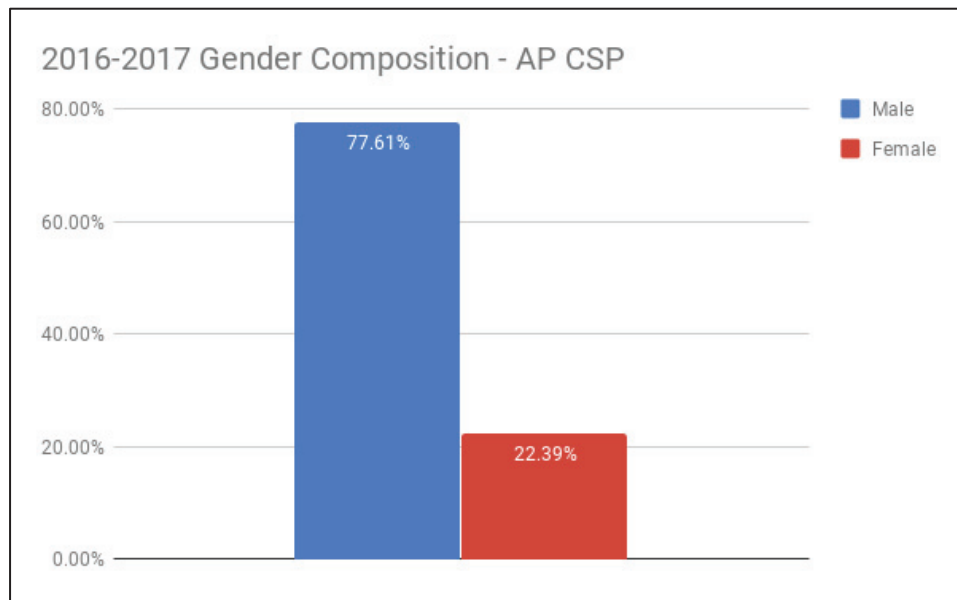
Figure 21: 2016-2017 AP CSP Gender Breakdown – AP CSP

This gender breakdown represents the entire population of students from the 12 different schools implementing URI's AP Computer Science Principles course. Comparing the collective gender breakdown of the classrooms to the collective gender breakdown of the schools will clarify gender equity of URI's AP CSP for the 2016-2017 year. Figure 22 shows the collective gender breakdown for the schools that participated in URI's AP Computer Science Principles.
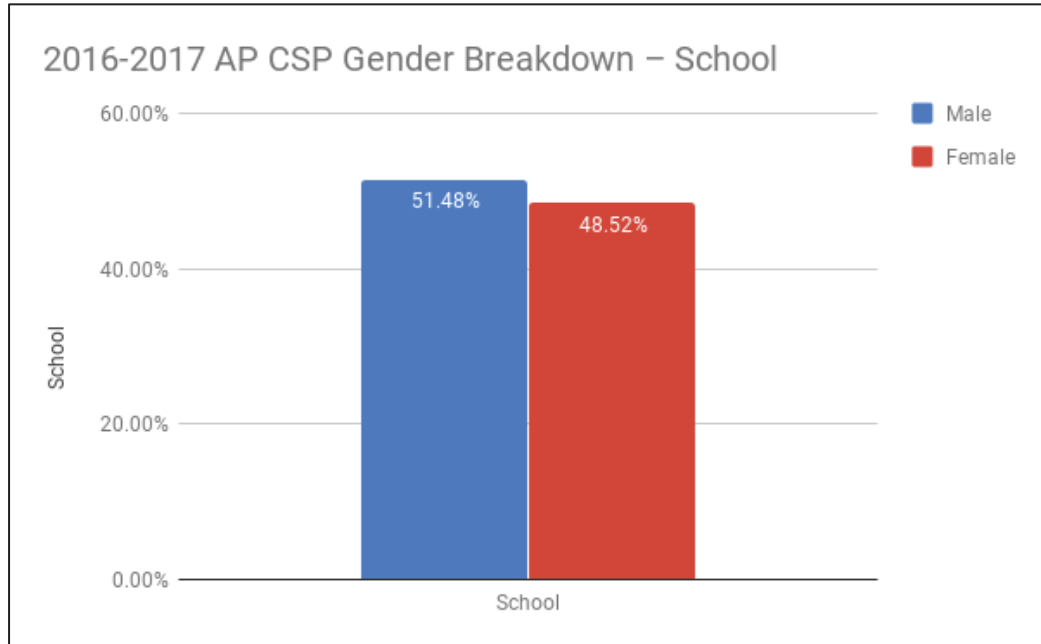
Figure 22: 2016-2017 AP CSP Gender Breakdown – School

Proportionally, we see that the gender breakdown for the school is almost a
one-to-one relationship. It's important to note that the school demographic data was not
available for the MET-East Bay and Cranston Area Career Technical Center schools,
so their demographic data is not considered here. Figure 23 provides a side-by-side
comparison between AP CSP classroom and school data to illustrate any disparity in
gender.
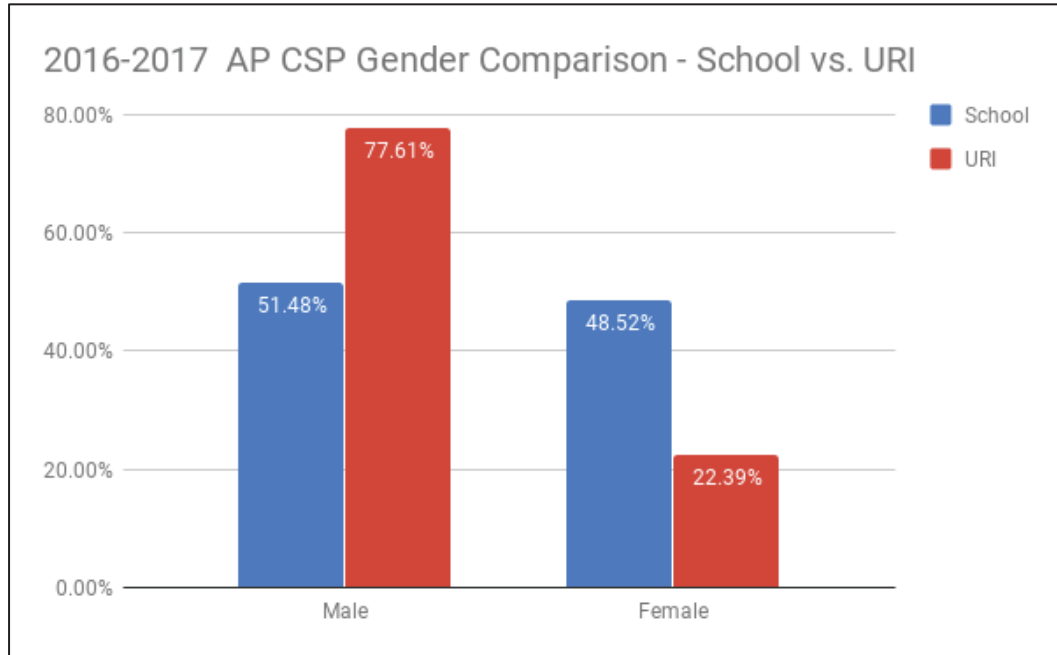
Figure 23: 2016-2017 AP CSP Classroom/School Comparison

We see a clear disparity in gender equity for the University of Rhode Islands

2016-2017 AP CSP course compared to the gender breakdown for the school. For the

context of this research, equity would mean that the classroom distribution is

proportional to the school distribution in both gender and race/ethnicity. However,

there is a 26.1% gap between the percentage of males in the University of Rhode

Island's AP Computer Science principles course and males in the total school

population and a 26.1% gap between women. For future implementations of URI's AP

CSP courses, the goal is to minimize or eliminate this gap in gender participation.

