Role of College Program Administrators in Addressing Gender Gap in Computer Science

by

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This dissertation is dedicated to my wife Victoria and to my children, Abby, Glen, and Nate.

I could never get this far without your encouragement, support, and love!

We are truly one.

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ABSTRACT

A computer science program leadership team at Technical College (TC) realized that to build a community of future computer science leaders, a primary mission of the program, they need to achieve a more diverse and inclusive environment at TC. For over a decade several initiatives focused on enhancing the organizational structure, work processes, and program culture were implemented resulting in TC becoming one of the more gender balanced top ranking computer science (CS) programs in the country. The purpose of this case study is to focus on the role that CS program administrators play in addressing the gender gap in computer science program at TC.

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Introduction of the Problem of Practice

The gender gap in the field of computer science (CS, computing) continues to distress the industry that has gained a significant economic and social prominence in the U.S. over the last 30 years (Shapiro, 2014; Stahl, Timmermans, & Mittelstadt, 2016; Vitores & Gil-Juárez, 2016). An increased demand for web developers, cloud computing experts, and information security specialists has resulted in CS becoming one of the top ranking professions in the U.S. (Prey & Weaver, 2013; Zweben & Bizot, 2014). Since 1985 the number of students pursuing CS degrees has increased from 44,000 to over 55,000 in 2013 (NCES, 2015). During this period the percentage of men selecting CS major has grown by more 75%, yet the percentage of women has decreased by 30% (Gries, 1987; NCWIT, 2014; Zweben & Bizot, 2014). The resulting gender gap in computing has led the higher education community to adjust college admission policies and improve instructional practices in order to increase the number of female students pursuing degrees in computer science (Stoilescu & McDougall, 2011). Despite their best efforts, however, improving gender diversity in college computing programs continues to be an elusive goal (Dasgupta & Stout, 2014; Vitores & Gil-Juárez, 2016). For the last decade, the average number of female students entering U.S. computing programs has remained constant, at around 18% (Broad & McGee, 2014; NCWIT, 2014; Zweben & Bizot, 2014). The inability to address the gender gap in computer science not only caps the economic opportunity for women at a time of an increased demand for this skill set, but also limits the creative and innovative contribution this group may make to the technology sector of the U.S. economy (Vitores & Gil-Juárez, 2016).

Importance of Addressing the Problem

Elimination of the gender gap in computer science would address existing social inequality concerns and would provide economic benefits that extend well beyond the field of

computing (Prey & Weaver, 2013). Current social constructs portray the field of computer science to be a male professional domain (Cheryan, Plaut, Handron, & Hudson, 2013). The dominant role of men in computing is further legitimized by their hierarchical position and control of societal capital (Charles, 2011; Stanton-Salazar, 1997; Varma, 2010). According to Cohen (2013), any form of dominance associated with occupational status is not only unfair, but is also a form of inequality that must be contested.

Inequitable representation of women in computing slows down the country's economic growth by preventing a large percentage of the population from entering high-in-demand opportunities. According to the Department of Labor, in 2015 the median annual wage for computer science skills was $81,000, significantly higher than the median annual wage for all occupations at $36,000. Yet, CS graduates from U.S. programs can only fill about 55% of the available computing opportunities (Prey & Weaver, 2013). Consequently, some social scientists argue that the gender gap in high-in-demand, well compensated professions, such as computer science, contributes to the labor shortage and restricts the country's economic growth (DiTomaso, Post, & Parks-Yancy, 2007; Weeden, 2002).

A lack of gender diversity has a direct impact on the computing industry's ability to innovate (Cohen, 2013). Innovation is a product of social interactions (Sawyer, 2012). According to Horwitz (2005), a more diverse group utilizes its distinct cognitive abilities to develop inventive solutions which are so critical in the computing industry. Other studies have also shown that a more diverse team improves the organizational performance where new and complex problems need to be addressed on a regular basis (Prieto, Phipps, & Osiri, 2009). Subsequently, addressing the gender gap issue in computer science is of paramount importance to the computing industry where the ability to innovate is a core competency.

Purpose of the Project and Questions

The purpose of this project is to study Technical College's (TC) success in attracting female applicants to its computer science program in relation to a larger problem of practice, a disproportionately low rate of women being admitted to the computer science programs in U.S colleges. The assets in the areas of knowledge and skill, motivation, and organizational resources that enable TC to admit the above national average percentage of women into the computer program without modifying curriculum and compromising academic rigor is being examined. While a complete study would focus on all stakeholders, for practical purposes the stakeholder group to be focused on in this analysis is the computing program leadership team at TC. As such, the following two questions will guide this study:

1. What are the TC computing program leadership team's knowledge and motivation in relation to reducing the gender gap in computing?
2. How does the TC computing program leadership team's knowledge and motivation interact with the school's context to reduce gender gap in computing?

Organizational Context and Mission

Technical College has one of the top ranked computing programs in the U.S. The school awards computer science degrees in machine learning, robotics, software research, and several others computing disciplines. Leading the school's computing program is an internationally recognized team of computer science faculty and administrators. Several current and past members of the faculty have earned national and international prominence for their research publications and scholarly awards.

TC is located in a metropolitan area, a home to several other higher education institutions. Several professional sports teams, a number of museums and arts exhibits are

located within a twenty mile radius and are easily accessible. Location of the school, a well-known faculty, and modern school facilities attract students not only from the U.S., but also from a number of foreign countries. Almost 20% of the TC's undergraduate population are international students. The computer science program acceptance rate is typically between five and seven percent, making it one of the most competitive CS programs in the country. The mission of the school has not changed since its inception. For almost 30 years the school's focus has been to provide superior educational experience to its students and to attract the best computer science faculty and staff to its program. The school has also identified student diversity to be a top organizational priority and a critical contributor to the school's future success. For over a decade the percentage of female candidates being admitted to TC's computer science program has exceeded the national average by 100%. In the fall of 2017 almost 50% of entering computer science students were women.

Organizational Performance Goal

During the early years of operation CS program leadership at TC has acknowledged the fact that the goal of achieving a more diverse and inclusive culture, one of computing program's primary objectives, has not been met. Only a handful of female applicants were admitted to the CS program each year. Having such a low admission rate of female candidates was unacceptable to the school's leaders. To achieve congruency with the program's diversity objectives, the CS administration has partnered with the National Science Foundation and several major corporate stakeholders. A working group that included members of the dean's office as well as experts in gender equity in education was tasked to develop a set of recommendations that would lead to a more gender diversity focused set of admission policies and program practices. The school set a goal of annually exceeding the national average of women applying and being admitted to the

computer science program at TC while keeping the computing curriculum unchanged and maintaining the program's high academic standards.

By the mid-2000 the school administration had experienced a significant improvement in their ability to attract talented female candidates into the program. For the first time the school was able to consistently exceed the national average percentage rate of women being admitted to computer science programs. Over the years the school leadership has experienced a number of personnel changes, yet the administration's success in reducing the gender gap in CS program and still maintaining program's national ranking has not been affected.

Description of Stakeholder Groups and Participating Stakeholders

All organizations, whether for-profit, nonprofit, government, or educational, have stakeholders (Lewis, 2011). A stakeholder group is a group of individuals who directly contribute to and benefit from the achievement of the organization's performance goal (Wheeler & Sillanpa'a, 1998). Organizations stratify stakeholders based on their ability to influence the direction and timing of an organizational change (Lewis, 2011). As a result, some stakeholder groups are recognized to be more important than others. At TC, the primary group of stakeholders includes the CS program leadership team, CS program faculty, and CS students.

The higher education institution leadership teams are responsible for all aspects of the administrative, academic, and social environment in the school (Kezar, 2001). At TC, the CS program leadership team is responsible for designing and implementing the academic curriculum, hiring the research and teaching faculty, and ensuring that organizational goals, such as gender diversity, are achieved. The faculty's primary goal is to deliver quality education and to ensure their students learn (Tagg, 2012). At TC, the faculty focuses on both teaching and research activities. Most faculty is expected to conduct and publish research, enhancing their

own and the school's reputation amongst the peer institutions and corporate sponsors. The undergraduate students are an important contributor to the successful reduction of the gender gap in the program (Varma, 2010). Their active engagement and support for a more inclusive school setting influences the academic and the social environment at the school. Student's views and feedback are also crucial in assessing success and shortcomings of the diversity focused initiatives at TC. While the joint efforts of all stakeholder groups contribute to the school's goal of attaining the above national average percentage of women entering the computer science program, it is important to focus on the CS program leadership team who is directly responsible for the admission policies and organizational practices at TC. For the purposes of this study, the TC leadership team comprised of the ranking members of the CS program administration and the CS department chairs is the stakeholder group of focus.

Literature Review Sections Overview

This literature review examines factors that contribute to the gender gap in the U.S. computing programs and discusses knowledge, motivation, and organizational (KMO) influencers that facilitate a more gender balanced environment at undergraduate computing programs. The review will begin with an overview of the computer science discipline and a summary of the scholarly literature covering the topics related to the causes of the gender gap in computer science. It will be followed with a discussion of a Gap Analysis Framework by Clarke and Estes (2008), an approach that will be used to examine KMO factors leading to TC's ability to significantly reduce the gender gap in the computer science program. Next, based on the literature review and the relevant theoretical models, the knowledge, motivation, and organizational influencers will be individually discussed. Finally, the KMO influencers, along

with the research questions posed earlier, will be used to advance the Interactive Conceptual Framework (Conceptual Framework) as a guiding mechanism for conducting this inquiry.

Literature Review

The computer science discipline is a body of knowledge that refers to the algorithmic modeling and analysis of data underlying natural and human made processes (Denning, 2003). It also includes the study of computer systems, communication technologies, and software design and programming. During the early days of the modern computer era, the primary focus of computer science was to develop mathematical models using digital computer platforms to solve calculation intensive problems (Ceruzzi, 2012). Based on the theoretical foundation, related abstractions, and corresponding designs, the field of computer science now includes more than a dozen of subareas, such as programming languages, artificial intelligence and robotics, and database and information retrieval, among others (Denning, 2003). In addition, computer science is used as a tool to create and manage context specific models and processes in other fields (Denning, 2003). Some researchers argue that other disciplines in the sciences and the humanities are able to pursue new areas of research as a result of employing the 'computational thinking' (Bundy, 2007). Computational thinking is an analytical tool, based on the fundamental concepts of computer science, that allows researchers to analyze complex problems and create multiple levels of abstraction used to solve the underlying problems (Wing, 2006). It conceptualizes the way people think, learn, and interact. For example, models of cognition in psychology, economic forecasting in business, and patient diagnosis in clinical medicine employ techniques originally developed by computer scientists (Bundy, 2007; Denning, 2003).

In the last 30 years a topic of gender gap in computer science has been widely studied by the social researchers. In their seminal work Cohoon and Aspray (2006) have reviewed an

existing body of research examining the underlying causes leading to the gender gap in computer science. Several broad themes requiring further analysis have been suggested by the authors. A first major theme discussed highlights a historical influence by the community of computing experts from 1940's on the present day male-dominated culture of college computer science programs and the resulting gender gap. Modern field of computing has its roots in World War II ballistic computation programs (Ceruzzi, 2012). Viewed as a war-time effort, most personnel recruited to oversee a digital computation program, a precursor to the modern computer science programs, were military men (Ceruzzi, 2012). In 1950's and 1960's, driven by the Cold War and the Space Race related efforts, most university computer science programs were established and led by the same group of men, portraying computing skills as masculine activity (Ceruzzi, 2012). The resulting culture and image of computer science has become closely aligned to the masculine culture deterring many qualified women from entering the field of computer science and therefore contributing to the gender gap in CS college programs (Pechtelidis, Kosma, & Chronaki, 2015). Ironically, the contribution by the female computer programmers and mathematicians, who were employed to manually perform ballistic calculations for the War Department during the World War II has been all but forgotten (Gurer, 2002; Light, 1999).

As a second major theme, the socio-cultural influences were also identified as negatively impacting female college applicants considering a major in computer science (Stoilescu & McDougall, 2011). From the early age young women are influenced by the social structures that dictate which professional fields are more suitable for men and which ones are more appropriate for women (Broad & McGee, 2014). The resulting gender-based professional divide steers many highly qualified women away from considering the field of computer science towards a more 'traditional' female dominated professions such as nursing and teaching (Dasgupta & Stout,

2014). Depiction of computer professionals as technology-centric nerds by the popular media in the U.S. was also singled out as a significant deterrent for many college-bound female students considering a CS major (Cheryan et al., 2013). Research focusing on the socio-cultural factors contributing to the gender gap in computer science suggests that changing cultural beliefs about the field of computing is a prerequisite for achieving a more gender-balanced academic environment (Varma, 2010).