Table 3 provides the tabular data for the demographic distribution in the URI

AP CSP classrooms.

Race/Ethnicity	Count	Participation (%)
Native Hawaiian	2	1.48%
Asian Pacific	14	10.37%
Black	13	9.63%
White	91	67.41%
Hispanic	5	3.70%
Multi-Race	7	5.19%
Omitted	3	2.22%

Table 3: 2016-2017 URI AP CSP Demographic

This data is represented graphically in Figure 24 below.
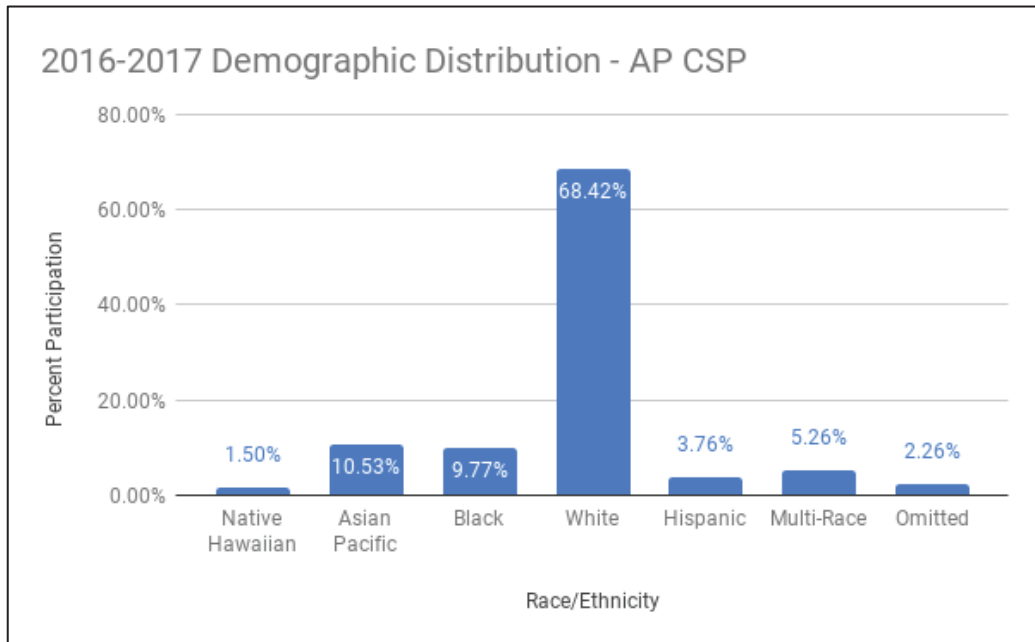
Figure 24: 2016-2017 AP CSP Demographic Distribution - URI

As Table 3 and Figure 24 illustrate, approximately 68% of students enrolled in URI's AP Computer Science Principles course self-identify as White, 10% as Black, and 4% as Hispanic. Comparing this distribution with the demographic distribution of the schools will demonstrate the equity and inclusion for race and ethnicity for the 2016-2017 academic year. Table 4 and Figure 25 provide the tabular and graphical data for the schools demographic profile, respectively.

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Race/Ethnicity	Count	Participation (%)
Native American	70	0.83%
Asian Pacific	368	4.35%
Black	638	7.54%
White	4818	56.93%
Hispanic	2289	27.05%
Multi-Race	280	3.31%

Table 4: 2016-2017 School AP CSP Demographic
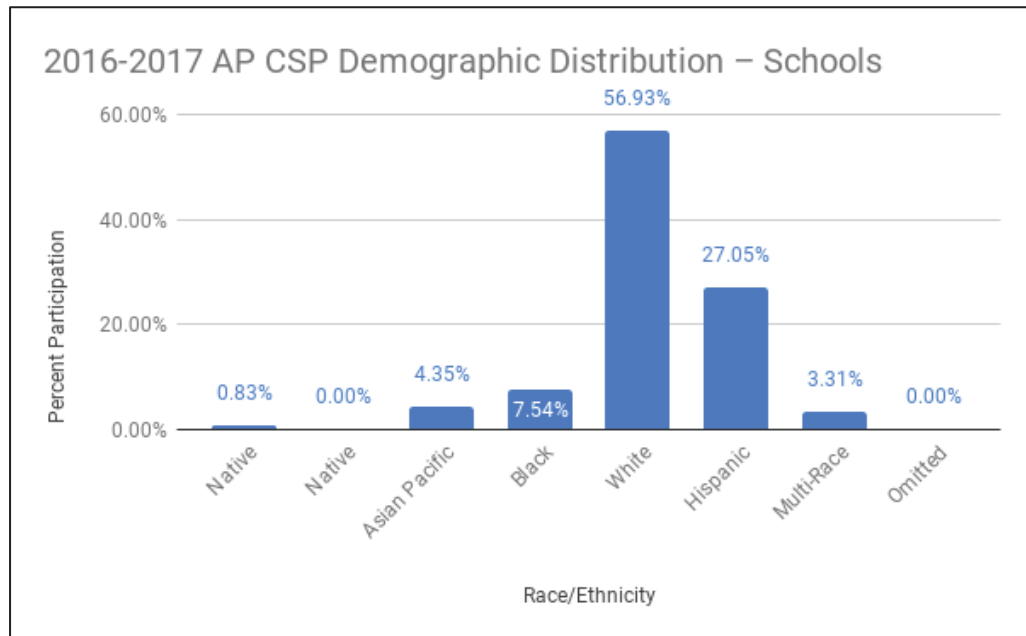
Figure 25: 2016-2017 AP CSP Demographic Distribution – Schools

At the schools level, approximately 57% of students self-identify as White, 8% of students self-identify as Black, and 27% of students self-identify as as Hispanic. Compared to the URI classroom demographic, the following disparity can be described in Figure 26.

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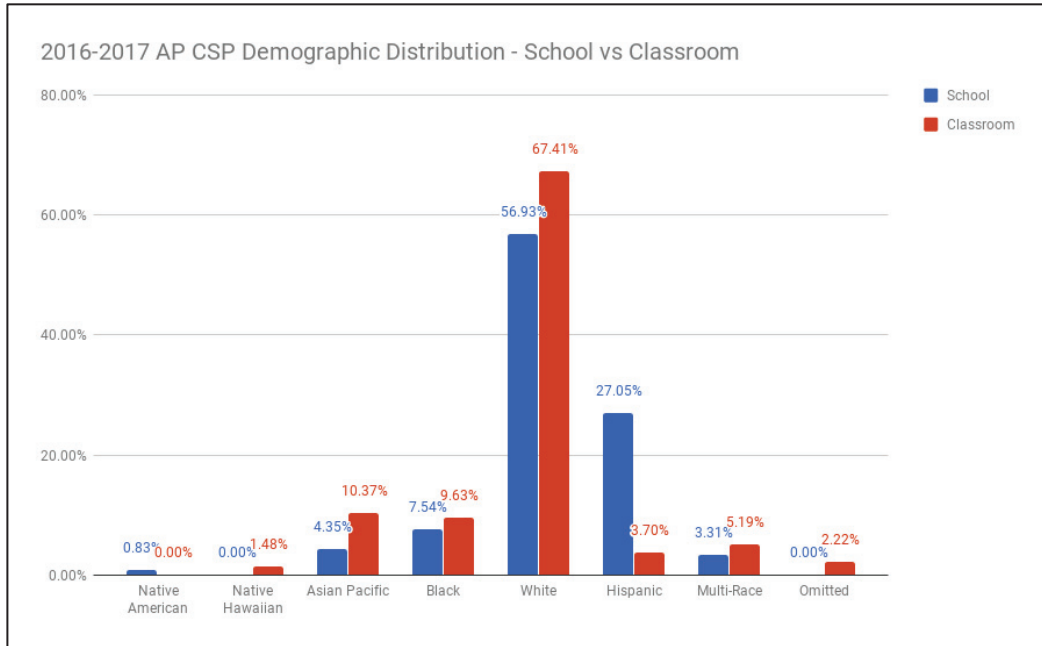
Figure 26: 2016-2017 AP CSP Demographic Distributions - School vs. Classroom

For the 2016-2017 academic year, equity and inclusion under in the context of race and ethnicity illustrate success in some considerations and areas for improvement in others. Notably, the percentage of Black, Multi-Race, and Native Hawaiian students taking the University of Rhode Islands AP Computer Science Principle course are greater represented when compared against their representation in the school demographic data. There is, however, an over representation of White students in AP CSP when compared to their school demographic representation.

One of the biggest disparities observed in the 2016-2017 academic year is the Hispanic population. While Hispanics represent approximately 27% of the population in the group of schools implementing AP Computer Science Principles, only about 4% of AP CSP students self-identified as Hispanic. This allows for a gap of 23% students in the Hispanic population that should be taking AP CSP for the class to be considered equitable in its enrollment ratio.

For the 2016-2017 academic year, AP Computer Science Principles reflected a disparity in gender and select demographic groups. At a high level, more men participated in AP Computer than women. While a representative number of Black, Native Hawaiian, and Multi-Race students participated in AP Computer Science Principles, the ratio of students from the Hispanic population were not representative in AP Computer Science Principles compared to demographic distribution in the set of schools surveyed.

Section 4.2 – 2017-2018 University of Rhode Island AP CSP and School Data

For the second iteration of the AP Computer Science Principles course in 2017-2018, 23 schools implemented the University of Rhode Island's curriculum. Table 5 contains the list of schools where data was collected

Schools	
360 High School	Narragansett High School
Block Island School	North Smithfield High School
Chariho High School	Providence Career & Technical Academy
Charles E. Shea High School	Rogers High School
Classical High School	Smithfield High School
Cranston Area Career & Technical Center	South Kingstown High School
East Bay - The MET	Tiverton High School
East Providence High School	Toll Gate High School
Exeter-West Greenwich Regional High	West Warwick High School
Homeschooled	Westerly High School
Juanita Sanchez Educational Complex	Woonsocket High School
Mount Pleasant High School	

Table 5: 2017-2018 AP CSP Schools

From these schools, a total of 288 students submitted surveys indicating that they were enrolled in AP Computer Science Principles. The same barriers that might have impacted the enrollment survey return count for the 2016-2017 academic year also existed for this year. That is, student attendance and computer availability could have prevented some students from submitting surveys.

Of the 288 students that participated in AP Computer Science for the 2017-2018 academic year, approximately 67% self-identified as male and 34% identified as female. The tabular data is given below as Table 6 and graphical data as Figure 27.

Gender	Count	Participation (%)
Male	192	66.67%
Female	96	33.33%

Table 6: 2017-2018 AP CSP URI Gender Breakdown
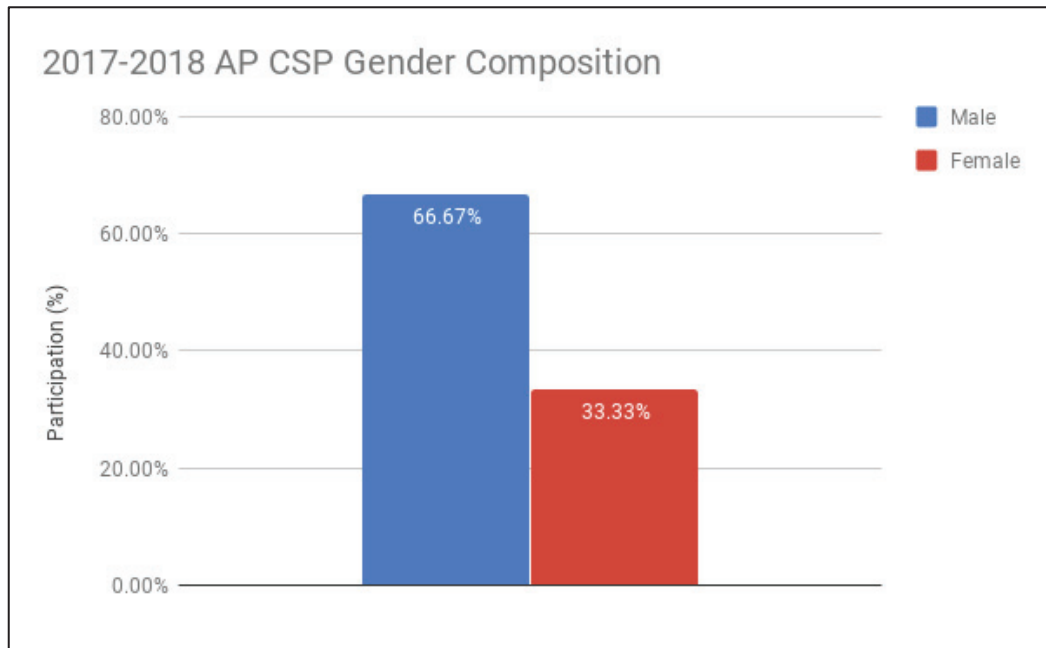
Figure 27: 2017-2018 AP CSP Gender Breakdown - URI