A third major theme leading to the gender gap in computer science focused on the innate differences between men and women (Trauth, 2002). According to these studies, as a result of the physiological differences men and women possess different computer science abilities and skills (Venkatesh, Morris, & Ackerman, 2000; Vitores & Gil-Juárez, 2016).). In order to reduce the gender gap in computer science these studies recommend changing the computing program curricula, a critical step in attracting and retaining more female students in the CS programs (Trauth, 2002). These studies argue that changing the CS program curricula and creating an alternative CS pathways for female students would enhance their computing skills and abilities making the computing field more attractive to them (Cohoon & Aspray, 2006).

Although the scholarly literature focusing on the gender gap in computer science reviews a broad spectrum of the underlying causes and recommends corresponding interventions, very few studies examine the role of school administrators in achieving a more gender-balanced environment in college computer science programs. Not surprisingly some social researchers highlight an urgent need to examine the role of college administrators in being able to effectively address current academic and social issues facing the institutions of higher education (Bray, 2010). As a key stakeholder group focused on improving organizational performance, the college program administrators are in the position to develop, implement, and evaluate programs

that facilitate diversity focused initiatives, such as a reduction of the gender gap in computing. Examining the knowledge and motivation of computer science program leadership as well as the organizational factors with respect to TC's ability to successfully reduce the gender gap in CS program is the primary objective of this study.

The Clark and Estes Gap Analysis Conceptual Framework

Improving organizational performance in a practical and cost-effective manner is a priority for all organizations (Clark & Estes, 2008). Performance research has provided ample evidence that a systemic, researched-based approach to addressing performance issues can deliver a timely and effective set of solutions at the same time avoiding the wastefulness of human and capital resources (Clark & Estes, 2008). The Gap Analysis Framework by Clark and Estes (2008) is a researched-based and practically validated approach that addresses two common problems related to the organizational performance. First, this framework helps to set and measure organizational goals that align with desired objectives. For organizations, whether looking to improve their current performance or to maintain their already high level of performance, it is mission critical to establish and support well-defined and time-bound set of goals (Clark & Estes, 2008). Second, this framework helps to analyze the causes of the gaps between current and espoused performance or to assist in identifying factors that facilitate superior performance for the market leaders. Clark and Estes (2008) have identified three primary factors: knowledge, motivation, and organizational barriers or facilitators that influence performance gaps in the organizations. Under the Gap Analysis Framework, each factor is examined to identify the root cause of the problem or the source of superior performance. In the following sections the Gap Analysis Framework will be used to examine the knowledge, motivation, and organizational influencers, shown in Table 1, that have contributed to the best

practices implemented by TC in attracting and enrolling female candidates to one of the more academically challenging computing programs in the country. In this context the role of the TC leadership, their knowledge, skills, and motivation, as well as their ability to implement computing program changes to significantly reduce the gender gap will be examined through the qualitative case study approach.

Table 1

Assumed Influencers on Performance at TC

Knowledge	Motivation	Organization
Conceptual Knowledge – CS administrators need to know social and cultural factors influencing women's decision to avoid pursuing college degrees in computing.	Expectancy Value – CS administrators pursue utility value in reducing gender gap in computing program.	Cultural Influencers – CS administrators need to balance academic and vocational influencers to reduce gender gap in computing programs.
Procedural Knowledge – CS administrators need to know how to enhance school's academic and social environment in order to attract and retain more women with little or no computing background.	Self-efficacy – CS administrators believe in their ability (driven by the successful past experiences) to facilitate organizational changes that reduce gender gap in computing program.	Cultural Settings – CS administrators need to modify computing program cultural settings by sponsoring equity-focused initiatives.
Metacognitive Knowledge – CS administrators need to be aware of their own attitudes and biases towards women pursuing degrees in computing.		

Knowledge, Motivation, and Organizational Influencers

Knowledge and Skills

Knowledge and skills are at the core of the innovative strategies organizations employ to compete in the global economy (Dyer, Gregersen, & Christensen, 2011). Several studies have highlighted a strong positive relationship between an organization's ability to create and manage knowledge and the corresponding improvement in the organizational performance (Clark & Estes, 2008; Lee & Choi, 2003). According to cognitive psychologists, knowledge is created by the individual's cognitive system while observing and interpreting the environment (Mayer, 2011). In this theoretical framework the four types of knowledge are (a) factual knowledge, (b) conceptual knowledge, (c) procedural knowledge, and (d) metacognitive knowledge (Krathwohl, 2002; Rueda, 2011). The factual knowledge refers to the specific facts, dates, and data needed to understand and analyze a specific situation or content (Krathwohl, 2002; Rueda, 2011). Knowing the specifics, such as a percentage of women graduating with CS degrees in U.S. colleges, is an example of the factual knowledge that could be useful to the CS administrators. Conceptual knowledge describes the models, theories, and ideologies associated with an area of inquiry (Krathwohl, 2002; Rueda, 2011). Analysis of the social and cultural factors that preclude college women from selecting CS as their major is an example of the conceptual knowledge. Procedural knowledge, commonly referred to as the 'how-to' knowledge, identifies steps needed to achieve a specific goal (Krathwohl, 2002; Rueda, 2011). A list of specific steps needed to improve a graduation rate of women with CS degrees is a type of procedural knowledge. Metacognitive knowledge is a knowledge of one's own way of thinking and learning, as well as the awareness of one's own attitudes (Krathwohl, 2002; Rueda, 2011). For example, a professor's comprehension of his own stereotypical thoughts on whether women are able to

succeed in the field of computing is a type of metacognitive knowledge. Review of the academic literature on the pervasiveness of the CS gender gap and its negative social and economic impact on the society has identified a number of knowledge influencers. The following three knowledge influencers: (a) social and cultural factors, (b) academic and school environment, and (c) school administrators' attitudes and biases, however, are at the forefront of the CS gender gap discussions and are reviewed next.

Social and Cultural Factors. Educational leaders rely on their conceptual frameworks to construct knowledge and resolve conflicts (Heck & Hallinger, 2005). Consequently, computing administrators' ability to reduce the gender gap in the field of computer science depends on their conceptual understanding of the social and cultural factors that influence college women's decision not to pursue degrees in CS (Charles & Bradley, 2006). To reduce the gender gap in computing programs, CS administrators need to be aware of such social and cultural factors as stereotypes and social biases, among others (Charles, 2011; Marini, 1990). Many of these factors are based on the beliefs that men and women have different neurological and cognitive abilities (Trauth, 2002). Despite studies showing that a human brain is an assortment of characteristics that vary between individuals, not between the genders, there is still a perception that men are more competent in computer science than women (Charles & Bradley, 2006). The resulting computing stereotype views CS professionals as males solely interested in computer related activities, e.g., writing software, playing video games, etc., with no interest in the social benefits of their efforts (Cheryan et al., 2013). Not surprisingly the masculine characteristic of the computing field is less appealing to female college students and may prevent them from majoring in CS (Eckel & Grossman, 2005). As most administrators of the top U.S. computer science programs are male, they may lack a conceptual understanding of social and

cultural barriers impeding women's entry into the computing field and may also not have any transferrable knowledge or procedural expertise essential for closing the gender gap in computing (Mayer, 2011).

Academic and social environment in computing programs. Lacking a procedural framework needed to identify and address performance gaps in education may lead to ineffective interventions and further compound the underlying problem (Rueda, 2011). Addressing the gender gap in computing creates a unique set of procedural challenges for CS administrators (Stoilescu & McDougall, 2011). This is evident in the case of establishing procedures related to the introduction of programming to women with no or little previous experience (Frieze & Quesenberry, 2015; Stoilescu & McDougall, 2011). Based on the assumptions that women typically display lower computer aptitudes and higher levels of computer anxiety compared to men, one procedural approach used by some CS administrators was to develop a set of introductory classes especially for women (Venkatesh et al., 2000). Creating a specialized computing track, the so called 'pink curriculum', was an attempt to compensate these students for their poor performance in regular computer programming classes (Frieze & Quesenberry, 2015). After two decades, a gender focused effort by CS administrators to implement procedures improving the retention rate of women in the CS programs leveraging this approach has remained largely unsuccessful (Frieze, Quesenberry, Kemp, & Velazquez, 2012). In fact, some researchers made an argument that explicitly identifying gender differences and creating separate tracks for men and women further enhanced the CS stereotypes discussed earlier and contributed to the widening of the gender gap in computing (Frieze at al., 2012). As a result, a list of procedural enhancements to the academic and social environment in CS programs needed to

attract and retain more women with no programming experience remains a challenge for many U.S. colleges.

CS administrator's attitudes and biases. Every person carries biases shaped by one's cultural environment (Banaji & Greenwald, 2013). Most people are unaware of these 'hidden' biases which can influence one's behavior and actions (Banaji & Greenwald, 2013). Dasgupta and Stout (2014) support this assessment by referring to studies where gender bias in academic hiring was demonstrated by both men and women with neither group being aware of their bias. As the number of male CS administrators across U.S. colleges outnumbers their female counterparts, it is not unreasonable to see how more male students would be admitted to computer science programs, further exacerbating the issue of gender inequality in CS. Nkomo and Al Ariss (2014) have reviewed the phenomenon of homosocial reproduction. Their analysis has shown that managers and administrators select candidates similar to their own sociocultural identity. Knowing the effects associated with homosocial reproduction allows a decision making group, whose membership is fairly homogeneous, to evaluate and compensate for their hidden biases. Gaining awareness of one's own attitudes and biases is an important step in ensuring that one's impartial views and equitable actions are maintained (Baker, 2006; Banaji & Greenwald, 2013). This higher level cognitive process is referred to by social scientists as metacognition (Baker, 2006). Metacognitive processes allow individuals to evaluate their strengths and weaknesses and, as in the case of CS school administrators, to assist with developing strategies to compensate for any biased-driven decisions related to the program admissions and curriculum.

Motivational Influencers

Motivation is an internal process that commences and retains a goal-oriented activity (Mayer, 2011; Rueda, 2011). As the definition implies, motivation is what drives individuals to

successfully perform a task. Three critical motivational factors influence one's ability to complete the task: (a) one must choose to work on the task, (b) one must persist and stay with the task to completion, and (c) one must invest mental effort to achieve a desired level of performance on the task (Clark & Estes, 2008). The impact of motivation on the performance has been a topic of research for several decades (Bolman & Deal, 2013). In the early 1950's a simple formula, Performance = Ability x Motivation, was widely used to explain the relationship between performance and motivation (Bolman & Deal, 2013). Clark and Estes (2008) have emphasized the role of motivation as one of the 'big three' factors responsible for the performance gap discussed earlier. Over the years research by social scientists has provided further insight into the influence of motivation on academic performance with new models examining motivational principles in educational environments (Rueda, 2011).

The following sections review two motivational models that influence the organizational objective of improving diversity and reducing the gender gap in college computer science programs. The expectancy value theory and the self-efficacy theory, as well as their motivational influencers on the CS administration are detailed below.

Expectancy value motivational theory. The expectancy value motivational theory (EVT) provides a framework for understanding the motivational drives for choosing and performing a task (Eccles, 2006; Rueda, 2011). The EVT states that in order for the individual to start the task, she needs to see the value in performing and completing the task (Eccles, 2006; Rueda, 2011). Eccles (2006) has identified four types of perceived values that motivate an individual to perform the task. They are: (a) intrinsic value, (b) attainment value, (c) utility value, and (d) cost value (Eccles, 2006). The intrinsic value construct refers to the enjoyment one expects to receive while performing the task. The attainment value construct refers to the

significance of achievement one perceives in performing the task. The utility value is derived when one sees a task contributing to her future personal or professional goals. The cost value refers to the cost of effort that is necessary to perform a task including the opportunity cost of not performing other tasks. The four types of value play a vital role in the academic environment (Eccles, 2006). For the CS administrators, who are focusing on improving student diversity and reducing the gender gap in computing programs, in order to succeed they need to pursue a utility value in their efforts.

CS administrators' expectations and value. College administrators are responsible for ensuring the high academic performance of the students and for meeting accountability requirements of the stakeholders (Kezar, 2001). To succeed in their role as stewards of the program, computing science administrators need to recognize the value in being able to achieve both objectives. Research has shown that increased student diversity in CS programs improves academic performance and attracts more female students to computing (Frieze at al., 2012). Hoogendoorn, Oosterbeek, & van Praag (2013) also highlight positive effects that a more diverse group of college students has on the overall organizational and academic performance. By focusing on student diversity and on reducing the gender gap in computing, CS administrators can improve the academic performance of students and while pursuing their professional goals.

Meeting accountability requirements is a top priorities for college programs. For CS administrators this is especially important as many computing programs are funded by state sponsored initiatives which mandate a diversity of students. A lack of focus on diversity or the inability to reduce the gender gap can lead to a loss of funds at the time when the sources of funding are becoming scarce. As a result, the CS administrators recognize utility value in seeking to attract more female students and reduce the gender gap in computing programs.