Comparing the URI AP CSP data for the 2017-2018 academic year with the school population data, a disparity in gender can be determined. Figure 28 shows the gender breakdown for the schools that participated in URIs 2017-2018 AP CSP professional development and implemented an AP CSP class.
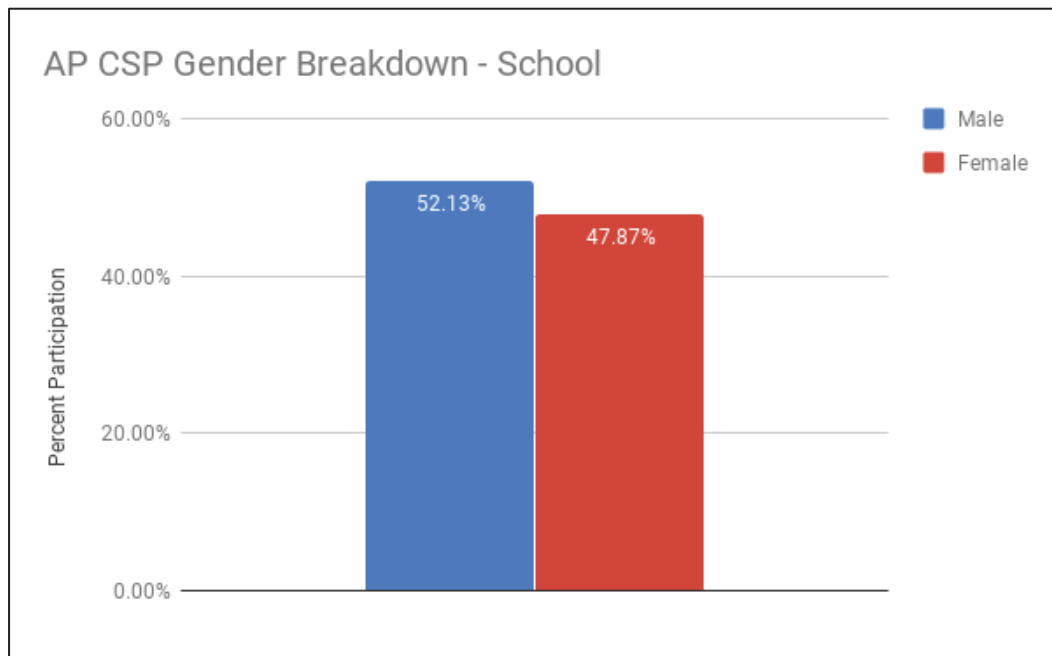
Figure 28: 2017-2018 AP CSP Gender Breakdown - School

The male and female figures for AP Computer Science Principles at the classroom and school level are not proportional. With the gender profile of the schools implementing URI's AP Computer Science Principles at approximately 52% male and 48% female and the gender classroom statistics at 67% male and 33% female, the gender ratio in AP CSP does not equal the gender ratio of the schools. Figure 29 provides a comparison view of the gender breakdown between the school and class populations.
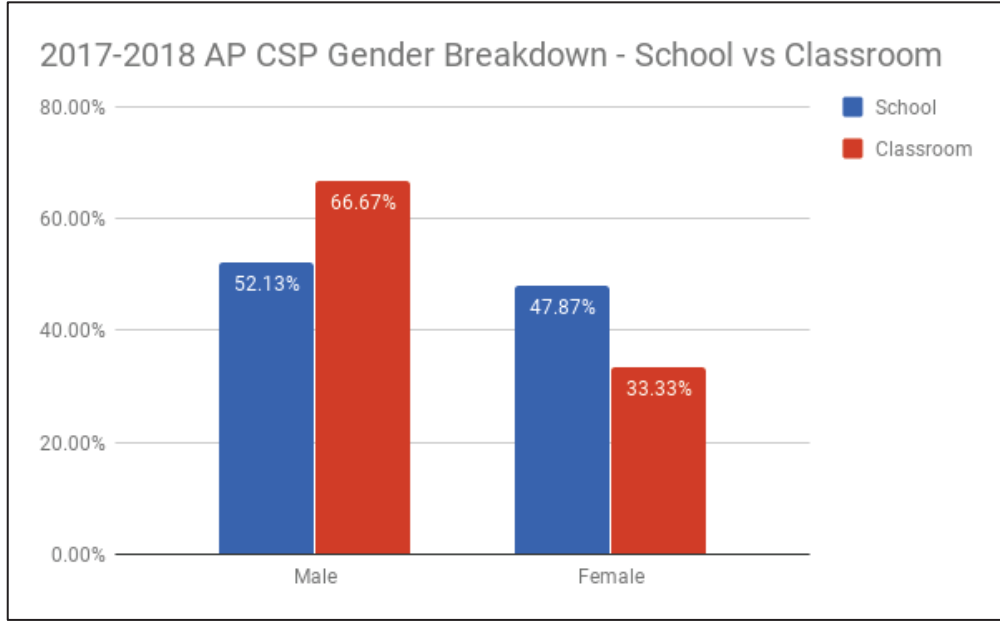
Figure 29: 2017-2018 AP CSP Gender Breakdown - School vs. Classroom

The AP Computer Science Principles demographic profile for the 2017-2018
year can help indicate the equity and inclusion of the University of Rhode Island's AP
Computer Science Principles course. Table 7 provides the tabular data for the
demographic makeup of URI's AP CSP course.

Race/Ethnicity	Count	Participation (%)
American Indian or Alaskan Native	1	0.35%
Asian	21	7.29%
Black	23	7.99%
Hispanic	68	23.61%
Middle Eastern	1	0.35%
Multi-Race	3	1.04%
White	171	59.38%

Table 7: 2017-2018 AP CSP Gender Breakdown – URI Tabular

Figure 30 graphically represents the demographic distribution for URI's AP CSP
courses.
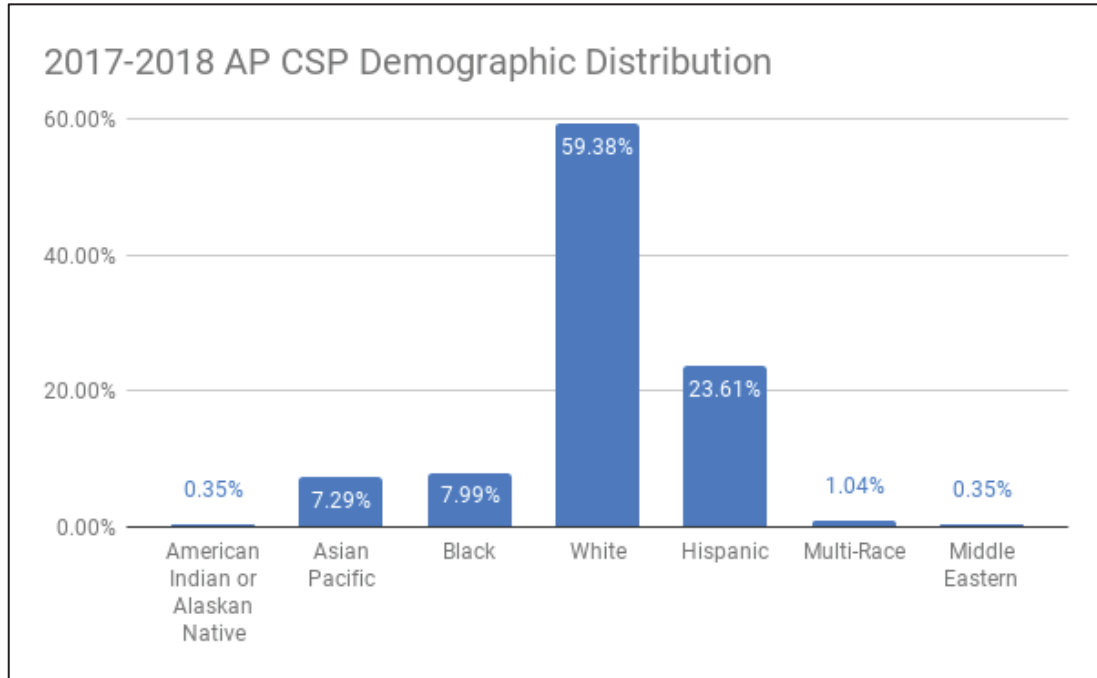
Figure 30: 2017-2018 Demographic Distribution - URI