Self-efficacy Theory. Self-efficacy theory describes motivational dynamics that reinforce beliefs in own competence (Bandura, 1993). Strong efficacy beliefs increase one's self-confidence resulting in improved outcomes (Pajares, 2006; Rueda, 2011). Low efficacy beliefs, on the other hand, may prevent an individual from engaging in tasks or reduce the level of effort needed to successfully complete a task. According to self-efficacy theory there are four primary factors that either facilitate or inhibit the formation of self-efficacy beliefs (Pajares, 2006). First, the self-efficacy beliefs are shaped by successes or failures associated with mastering a given task (Bandura, 1993, Rueda, 2011). Achieving a successful outcome increases self-efficacy, a failure to reach a goal lowers it (Pajares, 2006). Second, viewing success or failure of others affects the formation of self-efficacy beliefs (Pajares, 2006). Research shows a strong influence of vicarious experiences in educational setting (Rueda, 2011; Zimmerman, 2000). Third, social influences exerted by others can either positively or negatively influence the self-efficacy of an individual (Pajares, 2006). Several studies have found that CS faculty in many U.S. colleges expect male students to perform better in computer science classes than female students (Varma, 2010). As a result, female CS students may feel less confident in their own computing abilities. Finally, the physiological condition of an individual can increase or decrease the self-efficacy (Pajares, 2006). According to studies, attending computer science classes where faculty, teacher assistants, and a significant majority of students are male, can lead to high levels of anxiety in female students and decrease their self-efficacy (Varma, 2010).

CS administrator's self-efficacy. Self-efficacy beliefs determine the choice of actions undertaken by the individuals (Bandura, 1993; Pajares, 2006). As such, self-efficacy beliefs of CS program administrators play a role in their choice of priorities and allocation of resources needed to reduce the gender gap. One individual factor influencing leaders' efficacy for

implementing organizational changes have been frequently cited in the literature (Paglis & Green, 2002). Self-confidence is a concept that allows individuals to be certain about their abilities to succeed (Northouse, 2016). A proven record of overcoming difficult tasks increases leaders' level of self-confidence and therefore increases their self-efficacy in dealing with challenges (Paglis & Green, 2002). Having a CS leadership team with a track record of supporting and succeeding in diversity focused initiatives is likely to increase their efficacy in reducing the gender gap in the computer science program.

Organizational Influencers

Organizational influencers play an essential role in causing organizations to underperform or in facilitating organizational changes that lead to performance improvements (Clark & Estes, 2008). The level of employee engagement, communication strategy, policies and procedures, and executive leadership are just some of the organizational influencers that either support or inhibit institutional performance (Berger, 2014; Burke, 2005; Miller & Lee, 2014). Organizational culture, however, affects all of these influencers and ultimately determines whether organizational change approaches focused on improving performance are effective and sustainable (Clark & Estes, 2008). Given a wide variety of the industries, the types of firms, and the organizational structures that exist, it is not surprising to find many categories of the organizational change models (Kezar, 2001). Each category employs a different set of assumptions to explain how and why organizations change (Kezar, 2001). Despite their different approaches, however, all models share the same objective of developing a framework for improvement that includes the rationale for change, the process of change, and the evaluation of the effectiveness of change (Kezar, 2001; Langley et al., 2009; McEwan & McEwan, 2003).

Organizational models of change in higher education. The cultural models and settings uniquely define and affect each organization (Clark & Estes, 2008; Schein 2010). Understanding a cultural identity is an important step in developing a road map for improving organizational performance (Bolman & Deal, 2013). Identifying the cultural profile of higher education institutions with complex decision making structures, different institutional histories and goals, and many competing priorities is an especially challenging endeavor (Kezar, 2001). Failure to accurately assess the organization's cultural models and settings may lead to ineffective performance-enhancing strategies and may cause further deterioration in the institution's performance (Clark & Estes, 2008; Eckel, 2001). Adapting the appropriate change approach for improving performance or maintaining a market leading performance for a higher education institution warrants a special attention (Kezar, 2001). The type of institution and its cultural profile determines which model of change is more suitable for achieving the organizational goals (Kezar, 2001). Review of recent research has identified the cultural models of change as some of the more effective approaches to improving organizational performance in higher education institutions (Kezar, 2001). The cultural models of change emphasize the symbolic characteristic of higher education institutions. These models purport that the organizational change ensues only when the cultural models and settings of the institution are altered (Schein, 2010). Understanding the culture of a higher education institution along with its organizational symbols, history, and rituals are requisite to enhancing and facilitating the change process (Bolman & Deal, 2013; Kezar, 2001). The multitude of organizational goals that various academic disciplines within higher education pursue highlights a need to understand the cultural values and beliefs of each one individually (Kezar, 2001).

Cultural influences in computing programs. It is not unusual for a higher education institution to inherit cultural influences from more than one group with a joint set of influences emerging and ultimately defining the culture of that organization (Kezar, 2001). College computer science programs have characteristics of both the academic culture of the higher education institutions as well as the computing culture closely aligned with strong professional traditions. The academic culture values the history and traditions of the higher education institutions (Kezar, 2001). Academic accountability, school's independence, and safeguarding educational and social ideals are some of the characteristics of the academic culture (Burke, 2005; Ek, Ideland, Jonsson, & Malmberg, 2013; Kezar, 2001). The measure of school's successful performance includes students achieving mastery in the academic disciplines as well as the presence of the diverse student body (Ek et al., 2013). The computing culture, on the other hand, is professionally oriented and inherits cultural characteristics from the vocational side of computing (Ek et al., 2013). Social researchers have observed a strong parallel between computing professional culture and the masculine culture, a link sometimes used to explain the presumed aversion of women towards the field of computing (Cheryan et al., 2013; Cohoon & Aspray, 2006). Studies have also shown that the computing professional culture tends to emphasize the technical side of the field, such as programming and computer architecture, rather than focusing on the social priorities, such as diversity and inclusion (Cheryan et al., 2013; Cohoon & Aspray, 2006; Morelock, 2017). The dual influence of the academic and computing cultures on the cultural profile of the computing undergraduate programs guides the actions of the program's leadership.

Computing program culture and leadership. Changing values and beliefs ingrained in the organizational culture is a long-term effort that depends on the leader's ability to alter the

prevailing cultural models and settings (Kezar, 2001; Schein, 2010). In undergraduate computing programs, the program administrators oversee the academic and the cultural environment of the school ensuring that the organizational goals, such as academic excellence, diversity, and inclusion are being attained (Broad & McGee, 2014; Cohoon & Aspray, 2006). As organizational leaders, they are responsible for implementing change processes that modify the institutional culture to ensure the program objectives are being pursued. Consequently, to successfully implement equity-focused actions, such as incorporating diversity benchmarking in performance measuring framework, instituting more inclusive admission policies, and securing necessary resources in support of new initiatives, CS administrators need to alter and sustain the symbolic aspect of their program's cultural settings.

Conceptual Framework

The Role of the Conceptual Framework

Qualitative studies are characterized by their attention to the philosophical, scientific, historical, and social perspectives allowing the authors to pursue a unique form of inquiry (Merriam & Tisdell, 2016). Yet, despite a limitless way of structuring qualitative studies, there is a need to organize and synthesize empirical, theoretical, and experiential knowledge into logically arranged configuration that guides each study from its stated goal to the selection and implementation of the research design approach (Maxwell, 2013). The conceptual framework provides that foundational structure. It helps to narrow the focus of the study and connects the concepts, theories, and ideas to the problem being studied (Rocco & Plakhotnik, 2009). Without a conceptual framework underlying a qualitative study, there is a strong possibility of the study design, research questions, and the supporting literature being misaligned negating the scholarly value of the inquiry (Merriam & Tisdell, 2016). Maxwell (2013) identifies four factors that

contribute to the development of the conceptual framework: experiential knowledge, prior theory and research, exploratory studies, and thought experiments. According to Maxwell (2013), experiential knowledge plays an important role in helping the researchers to develop the vision and understanding of the problem being examined. To avoid the unduly influence of any personal experience on the study, researchers are advised to employ a concept of critical subjectivity, specifically developed to avoid a bias risk by leveraging individual experiences as only one of several contributing sources (Maxwell, 2013, Reason, 1994). Using prior research is also an important contributor to the development of the conceptual framework as it provides the background for the problem being studied, introduces theoretical concepts utilized in the earlier research, and assists the study authors in determining whether previous work has shortcomings and warrants another look (Maxwell, 2013; Merriam & Tisdell, 2016; Rocco & Plakhotnik, 2009). Pilot studies are sometimes conducted to further validate researchers' views and understanding of the problem being examined (Creswell, 2014; Maxwell, 2013). Finally, the thought experiments, which are popular in physical sciences, are also used by the social scientists to enumerate possible explanations for the phenomenon being studied and contribute to the development of the conceptual framework (Maxwell, 2013). The conceptual framework is uniquely constructed for each research study to encompass key concepts ascertained from the literature review and to capture the interaction between the knowledge and motivation of the stakeholder group and the organizational context. The conceptual framework for studying the best practices in attracting and enrolling female candidates at TC is presented below.

Interactive Conceptual Framework

To explain the best practices implemented by the TC administrators to attract female candidates to the computing program the following interactive conceptual framework, Figure 1,

is being advanced. It draws from the literature on the institutional culture, the social identity formation, and organizational models of change in higher education institutions that were previously discussed. Also, more than 30 years of experience in the computing industry by the study author as a software developer, program manager, and the industry advisor is being utilized in developing the conceptual framework.

Figure 1. Interactive Conceptual Framework

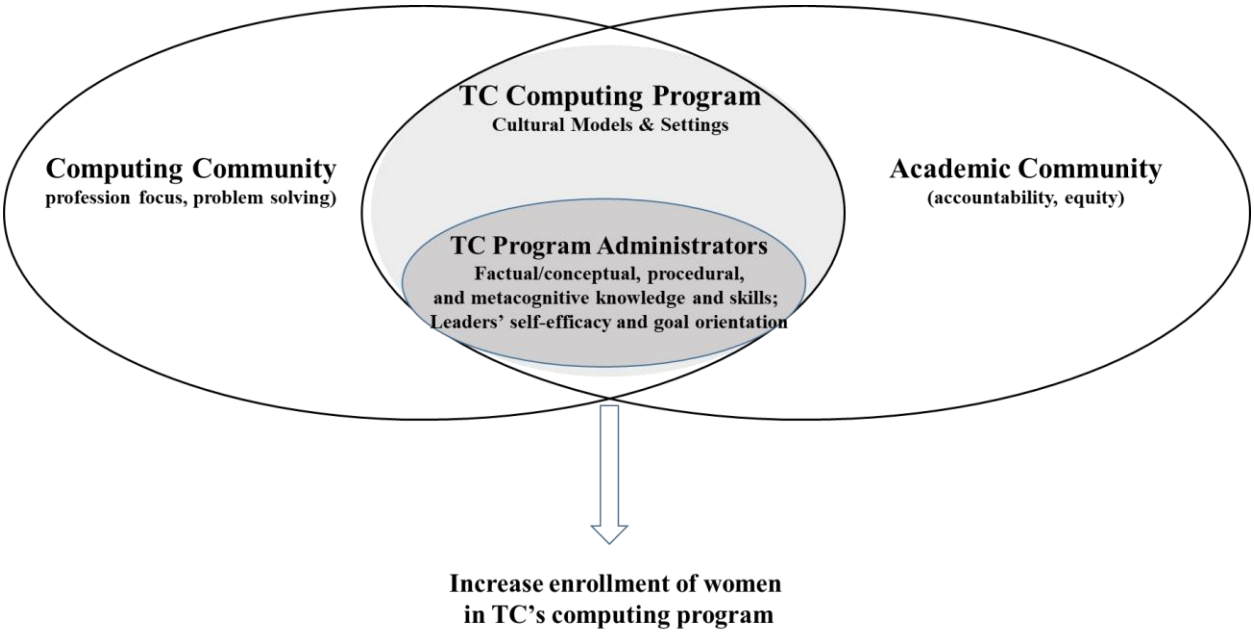

Figure 1. Conceptual framework depicts relationship between computing program culture and administrators' beliefs, behaviors, and actions resulting in an increased enrollment rate of female students at TC.