As Figure 30 reflects, the largest population participating in AP CSP for the

2017-2018 academic year includes White students, with the second largest group being

Hispanic students. Comparing URI AP CSP demographic data against school

demographic data will demonstrate the equity and inclusion of the 2017-2018 AP CSP

class. Table 8 and Figure 31 provide the tabular and graphical data, respectively.

Race/Ethnicity	Count	Participation (%)
Native American	151	0.95%
Asian Pacific	517	3.26%
Black	1551	9.79%
White	9331	58.91%
Hispanic	3700	23.36%
Multi-Race	589	3.72%

Table 8: 2017-2018 AP CSP Demographic Distribution -School
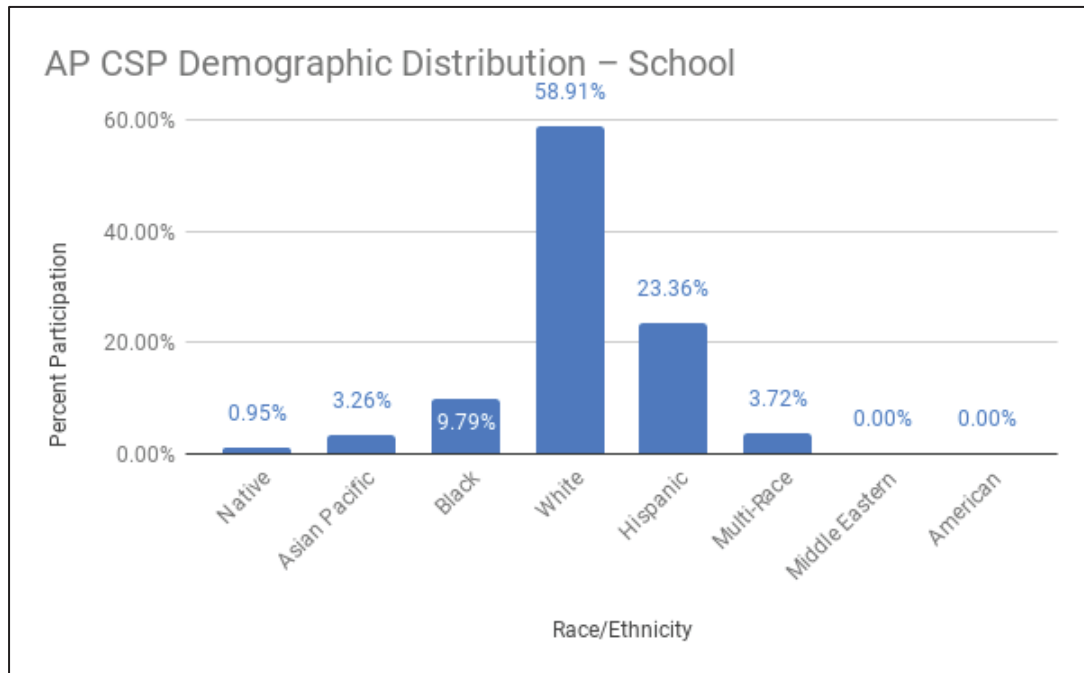
Figure 31: 2017-2018 AP CSP Demographic Distribution – School

At a first glance of the school demographic distribution data, the largest demographic population for the 2017-2018 academic year of all schools running an AP Computer Science Principles course includes White students, with the second largest group being Hispanic students. This mirrors the trend shown at the classroom demographic level. Figure 32 provides a side-by-side representation of the school data and classroom data for the 2017-2018 year. To be equitable, the percentage of students in each demographic group should be consistent between AP CSP enrollment and school demographic composition.
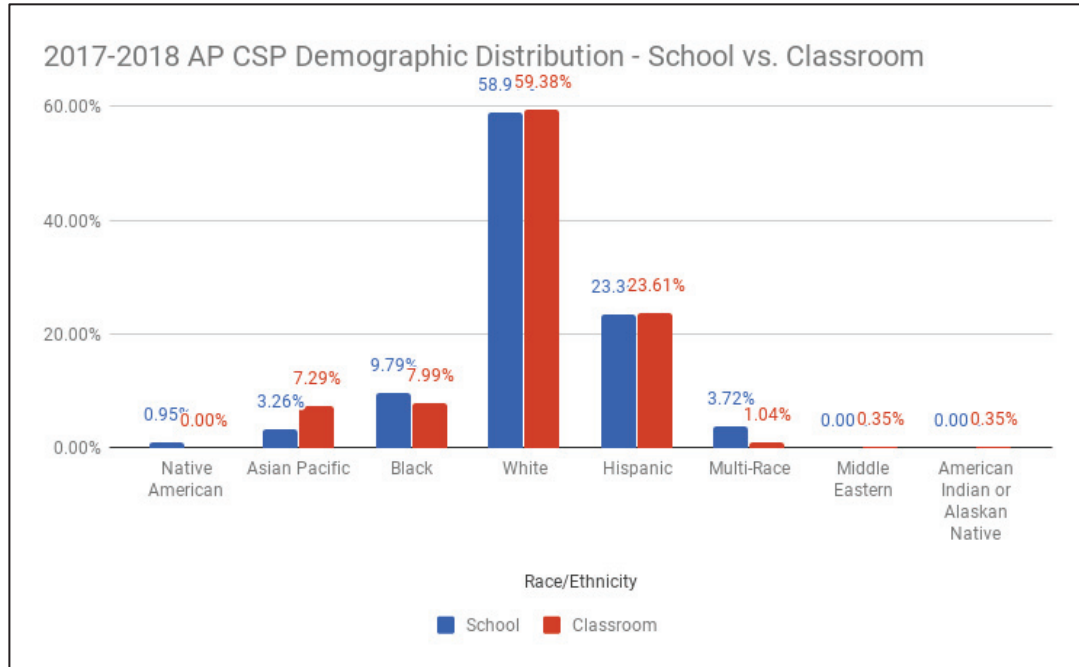
Figure 32: 2017-2018 AP CSP Demographic Distribution - School vs. Classroom

For the 2017-2018 academic year, the percentage of students taking URI's AP Computer Science Principles class and demographic profile of the school mirror each other much more closely than 2016-2017. Table 9 provides the percent difference between each demographic group.