Conceptual Framework Components

The earlier sections of this literature review focused on the individual theories, concepts, and research. The conceptual framework leverages them as foundational components used to establish a relationship between the computing program culture at TC and CS program administrators' skills and beliefs that guide their actions towards increasing number of women being admitted to the program. The focal point of the framework is the Venn diagram depicting

the overlap between the vocation-focused computing culture and the higher education academic culture. As an undergraduate computing program at a large research university, TC culture inherits cultural characteristics of both the computing culture and the academic culture. In Figure 1, the intersection of these two cultures is shown as the shaded area and signifies the resultant culture of the computing program at TC. Based on the institutional history, university's mission and vision, and the accountability pressures imposed by various stakeholder groups, the cultural profile of TC may closely resemble either the computing culture or the academic culture, a claim embedded in one of the guiding questions for this study. In addition to knowledge and motivational influencers of TC leaders, the conceptual framework also highlights the importance of choosing the appropriate organizational model of change needed to implement the diversity focused agenda at TC. This is depicted as the downward pointing arrow at the bottom of Figure 1. Implementing diversity focused policies in the male-dominated environment of the computer science programs could be a challenging effort. Research on social identity suggests that homogeneous teams with respect to social groupings tend to share the same norms and values and therefore resist any changes to their membership (Eckel & Grossman, 2005). To achieve a more diverse student body without sacrificing the academic standards of the CS program, the appropriate organizational change approach needs to be selected. The cultural models of change have shown promise in facilitating organizational changes in higher education institutions (Kezar, 2001). By challenging prevailing attitudes and addressing the symbolic characteristic of the higher education institution, policies and procedures that facilitate gender diversity in the program could be implemented (Kezar, 2001). The conceptual framework presented here brings several theoretical studies and scholarly discussions together to form a coherent view on the primary KMO influences affecting the computing program leadership at TC.

Qualitative Data Collection and Instrumentation

Data Collection

In qualitative studies, data is being collected in order to capture the description of the phenomenon experienced by the study participants as well as the meaning they assign to these experiences (Bogdan & Biklen, 2007; Maxwell, 2013; Merriam & Tisdell, 2016). Data collection is therefore a critical component of the researcher's ability to inductively develop a theory about the phenomenon being studied (Creswell, 2014). There are several methods of data collection, including direct observations, questionnaires, document analysis, and interviews (Johnson & Christensen, 2014; Merriam & Tisdell, 2016). For the purposes of the TC study, document analysis and interviewing was the primary method of data collection.

Document Analysis

Document analysis refers to the collection of existing data and materials created by others that are useful for the purposes of the new research (Bogdan & Biklen, 2007; Merriam & Tisdell, 2016). Documents such as previous research, memos, and public records are just some of the examples of the documents that could be included in qualitative studies (Bogdan & Biklen, 2007; Johnson & Christensen, 2014; Merriam & Tisdell, 2016). For the purpose of this inquiry, several scholarly articles published by the TC leaders that focused on the program's efforts to reduce the gender gap in CS were examined. Publically available information on TC's website discussing the on-going diversity focused initiatives at the school were also reviewed.

In addition to collecting information useful in answering research questions, there were other benefits of performing a document analysis. First, review of the previously published research provided a historical perspective on TC's efforts to reduce the gender gap in CS and assisted in preparing for the on-campus interviews with program leaders. Understanding the

organization's culture from the existing documentation is a prerequisite for any effective communication between the organizational leaders and the researcher (Schein, 2010). Second, by examining existing documents and reviewing both successes and challenges related to achieving a more gender-balanced environment at TC, the study author could learn more about the decision-making practices of the CS program leaders. This knowledge assisted in examining the knowledge and motivational influences guiding the actions of the CS program leaders. Finally, reviewing available documentation facilitated researcher's understanding of the characteristics of the inclusive culture of the computer science program that resulted in a more gender-balanced environment at TC.

Interviewing

Interviews can be conducted in a number of different ways, e.g., in person, via the phone, or on-line. In this study the two initial interviews were conducted on the phone. The rest of the interviews were conducted on TC campus in person over a five-day period. A typical purposeful sampling approach, detailed in Appendix A, was employed to select the interview participants. Once a list of TC participants has been established, the study investigator contacted a diversity program director at TC who has agreed to coordinate and schedule the interviews. Based on the availability of all the participants, on-campus interviews were scheduled and the researcher traveled to TC to initiate interviewing process. The interviews were conducted in a semi-structured manner and the questions, see Appendix B, guided the flow of the interview. The semi-structured type of interviewing style was chosen to allow the interviewer to maintain a maximum level of flexibility in wording the questions and in ordering of the questions asked while keeping the interviewees focused on the topics being discussed (Johnson & Christensen, 2014; Merriam & Tisdell, 2016). Each interview was scheduled for an hour and conducted at the

participant's office. With participant's permission, as discussed in Appendix E, each interview was recorded using a digital audio recording device and transcribed by the researcher within 24 hours of the interview taking place.

Role of Interviewer

An interview is a data-collection method where the interviewer asks questions related to the research being conducted and the interviewee provides answers (Johnson & Christensen, 2014; Merriam & Tisdell, 2016). To make interviewing process more effective it is critical to establish a research relationship between the interviewer and the interviewee (Bogdan & Biklen, 2007; Glesne, 2011; Maxwell, 2013; Merriam & Tisdell, 2016). Research relationships are both complex and dynamic and can either facilitate or impede data collection (Maxwell, 2013). There are three primary dimensions of the research relationship that affect the role of the interviewer in collecting data (Creswell, 2014; Merriam & Tisdell, 2016). First dimension relates to whether or not the interviewer is a member of the community being studied. As a former technology executive and advisory board member at several college computer science programs, it is possible that the study investigator could have been viewed as an insider. Being an insider has both advantages and disadvantages. One major advantage of being an insider is that it provides accessibility to the participants of the study (Maxwell, 2013). However, it is possible for the interviewees not to share personal experiences and beliefs for the fear of being embarrassed (Maxwell, 2013; Rubin & Rubin, 2012). The role of investigator is to anticipate such situations and periodically remind the participants of the interview purpose and the importance of the study (Creswell, 2014; Glesne, 2011). Second dimension of the research relationship relates to the positionality of the investigator with respect to the participants (Maxwell, 2013). The perceived power difference between an interviewer and the participant due to researcher's professional

experience, social status, or demographics may influence the researcher's ability to collect data (Glesne, 2011; Merriam & Tisdell, 2016). Since all interview participants at TC were senior members of the CS program leadership team, it is not likely that positionality was a factor in the interviewing process. Lastly, during the data collection phase of the research, an investigator needs to be cognizant of reflexivity, i.e., how the role and personal biases of the interviewer influence the participants and how participants' knowledge and views influence the interviewer (Maxwell, 2013; Merriam & Tisdell, 2016). During the interview, for example, a study participant may provide information that contradicts interviewer's own views and beliefs. In such situations, however, it is critical for the interviewer to remain focused on collecting the data and to continue treating participants with utmost respect (Merriam & Tisdell, 2016; Rubin & Rubin, 2012). At all times, the role of an interviewer is to learn about beliefs and experiences of the interviewees without the influence of the interviewer's own interpretation of the issues being discussed (Creswell, 2014). Appendix C, Credibility and Trustworthiness, and Appendix D, Validity and Reliability, document critical concepts adopted by the interviewer throughout the study.

Interview Instrument

Conducting interviews provides an opportunity for researchers to learn about the experiences and perspectives of the people being interviewed (Maxwell, 2013; Merriam & Tisdell, 2016; Seidman, 2013). To keep the TC interview participants focused on the topic of the inquiry a list of questions, sometimes referred to as the interview guide or instrument, has been prepared, see a full list in Appendix B. The semi-structured type of interviewing style allowed for the flow of the TC interviews to be attuned to the information being provided by the

participants. When appropriate, probing questions were utilized to further explore comments made by the TC leaders being interviewed.

The interview question guide included questions focused on three related areas posed by the research questions and the conceptual framework of the study. First, the TC leaders' knowledge and personal views on the role of women in computer science and the impact of the gender gap on the field will be examined. Second, interview questions that explore motivational forces behind TC leader's on-going efforts to reduce the gender gap in the program were asked. Finally, as highlighted by the conceptual model, the influence of the computing and academic social group identities on the actions and behaviors of the TC program leaders were explored.

Participating Stakeholders

To conduct this case study nine interviews were conducted with members of the CS administration team. Members of the dean's office, office of admissions, student advisors, and diversity program managers were interviewed for the purposes of this study. Two of the nine participants were women and everyone had over five years of experience in their current role. Two interviews were conducted on the phone. The seven remaining interviews were conducted during the campus visit several weeks later. In addition to the interviews, a number of artifacts were also examined. Internal documents, including the faculty hiring guidelines, meeting memos, management reports highlighting student application and admission rates, as well as publicly available information, such as TC published studies and school communication bulletins to prospective students were used as a source of information for analyzing the CS leaders' role in reducing the gender gap in the program. The Findings section below provides the results of the qualitative data analysis and discusses themes that answer the research questions.

Findings

Modern organizations are multifaceted and ever-changing (Bolman & Deal, 2013). No longer a mastery in one functional area is enough for the management teams to successfully lead organizational changes needed to improve performance (Northouse, 2016). To implement organizational agenda, managers need to possess knowledge, skills, and motivation to perform multiple roles (Dyer, Gregersen, & Christensen, 2011). Not surprisingly, the CS administration team at TC plays a number of roles in order to advance the diversity agenda in the program. A list of significant findings, described below, highlights a number of roles that CS administrators play in order to reduce the gender gap in computer science program. Although these findings are interrelated and may not precisely fit into any single analytical group, the organizational framework developed by Bolman and Deal (2013) is used to categorize them. This four-frame model views all organizations through the symbolic lens, the human resources lens, the structural lens, and the political lens. Using the symbolic lens, the first set of findings describes the role of CS administrators as diversity champions. In this role they focus on changing organizational mental models and attitudes that contribute to the gender gap in computer science. The role of CS administrators as adaptive leaders is analyzed using the human resource lens. Creating a supportive environment enables female students to overcome challenges associated with the CS stereotype. Next, the role of CS administrators as organizational managers is examined using the structural lens. Removing barriers and enhancing existing policies allows CS administrators to encourage more female students to select computer science as their major and prevents others from leaving the program. Finally, the role of administrators in setting an organizational agenda to prioritize diversity initiatives is viewed through the political lens. Leveraging their knowledge, experience, and beliefs enables CS administrators to work as a team addressing one

of the more challenging issues facing computer science programs in the U.S., i.e., how to improve the gender balance in CS.

Finding 1: Role of CS Administrators as Diversity Champions

The role of CS administrators as diversity champions can be examined using the symbolic frame of the organizational model developed by Bolman and Deal (2013). The symbolic frame examines the basic elements of the culture, such as shared beliefs, daily routines, and common traditions that bind organizations together (Bolman & Deal, 2013). Over the years, the computer science culture has acquired a distinctive identity of being male-dominated and unwelcoming to women (Bartol & Aspray, 2006). As Schein (2010) points out, however, it is not uncommon for a small group of people within a large organization to develop their own culture, sometimes called a microculture, that relies on a different set of beliefs and motivational forces needed to achieve organizational objectives. At TC, the CS administration team has developed a different perspective on the role of women in computer science. Every member of the CS administration team interviewed has expressed the same shared view that women do belong in computer science and that the CS stereotype is a by-product of the socio-cultural beliefs. The newly evolved microculture supported by the CS administration team not only recognizes the negative impact the gender gap in computer science has on academic programs, but also recognizes that gender diversity is a major contributor to creativity and innovation in the field of computer science. The following three assertions highlight common beliefs that enabled CS administrators to become diversity champions focused on improving the gender balance at TC.

Gender Bias in Computer Science is a Cultural Phenomenon

Stereotypical CS culture deters women from pursuing college degrees in computer science (Cheryan et al., 2013). A number of studies have shown that career choices for young women are influenced by social structures that define which professions are appropriate for men and women (Broad & McGee, 2014; Stoilescu & McDougall, 2011). Reinforced by cultural stereotypes that depict computer scientists as geeky men further detracts female students from taking CS courses in college (Pechtelidis, Kosma, & Chronaki, 2015; Cohoon & Aspray, 2006). The CS administration team at TC believes the gender gap in computer science is a cultural phenomenon that can be addressed through a coordinated effort of diversity focused initiatives. By leading the organization as diversity champions, they recognize and accept the challenge of creating a more inclusive CS program at TC. While discussing the effects of the CS stereotype in the field of the computer science, Alex who has been a part of the TC administration team since the program inception said,

> Most of cultural norms are established from very early on… like the notion that women are caregivers. Well, women are caregivers because women were in the home taking care of the kids all the God damn time. My mom was a caregiver, but she was also a really good secretary…I believe just from personal experience that gender bias in CS and these other things are typically gendered stereotypes. I think they are more a cultural norm than anything else.