Race/Ethnicity	School	Classroom	Delta (%)
Native American	0.95%	0.00%	0.95%
Asian Pacific	3.26%	7.29%	4.03%
Black	9.79%	7.99%	1.80%
White	58.91%	59.38%	0.47%
Hispanic	23.36%	23.61%	0.25%
Multi-Race	3.72%	1.04%	2.68%
Middle Eastern	0.00%	0.35%	0.35%
American Indian or Alaskan Native	0.00%	0.35%	0.35%

Table 9 – Percent Difference Between School and Classroom Demographics Ratio

Table 9 demonstrates that the percent difference between school demographics and classroom demographics are less than 5% across all demographic populations.

Focusing on the percent differences of underrepresented populations, approximately 9.79% of Black students make of up demographic profile of the schools implementing AP CSP and approximately 7.99% of students enrolled in AP CSP self-identify as Black, giving a 1.80% difference in participation. This is an equitable difference in demographic participation. The difference in Hispanic participation is 0.25%. This is significantly more equitable than the 2016-2017 academic year. In fact, a greater percentage of Hispanic students enrolled in AP Computer Science Principles than represented in school demographic. This is an important step towards equity and inclusion for AP CSP. This is also true for the Asian student population. A greater percentage of Asian students participated in AP CSP than represented in the schools demographic profile for the 2017-2018 academic year. It's important to note that only a 0.47% difference exists between the percentage of White students in AP CSP and of the school demographic profile.

For the 2017-2018 academic year, the University of Rhode Island's AP Computer Science class was equitable and inclusive for all race and ethnicity populations, with at most a 5% difference in participation across all demographic groups. The demographic profile for AP CSP classes and the schools running those classes were proportional. This data reflects that participation in the AP CSP course was equitable for the 2017-2018 students based on race and ethnicity. However, the percentage of women in AP Computer Science Principles for the 2017-2018 academic year was not representative of the female population at the school level. With a 14.54% gap between women enrollment in the group of schools implementing AP CSP and women participation in URI's AP Computer Science Principles, these two groups are

not proportional. Through active encouragement, exposing women to computer science, and an increase in incentive programs, more women are likely to peruse computer science as a field of study in the future.

Section 4.3 – AP Computer Science Principles 2016-2018 Progression

Looking at how the 2016-2017 and 2017-2018 academic years compare in enrollment and demographic distribution will give an idea of enrollment changes and trends that might occur in future iterations of AP CSP. Figure 33 gives the gender enrollment for the University of Rhode Islands AP Computer Science Principles course from 2016-2018.
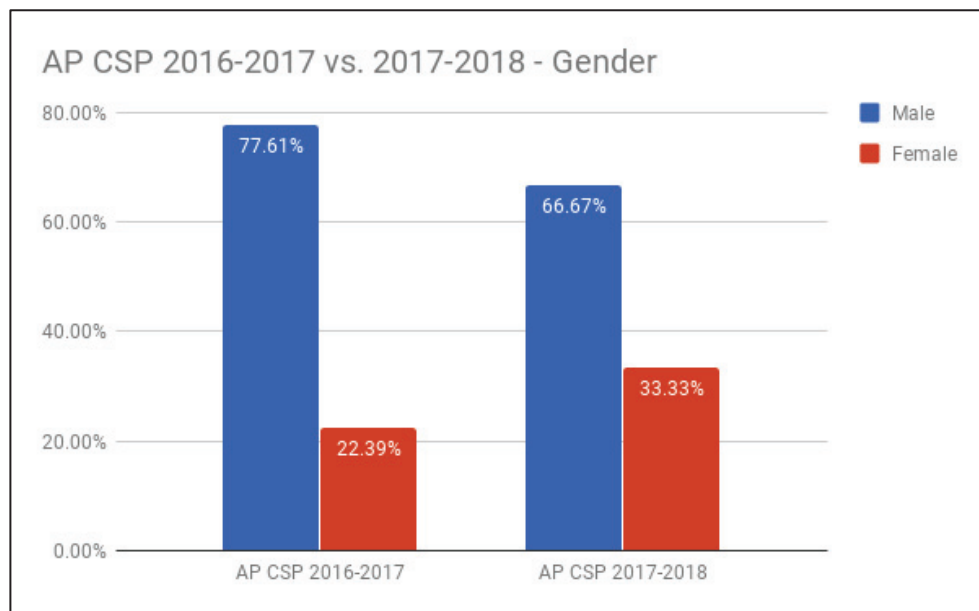
Figure 33 - AP CSP 2016-2017 vs. 2017-2018 - Gender

This two-year comparison shows an increase in enrollment female students. Because 2016-2017 was the first year that AP Computer Science Principles was implemented, awareness of the course could have been a barrier for initial enrollment. In addition to enrollment, the participation gap between males and females seems to

decrease in the 2017-2018 academic year. Based on the two years that data exists for AP CSP, URI's course is becoming more equitable in gender.

Below, Figure 34 compares the race and ethnicity enrollment and participation over time.
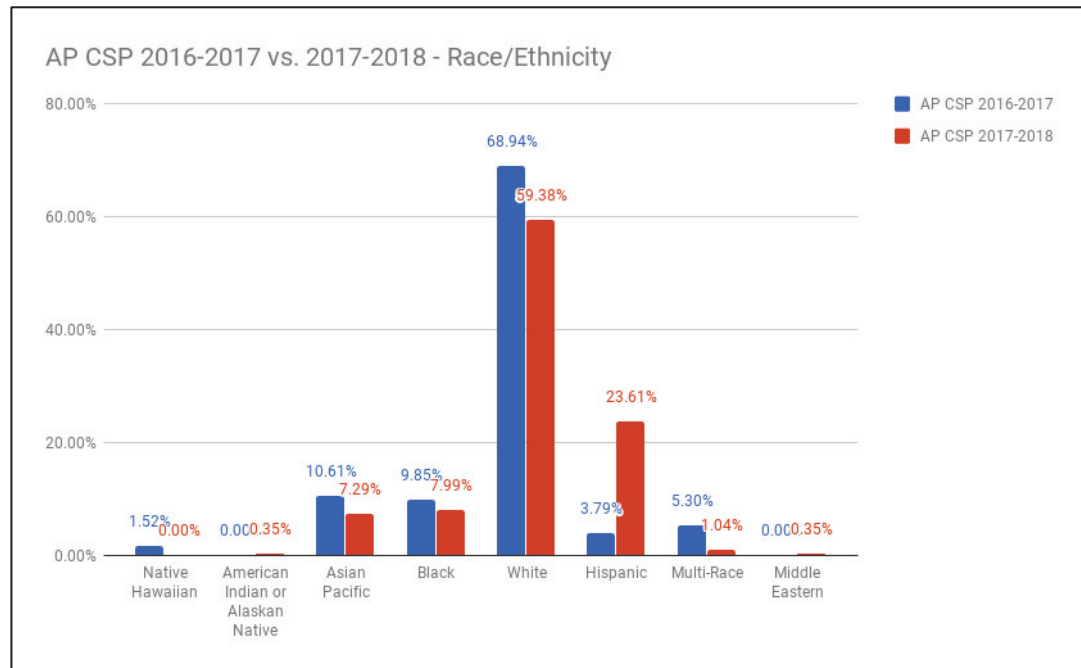
Figure 34 - AP CSP 2016-2017 vs. 2017-2018 - Race/Ethnicity

Figure 34 importantly shows the increase in the difference race and ethnicity populations in AP CSP over time.