David and Albert, both members of the administration team who came to the U.S. after receiving undergraduate degrees in their home countries, agree that socio-cultural factors deter many women from considering a career in computer science in the U.S. and in many Western countries. During the interview David stated, "I was born in a different society…[where] gender

[in CS] was never an issue. Coming here and doing what I do now, I never thought that I should treat this person differently because they have a different gender." Albert concurs, "I think it [the gender gap in CS] pertains to the general role of women in these [Western] countries and how they're being viewed. I think we have a general, sort of gender imbalance in many different ways and I think computer science may be simply a reflection of that."

Henry, a long tenured member of the leadership team, adds that "research shows that middle school teachers get used to the boys answering the technical questions and start to overlook the girls…Kids have already been brought up to think that these technical engineering type things are more male."

Mary, who oversees several diversity focused programs at TC, also expresses her frustration at how pervasive the negative attitudes and biases are towards women entering the field of computer science,

> I was just looking at one of the judges on the Supreme Court were saying things like we shouldn't have black students going to the top schools because they can't cope. That kind of attitude, I think we have to stop thinking that you need to somehow lower the bar for women and minorities. I think there is a cultural assumption that they're not there, women [in computer science] are not there because they're no good at it or because they're just not up to it. I think it's part of our culture, really. Broad culture. We need to address that as a nation and I don't think given the current political climate we're doing a good job on that.

The CS administration team at TC believes that the gender gap in computer science is a result of the socio-cultural attitudes in the U.S. This view is supported by a number of studies that highlight the CS stereotype and social structures as significant factors in women choosing to

avoid entering the field of computer science (Broad & McGee, 2014; Stoilescu & McDougall, 2011). As a result, the CS administration team is focused on creating a more gender-balanced program environment by supporting the diversity focused initiatives.

Diversity is a Source of Creativity and Innovation in Computer Science

Team diversity improves organizational performance and enhances organizational ability to innovate (Cohen, 2013; Prieto, Phipps, & Osiri, 2009). In their research, Bolman and Deal (2013) have observed situations where team diversity has provided technology focused organizations with a competitive advantage in attaining organizational goals. All interviewees support this view. Alex, a long tenured CS administrator at TC agrees by stating,

> Diversity matters because differences of experience, differences of opinion, all can drive better products, better outcomes, because if everybody's quacking like a duck, then all you make is something that works for ducks…You really need different ideas and different experiences at the table. And if you exclude women, you're excluding half the population and half the good ideas. So we shouldn't be doing that, and thankfully we're not.

Bill, a CS administrator with over ten years of experience at TC says, "when they [students] come in, they'll often tell us they want to change the world somehow, and so I think having that [gender] diversity here does help that process because they get a lot of different ideas about what they can do." He further states that "the benefit [of gender diversity] is more about what they [students] create as they start to use what they've learned."

Mary highlights the importance of gender diversity in computer science by saying,

> There is more and more research to show that diversity pays off in business, for example…People are paying more attention to diversity in general because it's been found that we need to have diverse people on teams to make products that are inclusive.

Anthony, a CS administrator who is involved with program admission process at TC, comments that "diversity is important to the field of computer science, diversity of experience, ideas. People diversity in general enriches computer science, makes a better field."

These interviewees summarize a common view shared by everyone on the TC leadership team that gender diversity in computer science leads to creativity and innovation. This view is also congruent with studies showing that a more diverse organization uses the distinct cognitive abilities of its members to develop innovative solutions (Cohen, 2013; Horwitz, 2005; Prieto, Phipps, & Osiri, 2009). Recognizing the importance of gender diversity in computer science is an important driver of CS administrators' efforts to reduce the gender gap in the program.

Women Do Not Display Lower Computer Science Aptitude than Men

It is not uncommon for many professionals in CS to accept the essentialist perspective that the gender gap in computer science can at least be partially attributed to physiological differences between women and men (Charles & Bradley, 2006). According to this perspective women are incapable of developing the same computer science knowledge, skills, and motivation needed to succeed in the field (Trauth, 2002). As a result, the claim is that the gender gap in computer science is a direct outcome of the human physiological differences between sexes. The entire CS administration team firmly rejects this perspective. Based on their professional and academic experience in reducing the gender gap in computer science program at

TC, every member of the CS administration team interviewed found this traditional view to be unrealistic, unfair, and offensive.

Responding to the question on whether physiological differences result in women staying away from the field of computer science Henry said,

> At the moment the [essentialist-based] hypothesis that because of our reproductive systems [there is a gender gap in CS] …I genuinely think that seems unlikely. Because we as a whole society would have noticed this somehow before, if there was that much of a difference in how we think. It would've come up somewhere else.

Rachel, who is a world-renowned computer scientist and a member of the CS administration team, has described her experiences when faced with questions regarding girls' abilities to succeed in computer science,

> Because I am computer scientist, when people said we need to change computer science curriculum to appeal to girls, I knew this was wrong. I knew that girls can do CS as well as the boys. Nobody could argue with me because they didn't have the same qualifications I did.

In reference to people who still think that women are incapable of becoming computer scientists, Alex' response was blunt and to the point, "Yes, some folks say it's human biology [a reason why girls unable to succeed in CS]. Well, these people are full of shit. I don't think it [aptitude in CS] is gendered because the X chromosome dictates that you're going to be like this.

Jon agrees by commenting,

> There are still dinosaurs there that will tell you that, 'Hey, computer science is for men, and you're a woman so you can't do it. You should be studying in an easier program, like a nursing school or something.' But those are fortunately fewer and fewer.

> Why…because they are seeing that, that's not the right way. There is no foundation, there is no scientific explanation for these things.

According to Mary, there are still many educators around the country who feel that women are incapable of succeeding in rigorous CS academic programs. She says,

> We challenge the findings of the research that went on in the 90's. That is so frustrating when people say to me, 'What did you do to change the curriculum to make it female friendly.' We have to keep saying that we did not change curriculum. It's crazy to think that our faculty would ever agree to anything like that. Women can do the work.

The CS administrators share a common belief that gender does not influence the aptitude in computer science. Years of teaching and observing the academic performance of men and women in CS programs have led this group to conclude that men and women are equally capable of succeeding in the field of computer science. The conclusion is supported by recent neurological studies where a human brain was shown to have more pronounced differences between individuals rather than between genders (Joel et al., 2015).

Understanding the underlying socio-cultural causes of the gender gap in CS and recognizing the importance of diversity in the field of computer science enables CS administrators to play an active role in creating a microculture that promotes a more inclusive environment at the school. As diversity champions, the CS administrators show their unyielding commitment to initiating and sponsoring initiatives that reduce the gender gap in computer science. They are effectively countering the socio-cultural forces that prevent many talented female college applicants from considering computer science as their major.

Finding 2: Role of CS Administrators as Adaptive Leaders

An adaptive leadership style employs strategy that assist followers in overcoming challenges they face (Northouse, 2016). Employing human resource strategies, such as creating a nurturing environment, encouraging participation, and promoting diversity, is an effective way for adaptive leaders to provide followers with the support and motivation they need to accomplish their goals (Bolman & Deal, 2013). In higher education, it is the responsibility of the school leaders to develop an academic and social environment that promotes student learning and supports student needs (Kezar, 2001). At TC, computer science program administrators have created a supportive environment that not only attracts female candidates to the program, but also encourages them to succeed in a field that has traditionally been dominated by male students. By frequently interacting with students and keeping them motivated, CS administrators have succeeded in creating one of the top computing programs in the country that is also gender-balanced.

Creating a Supportive Environment Improves Gender Balance in CS Programs

Creating an environment where people know they are being supported and feel they are part of the community is one of the critical roles played by adaptive leaders (Northouse, 2016). At TC, every member of the CS administration team is either teaching, advising, or directing student-run programs. This high level of student interaction allows CS administrators to ensure that both men and women in the computer science program feel a sense of belonging. It also enables administrators to identify specific issues that may contribute to the gender gap in CS. During the early days of the program members of the CS administration team realized that a significant number of female students admitted to the program succumbed to impostor syndrome and questioned whether they should actually be in the program. As Jack explains,

We have primarily female students who come and think, “Wow, they accepted me. That probably was a mistake, I'm going to keep it quiet because if they find out, they're going to send me back.” So there is a lot of work that we need to do for that.

Highlighting the negative effects of impostor syndrome on female students in the program, Jon says, “female students who are suffering from the impostor syndrome think that it was a mistake I got admitted, I don't belong here. Maybe I should change my major, go somewhere else, yada, yada, yada.”

During his interview Henry also mentions the impostor syndrome as a possible cause for the gender gap in computer science programs,

> Lots of people do have this impostor syndrome thing, where [they] think, “We don't really belong here,” and I can see how that has this non-liner effect, that if it happens a little bit, and it happens to other people like you, then it's going to just grow in on itself, so I think that might be one of the issues [contributing to the gender gap in CS].

The notion of fit has been extensively examined through several school administered studies. Student surveys and interviews are periodically conducted to assess how female students socially fit in the CS program. In describing the study findings, a recent report published by the school states that “we have consistently found that women were feeling comfortable in the CS community and fitting in with peers.”

A frequent level of interaction with students provides CS administrators with opportunities to develop a nurturing environment insuring that female students feel they do belong in the program. Describing a leadership role that CS administrators play in reducing the negative effects of the impostor syndrome, Jon explains,

> [We] tell them, "Well, you need to be a little bit more proactive, you are in the right place. We chose you, you got admitted because you have what it takes. You chose us and then we chose you. So this is a coalition that we have, and we're going to give you the support so that you don't feel totally isolated socially… you're here to shine and this is the right place."

Rachel further details the level of support provided by the CS administration team to female students,

> We make them feel as part of the school. The extra support by the way is not in terms of academic, like asking them to take remedial classes, or asking them to take extra classes, or having one-on-one special tutors for them. No. What I mean is a support in terms of making them feel comfortable about being in a male-dominated place.

In describing CS administration's effort to develop a supportive environment for female students Mary adds,

> Over the years, we've built more and more programs, more and more activities so that we have a very rich source in which the women can get visibility, leadership, the kind of opportunities that made them very central to the culture, to changing the culture…There is some research that shows women are less likely to ask for help. I think we've turned that around by telling the women this is okay. We all need help at times. We should all be asking for help when we need it.

Frequent and direct interaction with students has allowed CS administrators to identify a significant issue that prevents many potential female applicants and newly admitted students from considering a career in computer science. Believing that women belong in computer

science and can be as successful as their male counterparts motivates CS administrators to create a supportive school environment where female students are encouraged to succeed. In a school published report describing how to succeed building an effective CS program, the organizational support involving administrators, diversity program directors, and faculty members was cited as one of the more critical factors in improving the gender diversity in the program. All members of the CS administration team participating in this study believe that the gender gap in computer science can be significantly reduced, as Mary professed, if only program leaders "stop paying lip service and become directly involved in creating a nurturing environment for all students."

Maintaining Gender Balance in CS Programs is an On-going Effort

Implementing organizational changes, especially in tradition-bound institutions of higher education, is a lengthy process typically measured in years (Kezar, 2001; Schein, 2010). Despite achieving impressive results in admitting and graduating female students majoring in the computer science program, CS administrators recognize a need for continuing to invest in diversity focused initiatives. Several members of the CS administrators team have highlighted a possibility of losing momentum in their current efforts if diversity programs are not maintained. During the interview Jon commented,

> So we still offer the support [to female students]. Somebody may say, "Okay, well, you met your goal…why don't you get rid of all the support?" Well, because there are still all these issues, and still this is a male-dominated field even with female students [in our program].

Alex agrees with a need to continue investing in diversity initiatives that focus on reducing the gender gap in CS,

> I think you still need to create an environment in which women feel empowered and feel successful. If all they did was walk into class, and in class it was the same old stupid sexist jokes that were coming out of professors' mouths, I don't think that would work well. I don't think we'd retain all the women that we admitted…I think you can lose something as easily as you created it if you're not careful to adhere to the principles that got you to where you are…I do think we need to make sure that we do what has made us be successful and continue that as best as we can.

Mary also highlights the role program administrators play in sustaining the gender diversity focused efforts,

> I think you actually do have to keep your eye on the ball. I really do…I mean if leadership came in that had no interest, or didn't see this as a value, didn't see diversity as a value, things could change for the worse…I think the tone whether we're inclusive or not is said by many people throughout the school...Something that goes on in the classroom can send a [wrong] message. If there's somebody who can step in and say that's not acceptable, then you can sustain [current efforts] …I think we can still do more.

These interviewees highlight an important point that creating a nurturing environment for female students who may not feel they belong or can succeed in the program is just the first step in a protracted process of reducing the gender gap in CS. Investment in diversity initiatives needs to continue until the cultural environment of the organization is changed to sustain them. Albert has eloquently summarized this point, "When it comes to diversity [initiatives], you just can't take the foot off the pedal."

Program administrators and faculty's participation in social activities and professional conferences with students is also cited as an important component of the on-going efforts to support the gender diversity in the program. A school published report highlights the value associated with faculty-student lunch and dinner sessions sponsored by the school. This document states,

These dinners...provide a chance for students to meet faculty in a relaxed, non-judgmental atmosphere, and to increase the visibility of successful women computer scientists. We [program leaders] have found that a core group of senior faculty…are very supportive.

Published plans to jointly attend and present at The Grace Hopper Celebration of Women in Computing, ACM's Special Interest Group for Computer Science Education, and other conferences also highlight the on-going commitment by the CS program leaders to support the gender diversity efforts.

As adaptive leaders, the CS administration team at TC is focused on students' success. A frequent interaction between students and administration facilitates a nurturing program environment that provides all students with a support network. Many female students especially benefit from studying in such an environment as they feel empowered to succeed in a field still dominated by men.

Finding 3: Role of CS Administrators as Organizational Managers

Managers are responsible for developing organizational structures that enhance operational efficiency and improves organizational performance (Bolman & Deal, 2013). Whereas leadership is focused on developing and implementing adaptive organizational changes, the role of managers is to ensure that organizations function in an orderly and predictable manner (Northouse, 2016). One of the key roles of the organizational manager is to remove any barriers

and implement new procedures that help organization to achieve their goals (Clark & Estes, 2008; Rueda, 2011). Over the years, program administrators at TC have enhanced a number of policies and procedures focused on reducing the gender gap in CS. In particular, student admission policies and faculty hiring procedures were revised to accommodate a more inclusive environment at school.

Changing Student Admission Criteria to Focus on Conceptual and Analytical Abilities Reduces the Gender Gap in CS

Many computer science programs in the U.S. favor applicants with coding experience. As the curriculum of these schools is focused on computer science languages and programming techniques, prior exposure to coding is viewed as a major advantage for student academic success in computer science. Due to the CS stereotype, however, many young women avoid learning computer programming and may not be admitted to CS programs even when they apply (Cheryan et al., 2013). Although programming plays a prominent role in the field of computer science, CS administrators reject the view that computer science is mostly about programming. They view CS field to be more intellectual with a theoretical core analogue to the ones in mathematics and sciences. As a result, at TC the focus is on identifying CS program applicants with strong analytical and conceptual skills. Changing admission polices to accept students with broader abilities, and not just programming experience, also widens the pool of qualified applicants resulting in more women being admitted. Bill explains the current admission philosophy at TC which contributes to a more gender-balanced school environment,

> [We] basically told admissions, programming and especially programming in high school is not absolutely necessary. What is necessary is mathematical and scientific thinking…[We] want to see students that are strong on the STEM side, specifically

> science and math, because we know that that's in high schools, of course. A lot of places don't have computer science, even today…When we ask for things like that, more women start to pop up towards the top because they are very strong in math and science…They can pick up programming, they can pick up the computer science ideas because we were so connected to those fields.

Alex also comments on how changing the admissions policies at TC facilitates an increase in women being admitted to the computer science program,

> We explicitly instructed the admissions office not to look for prior programming experience as a key admissions decision maker because again, women were so underrepresented in high school computer science classes. If you're going to hold that against them just because of whatever is operating at the high school level, that's a problem. So we were looking more at mathematical aptitude…We believed that we could take smart kids and teach them what we needed to teach them. And that turned out to be true.

Rachel adds, "We knew that computer science courses at the high school level were strongly mis-gendered in terms of representation. So if we were going to focus on that as a pre-req, if you will, or a hidden pre-req, that was not going to serve this [reducing the gender gap in CS] cause well at all."

Anthony strongly agrees with Rachel, Alex, and Bill that de-emphasizing programming experience for CS program admissions enables more women to be admitted,

> [We] look for things at a different level than how much computer science has this person actually had. And it allowed us to put students perhaps on a more level playing field because there are some school districts and some independent schools that offer a great

> deal in computer science, and then there are others that just don't offer much at all. And so if you're really looking for a representative group of students, whether or not there's a lot of computer science or a deep dive in computer science coursework available, [it] limits who you can ultimately be interested in. And so we found this [revised admission policies] to be one of the freeing factors for us.

While reviewing a list of requirements in order apply to the computer science program at TC, one common requirement or a recommendation was noticeably missing. None of the examined documents and web pages mention the importance of or even a preference for candidates with programming background. Instead, a strong emphasis is given to candidates who are interested in leveraging the CS education to pursue broader interests. The Office of Admissions web pages, describing the CS program to prospective students state, "Computing is a discipline with strong links to many fields, and our program gives you unparalleled flexibility to pursue these fields."

According to the Information Processing Theory, any new information that is connected with prior pertinent knowledge is acquired and assimilated more quickly (Schraw & McCrudden, 2006). CS administrators at TC believe that conceptual understanding of mathematics and sciences is more relevant to the students' future success in computer science than knowing how to program. In addition, the CS administration team recognizes that requiring a programming experience for CS program admission is reducing the pool of qualified students and excludes many qualified female applicants from being considered. Changing the criteria for student admission to focus more on conceptual and analytical abilities attracts stronger candidates and reduces the gender gap in CS.

Diversity Focused Education for Faculty Improves Gender Balance in CS

Education is a critical, research-based approach to acquiring conceptual knowledge to deal with new situations (Clark & Estes, 2008). As most faculty in the U.S. computer science programs are male, they may not be aware of their unconscious biases that can potentially lead to discriminatory behavior (Jackson, Hillard, & Schneider, 2014). Implementing diversity focused training is an effective intervention to reduce gender biases in organizational settings (Carnes et al., 2015).

To negate effects of the homosocial reproduction and to ensure a more inclusive hiring process, the CS administration team has implemented mandatory diversity training for all members of the faculty hiring committee. As part of this process one of the member of the faculty hiring committee is nominated as a diversity champion, advocating for female and other diversity candidates. Rachel describes the role of the faculty diversity champion as a "diversity advocate, who is on the faculty search committee, who is designed to make sure that we're paying attention and not just selecting people who walk and look and talk like us." While discussing the faculty hiring process, Bill adds, "we have a representative in the school, in the [faculty hiring] committee that purposely makes sure that people don't forget about diversity and diversity is not just male female and so there's all dimensions that way."

Additionally, diversity and unconscious bias training is offered to all CS faculty at school to ensure they gain awareness of any hidden biases that may influence their own attitudes towards female students in CS major. These sessions are either presented or attended by members of the CS administration team. Albert, who attended one of the diversity sessions for CS faculty, describes his experience,

> We had a session on gender issues in the classroom [focusing on how] to sort of be equal. If you had one female in your class and you had ten guys, well, you call on the woman ten times because then it's all equal. Right? So we had some videos that were produced…about sort of, again, stereotypical comments that instructors might make. We talked about how to actually give women a voice, not by calling on them ten times because we had a lot of women in the major who said, "You know, I can always tell when an instructor thinks that he's got to do something because he calls on me all the bloody time."

Members of the CS administration team believe that diversity focused education has already contributed to a more inclusive culture in the program. Mary says,

> Faculty are thinking about diversity…It comes into play when they're making decisions. Major decisions, for sure. Like hiring, promotion, these kinds of things. I think that they are aware that we can be very biased towards women, especially in a field like computer science. I think there is a general awareness.

Jack feels that outcomes of the diversity focused education can also be seen in the classroom. As evidence, Jack comments on how the class assignments have become more topic relevant and less gender specific,

> We get very few cases where a [female] student, I can't think of anything recently where a student came and said, "Wow, that particular assignment, that was like so male biased." I've never seen anything like that here. I have seen that in my previous stints where part of your assignment is to help with some sport or something like that, like football. And it's like, the female students got disengaged almost immediately. Even some of the male students did too, they're like, "I don't even follow this, why is this here?"

Alex supports Jack's comments and adds, "[our faculty is] thinking about creating assignments that are not all first-person shooters that appeal to one stripe of personality, not strongly gendered, but also exhibits traits on both sides."

Education plays a central role in implementing organizational changes that require new knowledge and skills (Schein, 2010). To reduce the gender gap in the computer science program, CS administrators promote diversity and unconscious bias educational sessions for all CS faculty. A 2017-2018 Faculty Hiring Plan memo from the dean's office outlines a 5-year diversity plan. Highlighting the importance of diversity education, one line of the memo states, "You must read chapter 4 of Joann Moody's excellent book on faculty diversity or I will kill you. The key observation is that we're not helpless when it comes to ensuring diverse faculty." The focus on diversity education has resulted in improved faculty hiring practices and enhanced teaching methods employed in the classroom, which CS administrators believe, further reduces the gender gap in the computer science program.

Organizational managers possess authoritative powers to revise policies and procedures in order to achieve organizational goals (Bolman & Deal, 2013). As part of their management responsibilities, CS administrators focus on implementing organizational changes that reduce the gender gap in the program. Enhancing student admission policies and introducing diversity focused training for the faculty were some of the more prominent changes implemented by CS administrators. In their role as managers, they continue to review existing program policies and introduce new procedures that can further improve student performance and diversity in the program.

Finding 4: Role of CS Administrators in Organizational Agenda Setting

Organizations are comprised of different internal groups, each having different priorities, expectations, and resource requirements (Bolman & Deal, 2013). Managing competing priorities of each stakeholder group in higher education institutions is a complex endeavor that can distract leaders from maintaining focus on organizational goals (Kezar, 2001). Achieving organizational congruency often requires political prowess by the leadership team (Schein, 2010). To ensure that attainment of the gender-balanced program environment is being viewed by internal groups as a top organizational priority, CS administrators set an organizational agenda to include diversity topics.

Including Diversity on the List of Organizational Priorities Improves Gender Balance in the Program

Agenda setting is a political skill that allows leaders to promote organizational changes and define a roadmap to achieve them (Bolman & Deal, 2013). Information dissemination and collecting feedback is an effective method to set and communicate the organizational agenda to the stakeholders (Lewis, 2011). This is especially important where professional priorities, such as research, and organizational priorities set by the administrators may diverge (Lewis, 2011).

At TC, CS administrators regularly meet with faculty to ensure that they appreciate the priority of improving the gender balance in the computer science program and maintain vigilance in their efforts. According to Mary, it is critical for the school faculty to understand that reducing the gender gap in computer science is a top priority and requires their support. She explains,

> The big message [to faculty] is you don't do this alone. Diversity is not a one-person thing. It really is a community effort. From the top, from the leadership to the students, it's a community you build.

Henry agrees that involving faculty members in diversity discussions not only creates a more participatory program environment, but also emphasizes diversity as a major focus for the administration team,

> I'm very comfortable with smallish meetings, where everyone is around the table like this, and gets a chance to talk. So for example, it's very important we have these [diversity] conversations with faculty…I bring them in and say, "What do you think? Tell me what you really think, and let's see if we can make it better." In a recent faculty survey, we asked people about their experience, one of the things were the gender related issues.

Albert explains how collecting feedback from faculty is an important part of the diversity agenda in the program,

> [While meeting faculty] you do get reasonable concerns, but you actually get them out on the table. A typical concern might be something like, "Well, if we look like we're working harder to attract women to apply here, wouldn't that mean that the women who are here…feel like they got in on some special play there?" It's not crazy. These are actually real concerns…So I might go to some of those faculty lunches and talk at that level.

Another example of how the diversity-focused agenda is being communicated to the faculty can be seen in the management meeting minutes. One such memo discusses a proposal to include a new language into the faculty recruiting job ads, “We particularly encourage

applications from candidates who have a demonstrated track record in mentoring and nurturing female and under-represented minority students." This example clearly demonstrates the importance that the CS leadership team places on achieving the gender diversity in their program.

A frequent dialogue with faculty is an effective way to sustain focus on such diversity initiatives as improving the gender balance in CS program. It sets diversity as an integral part of the organizational agenda and allows CS administrators to emphasize diversity as one of the organizational priorities. Discussions with faculty also provide CS administrators with an opportunity to address any diversity related concerns that faculty may have.

Agenda setting is a political tool that enables leadership teams to specify organizational priorities and areas of focus (Bolman & Deal, 2013). Having clarity with respect to organizational goals allows internal groups to become more cohesive in implementing organizational agenda (Schein, 2010). CS administration team continues to emphasize diversity initiatives to be an area of focus ensuring that a reduction of the gender gap in computer science remains a top organizational priority at TC.