Because only two years of data exist, it is difficult to find explicit patterns or identify trends that will predict the progression of equity and inclusion in AP Computer Science Principles. It is worth noting, however, that an increase in equity and inclusion exists from the 2016-2017 and 2017-2018 academic years. This positive outcome allows for the hope of a truly equitable, accessible, and inclusive AP Computer Science Principles course for all in the years to come.

Chapter 5

CONCLUSION

5.1 – Present Conclusion

Equity, inclusion, and access in the field of computer science, while not as diverse as it should be, are slowly taking steps in the right direction. For the 2017-2018 academic year, AP CSP was equitable and inclusive in its demographic composition. Gender participation, while approaching equity, is still an area for improvement. This positive trend towards equity, inclusion, and accessibility for all is further reflected in the enrollment and participation of Rhode Island students in the University of Rhode Island's AP Computer Science Principles course.

For the two years of enrollment and demographic data that exists for URI's AP Computer Science Principles course, an increase in enrollment, diversity, and equity is observed. That is, the gender gap between male and female students is diminishing. The race and ethnicity composition of the school and AP CSP class population gaps are also diminishing for students who self-identify as Hispanic, Black, or Asian. While there is still a lot of work to be done to diversify the field of Computer Science and increase the equity and inclusion of the AP Computer Science Principles exam, the closing disparity gap for gender, race, and ethnicity is an encouraging step for the future work and efforts to achieve true equity and inclusion in computer science.

5.2 – Future Work

For future consideration, a limitation of this study includes the lack of longitudinal analysis of AP CSP students that moved forward in computer science after taking the University of Rhode Islands AP Computer Science Principles course. The instruments that were used to collect data in this study did not have mechanisms that allowed for a longitudinal study of underrepresented minority groups. Designing and implementing instruments to allow for a longitudinal study to better understand how URI's AP Computer Science Principles would allow a better understanding of the impact AP CSP has on K-12 students.

Furthermore, creating professional development workshops that better communicate the broadening participation strategies discussed in RIDE's broadening participation rubric will benefit both the AP Computer Science Principles workshops and the educator's understanding of how to propagate the motivation and values of broadening participation in computer science.

Finally, a continuation of data collection and comparison in both demographic composition and gender participation is required to ensure the equity and inclusion of AP Computer Science Principles is still making progress in a positive direction. With these future considerations in mind, a stronger understanding of equity and inclusion in AP Computer Science Principles can be achieved.

Broadening Participation Rubric - Curriculum

Emerging: Evidence suggests no serious effort has been applied to this goal.

Approaching: Evidence suggests some effort has been applied toward this goal.

Developing: Evidence suggests appropriate or adequate meeting of goal.

Mature: Strong evidence of meeting or exceeding goal.

Culturally Responsive Curriculum	Emerging	Approaching	Developing	Mature	**Specific Examples**
Students see themselves represented in curricular materials.				X	*See Table 12
Curriculum is relevant to students' community and culture.			X		*See Table 12
Curriculum is accessible so that all students can participate.			X		*See Table 12
Curriculum promotes active, inquiry-based learning.			X		*See Table 12
Curriculum promotes small group learning.				X	*See Table 12
Curriculum demonstrates that individuals from diverse backgrounds can achieve in CS careers			X		*See Table 12
There are frequent opportunities for dialogue and problem-solving.				X	*See Table 12
Assessments provide multiple opportunities to demonstrate understanding.				X	*See Table 12

Table 10 - Broadening Participation Rubric - Curriculum

Broadening Participation Rubric - Professional Development

Emerging: Evidence suggests no serious effort has been applied to this goal.

Approaching: Evidence suggests some effort has been applied toward this goal.

Developing: Evidence suggests appropriate or adequate meeting of goal.

Mature: Strong evidence of meeting or exceeding goal.

Culturally Responsive Professional Development	Emerging	Approaching	Developing	Mature	Specific Examples
Educators learn how to recruit URG students into computer science courses.			X		*See Table 13
Educators learn how to create an inclusive physical environment.		X			*See Table 13
Educators learn how to create an inclusive social classroom atmosphere.			X		*See Table 13
Educators learn about implicit (unconscious) bias and how that can negatively impact URG learners.		X			*See Table 13
Educators learn about how to promote a growth mindset among students and to emphasize how abilities are expandable.		X			*See Table 13
Educators learn how to teach without necessarily being an expert.				X	*See Table 13
Educators learn instructional methods that inspire interest and engagement for in computer science for all students.			X		*See Table 13
Educators learn to create inclusive assignments and assessments.			X		*See Table 13