Solutions and Recommendations

Discussion

Very few schools in the U.S. have achieved the same level of success in addressing the gender gap in their computer science programs as the CS program at TC. While preparing for the on-campus interviews, the study author fully expected CS administrators to take the opportunity and discuss how their unique leadership style or innovative management practices led to the program becoming one of the more gender balanced in the country. Yet, this is not what happened. As the interviews progressed, it became obvious that improving the gender

balance in CS program was not viewed as the ultimate objective, but rather as a first step in the process of achieving the overall diversity in the program. The most interesting and somewhat surprising aspect observed during the interviews was how CS administrators internalized the importance of diversity to the field of computer science. They did not see diversity as an add-on function in their daily practice. To them, achieving diversity in the program was a foundational element in becoming successful CS program leaders. Accepting the gender gap in computer science as a professional challenge, CS administrators applied their knowledge, skills, and motivation to solve it as they would solve any other challenging problem. Once solved, their expectation was to move on to face the next set of challenges in the diversity space. Every single member of the CS administration team spent time describing diversity challenges facing the organization. For example, they talked about difficulties in attracting and admitting Latino and African American students to the undergraduate computer science program and hiring female candidates for the open faculty positions. At times it felt like this group of leaders was more interested in discussing their diversity challenges rather than their successes in reducing the gender gap in the program. As a team, they were quite pleased with progress made in the gender space, but were disappointed in slow progress of attracting other underrepresented groups to the computer science program. To a computer scientist with over 30 years of experience in leading technology organizations and recruiting graduates from dozens of CS programs in the U.S., this was a new and a very welcomed experience.

Recommendations for Practice to Address KMO Influences

The CS administration team at TC has made a significant progress in reducing the gender gap in the computer science program. Over the years several interventions have been successfully implemented resulting in the computer science program at TC to become one of the

most gender balanced programs in the U.S. Despite recent success in changing the cultural aspects of the program that has significantly reduced the gender gap in the program, several recommendations described below, as well as associated implementation and evaluation plan included in Appendix F, are being proposed in order to sustain the momentum of the diversity focused initiatives. Many of the recommendations support the already existing practices at TC. However, as mentioned by most administrators, there are several factors that necessitate the CS administration team to continue investing in gender and other diversity focused initiatives. The length of time it takes for the cultural environment of the professional practice to change, personnel changes on the leadership team, as well as the ever-evolving field of computer science are just some of the factors that can negatively impact the progress of the organizational changes (Bolman & Deal, 2013; Denning, 2005; Schein, 2010).

Recommendations section is based on the KMO model that permeates all components of this study. It highlights a role that declarative, procedural, and metacognitive knowledge factors play in CS administrators' ability to reduce the gender gap in computer science program at TC. Motivation influencers show how self-efficacy and utility value enable CS administration team to see significance in reducing the gender gap in computer science program and gain confidence in their ability to successfully implement aspired changes. Finally, the organizational influences review how the organizational vision, policies and procedures, as well as the allocation of resources provide support to the CS administrators' efforts in designing and implementing diversity focused initiatives that reduce the gender gap in the program.

Knowledge Recommendations

CS program administrators' ability to reduce the gender gap in computer science at TC has been recognized by many educators and practitioners as a significant milestone. Despite the

accomplishment, most members of the CS program leadership team have highlighted a risk of losing the gains unless the school maintains its current level of knowledge-based interventions. Hall and Theriot (2016) have identified three types of knowledge that support a more diverse environment in college programs. First type refers to the conceptual knowledge that influences stakeholders' views and actions. At TC, CS administrators need to know different social and cultural factors that influence female students not to choose majoring in computer science. Second type is knowing how to structure interventions in order to achieve a more inclusive environment. CS administrators at TC need to know how to enhance social setting in the program to attract and retain more women with little or no programming experience. Third type of knowledge is a knowledge of one's own awareness as it plays a significant role in achieving diverse focused efforts. At TC, CS administrators need to reflect on their own attitudes and biases towards women pursuing degrees in computer science. Jointly, conceptual, procedural, and metacognitive knowledge of the CS program leaders at TC plays a significant role in sustaining gender parity in computer science program. Table 2 provides a summary of knowledge influences and associated recommendations.

Table 2

Summary of Knowledge Influences and Recommendations

Assumed Knowledge Influence: Cause, Need, or Asset*	Validated (H, HP, N)	Priority (Y, N)	Principle and Citation	Context-Specific Recommendation

CS administrators need conceptual knowledge of different social and cultural factors influencing female students' decision not to pursue college degrees in computer science. (D)	HP	Y	Information Processing Theory – How individuals organize knowledge influences how they learn and apply what they know (Schraw & McCrudden, 2006).	Provide CS administrators with diversity education to further strengthen their conceptual understanding of the social and cultural influences that affect the college major choice of female students.
CS administrators need to know how to structure program environment in order to attract and retain more women with little or no programming experience. (P)	HP	Y	Information learned meaningfully and connected with prior knowledge is stored more quickly and remembered more accurately because it is elaborated with prior learning (Schraw & McCrudden, 2006).	Provide CS administrators with feedback data from students new to programming to determine how to enhance computer science social environment at TC.
CS administrators need to be cognizant of their own attitudes and biases towards female students pursuing degrees in computer science. (M)	HP	Y	Information Processing Theory -- The use of metacognitive strategies facilitates learning (Baker, 2006).	Continue to provide CS administrators with implicit bias training to reflect on their own attitudes and biases towards female students seeking degrees in computer science.

*Indicate knowledge type for each influence listed using these abbreviations: (D)eclarative = (C)onceptual & (F)actual; (P)rocedural; (M)etacognitive

Declarative: (Conceptual) knowledge solutions, or description of needs or assets. To reduce the gender gap in computer science, program administrators need conceptual knowledge of various social and cultural factors that influence female college students not to pursue degrees in CS. Conceptual knowledge describes theories and models underlying the problem of practice being studied (Krathwohl, 2002). According to Information Processing Theory, which describes the role of cognition, memory, and thinking, an individual's ability to learn and to apply

knowledge is highly dependent on how the knowledge is organized (Schraw & McCrudden, 2006). According to Clark and Estes (2008), education is an effective approach to organizing and delivering conceptual knowledge necessary to address new, complex, and unanticipated challenges. Providing computer science program leaders with diversity education based on the latest research findings will further strengthen their conceptual understanding of the social and cultural influences that affect the college major choice of female students (see Table 2, for conceptual knowledge influences and recommendations).

Many educational leaders have conceptual knowledge gaps in understanding social and cultural factors contributing to a gender disparity in computer science programs (Cohoon & Aspray, 2006). Studies show that a diversity-focused education promotes a more inclusive academic and social environment by further enhancing the conceptual knowledge of the trainees (Hall & Theriot, 2016). These studies also indicate that the same educational approach can provide information that facilitates development of the strategies focused on how to reduce the gender gap in CS.

Procedural knowledge solutions, or description of needs or assets. Procedural knowledge provides guidelines for designing and managing tasks needed to achieve a goal (Krathwohl, 2002). Many of the female CS program applicants do not have any previous experience in computer programming and may feel they do not belong in the program. As a result, CS administrators need procedural knowledge of how to enhance school's social environment to ensure that students with little or no programming experience can succeed. Information Processing System Theory posits that information learned meaningfully and connected with prior knowledge is stored more quickly and remembered more accurately (Schraw & McCrudden, 2006). Information also guides development and implementation of

procedures in a familiar environment (Clark & Estes, 2008). Providing CS administrators with academic performance data collected from female students with no or little programming experience can enhance their procedural knowledge on how to develop a more inclusive academic curriculum (see Table 2, for procedural knowledge influences and recommendations).

Improving academic and social environment of the educational programs in higher education institution is a primary responsibility of its leadership (Kezar, 2001). According to leadership theories, information plays a powerful role in guiding leaders' actions (Northouse, 2016). Missing or incorrect information may result in the implementation of the ineffective procedures, further compounding the problem of practice (Rueda, 2011). As a result, developing and utilizing procedural knowledge based on elucidated information is a critical factor in enhancing the social environment of the computer science program.

Metacognitive knowledge solutions, or description of needs or assets. To develop effective strategies for reducing the gender gap in computer science, programs administrators need to be cognizant of their own attitudes and biases towards female students pursuing degrees in computer science. Metacognitive knowledge facilitates awareness of one's own views and allows individuals to assess their strengths and weaknesses (Krathwohl, 2002). According to Information Processing Theory, this type of knowledge also enhances learning (Baker, 2006). Studies have shown that a lack of metacognitive knowledge negatively influences decision-making and corresponding actions of the educational leaders (Dasgupta & Stout, 2014). To inhibit the influence of subconscious preconceptions, program leaders may need to continue to participate in unconscious bias training. Training allows individuals to acquire knowledge and practice skills while receiving corrective feedback (Clark & Estes, 2008). Providing bias training to CS administrators may be an effective strategy in acquiring metacognitive knowledge

required for developing and implementing the gender diversity focused initiatives (see Table 2, for metacognitive knowledge influences and recommendations).

All people have attitudes and biases shaped by their cultural environment that they may not be aware of (Banaji & Greenwald, 2013). As most of CS administrators are men, such implicit biases can lead to inadvertent discriminatory behaviors and can negate the efforts of achieving the gender parity in computer science programs (Jackson, Hillard, & Schneider, 2014). Recent research has shown that bias training focused on enhancing the metacognitive skills is an effective intervention in reducing gender bias across all academic environments, even those where such training has been previously conducted (Carnes et al., 2015; Jackson, Hillard, & Schneider, 2014).

Motivation Recommendations

Motivation plays a critical role in leaders' ability to develop and implement initiatives that advance organizational goals (Clark & Estes, 2008). To be effective in their roles, leaders need to choose and persist in addressing a complex organizational problem as well as to take responsibility for advancing the social good of the organization (Northouse, 2016). Driven by the broader sociocultural, economic, and demographic changes, higher education leaders are challenged to implement diversity focused initiatives in programs they oversee (Kezar, 2001). In order to champion diversity initiatives, such as a reduction of the gender gap in computer science program, school administrators need to perceive a significance in achieving the task as well as to believe in their own abilities to succeed (Eccles, 2006, Pajares, 2006). Expanding interactions and establishing a participative dialogue with various stakeholder groups may increase educational leaders' motivation to manage complexity of successfully implementing diversity

initiatives (Pucciarelli & Kaplan, 2016). Table 3 below shows motivation influences and the corresponding recommendations for CS administrators at TC.

Table 3

Summary of Motivation Influences and Recommendations

Assumed Motivation Influence	Validated (H, HP, N)	Priority (Y, N)	Principle and Citation	Context-Specific Recommendation
CS administrators need to believe in their own competences to engage in initiatives that reduce the gender gap in computer science programs.	HP	Y	Feedback and modeling increases self-efficacy (Pajares, 2006).	Provide CS administrators with opportunities to engage in diversity focused discussions with educators in other college STEM disciplines where gender parity has been achieved.
CS administrators need to perceive utility value in their efforts to reduce the gender gap in computer science program.	HP	Y	Learning and motivation are enhanced if the learner values the task (Eccles, 2006)	Provide CS administrators with opportunities to engage in diversity focused discussions with external stakeholders who advocate for a greater diversity in computer science programs.

Self-Efficacy. To engage in challenging tasks, such as achieving gender parity in computer science program, CS administrators need to believe in their own abilities to succeed. Self-efficacy beliefs determine how individuals assess their own competencies (Bandura, 1993).

Strong self-efficacy beliefs motivate individuals to select and perform challenging tasks and to prioritize task completion over other competing alternatives (Pajares, 2006). According to self-efficacy theory, a number of factors facilitate formation of self-efficacy beliefs. Vicarious experiences play a major role in affecting individual's self-efficacy (Bandura, 1993). Observing success or failure of others working in the same domain and facing similar challenges can either raise or lower beliefs of one's own capabilities (Pajares, 2006; Rueda, 2011). Providing CS administrators with opportunities to engage in diversity focused discussions and receive feedback from peers in other STEM disciplines, such as mathematics and sciences where gender parity has been largely achieved, may assist in implementing initiatives that reduce the gender gap in computer science programs.

In the last two decades several college STEM disciplines have made a significant progress toward achieving gender parity in their respective fields. More than half of undergraduate degrees in mathematics, biology, and chemistry are now awarded to women (Cheryan, Ziegler, Montoya, & Jiang, 2016). Although several factors have facilitated this increase, program changes that emphasized hard work and not gender-based innate abilities of students may have also contributed to a greater number of female students selecting mathematics and sciences as their majors (Cheryan et al., 2016). A field of computer science shares many educational principles with mathematics and sciences (Denning, 2005). Examining diversity focused initiatives successfully implemented by other college STEM educators may increase CS administrators' self-efficacy in achieving gender parity in computer science program.

Value. To prioritize and sponsor initiatives that aim to reduce the gender gap in computer science programs CS administrators need to perceive utility value in accomplishing diversity focused goals. According to the Expectancy Value Motivational Theory, utility value

is derived when achievement of specific tasks is congruent with individual's personal or professional goals (Rueda, 2011). Eccles (2006) states that recognizing utility value associated with a given task facilitates learning and motivates individuals to accomplish that task. Many external stakeholder groups, including federal and state legislators, industry sponsors, etc., support diversity focused efforts in higher education and hold school administrators accountable for their implementation (Firestone & Shipps, 2005). Providing CS administrators with opportunities to directly engage in diversity focused discussions with external stakeholders may achieve accountability goals and further increase utility value associated with efforts to reduce the gender gap in college computer science programs.