Table 11 - Broadening Participation Rubric - Professional Development

Broadening Participation Rubric – Curriculum Rational

Students see themselves represented in curricular materials. Peer programming, dialogue, and problem solving are critical elements of computer science and are all communicated in the AP CSP curriculum through readings, assignments, and group projects. Breaking down problems into smaller and more manageable tasks is a technique that is enforced and encouraged throughout the AP CSP course. Group projects that encourage peer dialogue and problem solving prove to be a reoccurring motif of URIs AP CSP course. All of the assessments include problem solving. Opportunity of dialogue. Unit 1: Computing Innovations- Week 1: Computing Innovations Unit 6: AP Explore Performance Task- Week 16-17: Impact of Innovation Explore Performance Task Unit 9: AP Create Performance Task - Week 28-30: Create (Programming) Performance Task
Curriculum is relevant to students' community and culture. Here, we see a direct relationship between the students' community and culture. This lesson will produce different results based on the student's community and culture. This theme of making personal connections to the student's life and culture continue across different units and lessons, encouraging the student to consider how they interact with technology. Unit 3: Computational Artifacts - Week 7: Video and Audio
Curriculum is accessible so that all students can participate. AP Computer Science Principles is designed in an inclusive and accessible way so all students can participate in AP CSP curriculum. This is reflected in not mandating a specific programming language to be used and the concept of the "Big Ideas" that students should walk away with after talking AP CSP. This type of accessibility is further reflected in URI's implementation through the creation of digital artifacts that often reflect student interest. Many of URI's AP CSP unit and lesson descriptions conform to the Universal Design for Learning model, allowing for increased accessibility to curriculum concepts and material. Student deliverables and assessment vary, allowing for the different academic aptitudes and learning styles students possess to be reflected in URIs AP CSP. Unit 4: Computing Systems - Week 11: Cyber Security Unit 7: JavaScript Programming- Week 18: Introduction
Curriculum promotes active, inquiry-based learning. The specific examples below include instances where students are encouraged to interact with AP CSP material in an active, inquiry-based way. That is, these units and lessons have students doing hands-on work, allowing for inquiry and discovery when things don't go as expected or the student needs to develop a strategy to solve a problem. Unit 3: Computational Artifacts - Week 7: Video and Audio Unit 4: Computing Systems - Week 11: Cyber Security Unit 4: Computing Systems - Week 12: Cryptography Unit 9: AP Create Performance Task - Week 28-30: Create (Programming) Performance Task
Curriculum promotes small group learning. Here, students are encouraged to work with each other and collaborate on how best to present the required content. Several lessons in URIs AP CSP curriculum allow for outside and group participation. Here in the lesson summary, it is specified that collaboration is strongly encouraged. This lesson is a quintessential instance of small group learning being promoted in AP CSP units and lessons. Unit 1: Computing Innovations- Week 1: Computing Innovations Unit 3: Computational Artifacts - Week 7: Video and Audio Unit 9: AP Create Performance Task - Week 28-30: Create (Programming) Performance Task
Curriculum demonstrates that individuals from diverse backgrounds can achieve in CS careers Unit 1 provides resources that specifically demonstrate that individuals from diverse backgrounds can achieve in the field of computer science. Specifically, Code.org has published the short film What Most Schools Don't Teach, which includes a diverse range of individuals discussing their

| involvement and experience in computer science. |
| Unit 1: Computing Innovations- Week 1: Computing Innovations |
| **There are frequent opportunities for dialogue and problem solving.**
Peer programming, dialogue, and problem solving are critical elements of computer science and are all communicated in the AP CSP curriculum through readings, assignments, and group projects. Breaking down problems into smaller and more manageable tasks is a technique that is enforced and encouraged throughout the AP CSP course. Group projects that encourage peer dialogue and problem solving prove to be a reoccurring motif if URIs AP CSP course. All of the assessments include problem solving. Opportunity of dialogue.
Unit 4: Computing Systems - Week 8: Hardware and Abstraction |
| **Assessments provide multiple opportunities to demonstrate understanding.**
The assessment opportunities for AP CSP are consistent throughout its curriculum. That is, at the end of each week there is a conceptual quiz and practical assignment in the form of a Google document that the student is expected to read, follow directions, and complete. This assessment strategy might not allow students with different academic aptitudes to clearly demonstrate their content knowledge. For this reason, AP CSP's ability to provide multiple opportunities to demonstrate understanding through its assessment is developing. While it's true that the deliverables for each assignment differ as in the image and video assignments, effectively catering to individual learning and assessment styles, the directions for each assessment purley text based, inhibiting access for ELL students or individuals with low reading comprehension. Also, only using timed paper/pencil quizzes for a conceptual assessment is not equitable to students who have test anxiety or do not prefer the pater/pencil medium. Having take home, online, or alternate options for the student to demonstrate content knowledge provides more opportunities for students to demonstrate understanding.
Unit 3: Computational Artifacts - Week 6: Images
Unit 3: Computational Artifacts - Week 7: Video and Audio |

Table 12: Broadening Participation Curriculum Rational

Broadening Participation Rubric – PD Rational

| **Educators learn how to recruit URG students into computer science courses.**
Time for the AP Computer Science Principles Professional Development is spent towards discussing recruitment strategies for underrepresented students in computer science. Specifically, educators are encouraged by staff to reach out to school and district leads to increase the advertisement and accessibility of AP Computer Science Principles to URG students. Additionally, time is spent during the PD discussing the significant impact guidance counselors and other educations can have to encourage URG students. Contact information for school and district leads is also collected to encourage communication, advertising, and accessibility to for AP Computer Science and URG students. Explicitly tell teachers, from NCWHIT, one of the most effective ways of recruiting underrepresented groups is for teachers to personally approach them. Offering full course to teach strategies for recruiting URM |
| **Educators learn how to create an inclusive physical environment.**
The professional development offered by the University of Rhode Island or AP Computer Science Principles does offer some recommendations to create a physically inclusive environment such as classroom layout and student grouping based on performance and aptitudes. However, while these qualities are present in URI's PD, they are not the focus of the professional development.
It is worth noting that inclusion is embedded in the curriculum itself and covered when that material is viewed. However, this does not mean that a significant amount of time is used to discussed the physical environment of the classroom. For this reason, this category is marked 'approaching'. |
| **Educators learn how to create an inclusive social classroom atmosphere.**
The AP CSP material and resources encourage an inclusive and social classroom atmosphere in the nature of curriculum assignments and activities. This inclusive classroom atmosphere is further discussed and encouraged during PD. This translates into an inclusive and social classroom atmosphere during the PD process with the hope that teachers will emulate a similar environment |

when implementing AP CSP curriculum in their schools. Group activities and discussions are a pivotal part of the University of Rhode Island's AP CSP professional development. A teach, learn, share model is used for many parts of the AP CSP. This inclusive and social atmosphere is further observed through the on-going Community of Practice established by URI. URI Supports an on-going Community of Practice with URI staff and all teachers teaching this course. The CoP provides an online forum, a phone/online teacher help line, and site visits/in-person help.

Educators learn about implicit (unconscious) bias and how that can negatively impact URG learners.

While equity and inclusion is discussed during AP CSP professional development, the specific topic of implicit bias and its negative effects is not directly addressed. With the research collected for this project, data can be presented at future PDs that highlight the negative impacts of implicit bias and strategies that can be used to counter unconscious bias.

Educators learn about how to promote a growth mindset among students and to emphasize how abilities are expandable.

PD we show teachers how to use Kahn docs so they can show the students that not all of JS will be taught, but they can go out and find stuff through the documentation and example.

Educators learn how to teach without necessarily being an expert.

The notion that educators can learn how to teach without AP CSP material without being an expert is strongly convey before, during and after AP CSP professional developments. This is clearly outlined on the AP CSP registration page, "The PD makes no assumptions about the background of the teacher, except that they are willing to learn".The focus of this assignment that any teacher that is willing to learn AP CSP should be able to implement AP CSP in their schools.

Educators learn instructional methods that inspire interest and engagement for in computer science for all students.

The community of practice helps encourage educators to learn instructional methods that inspire interest and engagement in computer science for all students.

Educators learn to create inclusive assignments and assessments.

URI Supports an on-going Community of Practice with URI staff and all teachers teaching this course. The CoP provides an online forum, a phone/online teacher help line, and site visits/in-person help. Tell them to use our assessments. Learning to use ours.

Table 13 - Broadening Participation PD Rational

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