College leaders are responsible not only for the high academic performance of students and for hiring the best faculty, but also for meeting accountability requirements imposed by many stakeholder groups (Kezar, 2001). State legislatures, among other external stakeholders, are looking to increase a number of diverse students majoring in engineering and computer science as part of state higher education appropriations (State General Session, 2001)[1]. Inability to improve program performance related to diversity initiatives may cause both financial and reputational risks to the higher education institutions failing to comply with stakeholder mandates (Conner & Rabovsky, 2011). By interacting directly with stakeholder groups that advocate for a greater gender diversity in CS programs, school administrators can further ascertain importance of reducing the gender gap and prioritize diversity focused initiatives in programs they lead.

[1] To ensure anonymity of the source, the link to the state website is not provided.

Organization Recommendations

Organization influencers play a critical role in determining whether organizations underperform and fail or are able to implement organizational changes needed to achieve organizational goals (Clark & Estes, 2008). Different types of organizations have different organizational structures, goals, and philosophies (Kezar, 2001). As a result, each organization has a unique combination of influencers that facilitate implementation of organizational objectives (Bolman & Deal, 2013). Higher education institutions, despite their primary focus on delivering quality education and supporting research, are also influenced by different organizational factors (Kezar, 2001). Each institution adapts a different approach to implementing initiatives, driven by organization's own identity. Computer science program at TC has its own set of organization influencers driven by the school's priority to achieve a more gender diverse environment. Communication processes, policies and procedures, as well as resources allocated by CS administrators to diversity initiatives are just some of the key organization influencers that support organizational goals at TC. Table 4 below highlights organization influences and corresponding recommendations supporting the ongoing efforts to reduce the gender gap in computer science program at TC.

Table 4

Summary of Organization Influences and Recommendations

Assumed Organization Influence: Cause, Need, or Asset	Validated (H, HP, N)	Priority (Y, N)	Principle and Citation	Context-Specific Recommendation

CS administrators need to communicate organizational vision and their commitment to achieving the gender balance in the computer science program.	HP	Y	Effective leaders are knowledgeable of communication processes and how to use them for effective organizational change (Denning, 2011; Lewis, 2011).	Enable CS administrators to conduct internal information campaign about the academic and social benefits of student diversity in the computer science program.
CS administrators need to develop student admission policies to foster a culture of inclusion in the computer science program.	HP	Y	Effective leaders demonstrate a commitment to valuing diversity through inclusive action. They promote an organizational culture that promotes equity and inclusion and cultivate an atmosphere where diversity is viewed as an asset to the organization and its stakeholders (Prieto, Phipps & Osiri, 2009).	Allow CS administrators to enhance admission policies that extend the pool of candidates being considered for admission.
CS administrators need to align the allocation of resources with the gender-diversity focused goals of the computer science program.	HP	Y	Effective change efforts ensure that everyone has the resources (personnel, time, etc.) needed to do their job, and that if there are resource shortages, then resources are aligned with organizational priorities (Clark and Estes, 2008)	CS administrators to ensure that diversity focused initiatives are prioritized, and have adequate funding and human capital resources allocated to reducing the gender gap in computer science programs.

Communication Processes. To lead organizational changes focused on improving the gender diversity in computer science program CS administrators need to effectively communicate the organizational vision as well as specific initiatives related to this goal. Communication is a social interaction tool by which the timing and the direction of the organizational change is negotiated between the organizational leaders and other stakeholders (Hattaway, 2012). It plays a critical role in introducing, implementing, and evaluating organizational changes (Lewis, 2011). For higher education institutions communication processes help to transmit important organizational values such as diversity and inclusion that go beyond the traditional focus on research and teaching (Denning, 2011). Developing and conducting an internal information campaign that highlights academic and social advantages of reducing the gender gap in computer science program may be an effective approach to successfully implementing diversity focused initiatives.

A communication between the organizational leadership and its stakeholders enhances the decision-making process and improves the results of the organizational changes (Clark & Estes, 2008; Denning, 2011; Wheeler & Sillanpa'a, 1998). Research has shown that poor communication of organizational goals can act as a barrier to implementing a change (Gilley, Gilley, & McMillan, 2009; Waters, Marzano, & McNulty, 2003). An internal information campaign designed to socialize how organization can benefit from the espoused change is an integral component of the communication process (Berger, 2014; Lewis, 2011). At TC, a communication process that focuses not only on disseminating information and soliciting feedback on specific diversity focused initiatives, but also on creating shared values among all stakeholders with respect to achieving a more inclusive school environment can further enhance administrators' ability to reduce the gender gap in computer science program.

Policies. To reduce the gender gap in computer science program, CS administrators need to develop new and enhance existing policies that would foster a culture of diversity and inclusion. Organizational policies provide guidance for identifying and implementing tasks that advance the organizational mission (Bolman & Deal, 2013). In higher educational institutions, policies are established to support learning and working environment as well as to promote diversity and inclusion (USC Policy, 2011). The amount of diversity in college programs is directly dependent on the student admission policies (Galinsky et al., 2015). By enhancing existing policies that broaden the criteria for student admission, CS administrators may promote a culture of inclusion and reduce the gender gap in computer science program.

Alignment of policies with organizational goals, such as creation of an inclusive academic environment, narrows the gap between organizational culture and organization's ability to achieve espoused outcomes (Clark & Estes, 2008; Prieto, Phipps & Osiri, 2009). Research has shown that diversity focused policies are readily accepted by the organization when the entire leadership team is involved in developing and implementing specific actions that promote the culture of inclusion (Hunt, Layton, & Prince, 2015). By enacting admission policies that allow the non-traditional candidates, such as those without any prior programming experience to be admitted to TC, CS administrators can improve the gender balance in the computer science program.

Resources. Allocating adequate resources to diversity focused initiatives is a critical component of CS administrators' ability to reduce the gender gap in computer science programs. Resource allocation is a process which ensures that necessary resources are shifted to initiatives that support organizational goals of the higher education institution (Rueda, 2011). It is also one of the core functions performed by the management teams (Northouse, 2016). At a time when

availability of public and private funds accessible to universities continues to be under pressure resource allocation to diversity focused initiatives, such as a reduction of the gender gap in computer science, is of paramount importance (Burke, 2005). To ensure the advances in achieving the gender balance in computer science program are not hindered, CS administration at TC needs to continue prioritizing and deploying sufficient level of resources to the diversity focused initiatives.

A critical review of the research on the gender gap in computer science has identified several factors, including a lack of familiarity with the field and a lack of peer interaction, as significant barriers to entry for many female college applicants (Cohoon & Aspray, 2006). Not surprisingly, the same studies have highlighted the importance of allocating various types of resources to ensure that such barriers were removed. Capital resources used for organizing recruiting events and sponsoring guest speakers are needed in order to market computer science programs to female college applicants (Robertson, Newell, Swan, Mathiassen, & Bjerknes, 2001). Human resources, including senior CS leaders overseeing the female-run student programs, are also needed to be available on a full-time basis (Robertson et al., 2001). Allocation of resources to the diversity focused initiatives is a critical element in reducing the gender gap in computer science programs and needs to remain a primary focus for the CS administrators at TC.

Based on the New World Kirkpatrick Model, the implementation and evaluation plan discussed in Appendix F can provide a practical approach to implementing the KMO-based recommendations. Using this approach would further support CS program administrators' efforts in reducing the gender gap in computer science and achieving one of the primary organizational objectives.

Limitations

This research is a case study of a single U.S. higher education institution that has made a significant progress in reducing the gender gap in its computer science program. As such, a number of limiting factors bound this study. First, TC is a high-ranking school that attracts a large number of applicants to its CS program. This allows the CS program administrators to review and potentially select more female candidates. Second, TC is in a geographical area with a high concentration of technology companies. Proximity to these companies may potentially attract more female applicants seeking employment in the industry. Lastly, as a high-ranking school TC attracts more funding from the private donors and industry sponsors. Having access to more funding may allow CS administrators to provide additional support to the diversity focused initiatives on the on-going basis.

TC is just one of several schools in the U.S. that was able to significantly reduce the gender gap in CS. Other higher education institutions that have also succeeded in improving the gender balance in their CS programs have different school characteristics, such as the size of the program, funding sources, and geographic location, among others. Additional research focused on identifying common factors that enable all these schools to reduce the gender gap in CS programs is needed.

Conclusion

The field of computer science is a primary driver behind major technological innovations. Yet, almost 50% of the population is missing from the field. For decades, both educators and CS practitioners have been looking for ways to increase the number of women entering college computer science programs, in most cases only to be disappointed with the results. One school, however, has risen to the challenge and has been able to succeed where many others have failed.

For over a decade the CS leadership team at TC has been examining various reasons for female students' avoidance of the computer science major. Focusing on the socio-cultural factors and organizational influencers that deter many talented young women from entering a CS major, the program administrators implemented several interventions resulting in the number of women being admitted to the computing program to significantly exceed a national average of about 16%. As a result, TC has now become one of the more gender balanced top ranking computer science programs in the country.

This case study examines the role of CS college administrators in reducing the gender gap in the computer science program at TC. Literature Review section of the manuscript provides a background and serves as a foundation for the analysis conducted in this study. Using the Analytic Conceptual Framework, developed by Clarke and Estes (2008), knowledge, motivation, and organizational factors that contribute to the gender gap in CS are reviewed. To organize and synthesize empirical, theoretical, and experiential knowledge into logically arranged configuration guiding this qualitative study, the original conceptual framework is advanced. Data Collection and Instrumentation section provides details on how the data collection and analysis were performed. A detailed discussion outlining the study findings based on the document analysis and interviews describes the multiple roles that CS administrators play to achieve a gender balanced environment in the program. Finally, a list of recommendations to sustain CS administrators' efforts to reduce the gender gap is provided.

The CS administrator team at TC has demonstrated that with proper knowledge, motivation, and organizational support it is possible to reduce the gender gap in the computer science program. It is a hope of this investigator that this study encourages additional research needed to achieve a diverse and inclusive environment in the field of computer science.

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Appendix A: Participating Stakeholders with Sampling Criteria for Interviews

Deciding on how to select interview participants is one of the critical decisions facing a qualitative study investigator (Maxwell, 2013). A purposeful selection or a purposive sampling of interviewees is the most common approach and provides researchers with a strategy to gain an in-depth knowledge and to learn a meaning that participants assign to a set of experiences (Maxwell, 2013; Merriam & Tisdell, 2016). The richness of the data gathered from the purposefully selected participants assists the researcher in learning about issues that are principal to the study's focus (Merriam & Tisdell, 2016; Seidman, 2013). To examine the KMO influencers that facilitate TC's efforts in reducing the gender gap in computing, nine members of the TC computing program leadership team were purposefully selected for the interviews. Two primary limitations dictated the size of the sample. First, there were practical considerations. Interviewing all members of the leadership team was likely to be a challenging and unrealistic endeavor considering how busy these individuals are and the amount of time it takes to prepare for and conduct each interview. Hence, interviewing nine participants seemed a more reasonable objective. Second, the purpose of the interviews was to learn about the knowledge, motivation, and the organizational influencers that impact CS leader's actions with respect to reducing the gender gap. As such, the effectiveness of the interviews, i.e. the focus on the specific actions and experiences of the interviewees was by far more important than the number of the interviews conducted (Johnson & Christensen, 2014; Maxwell, 2013; Merriam & Tisdell, 2016).

To ensure that data collected during the interviews captures as many diverse responses of interviewees as possible, a maximum variation sampling strategy was adopted (Merriam & Tisdell, 2016; Johnson & Christensen, 2014). A maximum variation sampling technique allows the investigator to capture the widest possible range of views and experiences that participants

may share (Merriam & Tisdell, 2016; Seidman, 2013). In this study the sampling was stratified along two dimensions, the gender and the role within administration. As the total number of women leading the computing program at TC stood at three, the goal was to interview at least two female leaders in order to capture their views and experiences in addressing the gender gap in CS complementing data collected for their male counterparts. Also, two of the interviewees selected were members of the dean's office; the others were either the heads of the departments or program directors. Since the goal of the interviews was to learn about the TC leaders' views, experiences, and actions in reducing the gender gap in computer science program, two selection criteria were observed.

Criterion 1. Each interview participant must be a member of the computing leadership team at TC. The focus of the study is to examine the KMO influencers of the TC leadership team that facilitate increased admission rates of female candidates to the computing program. As discussed earlier, the computing program leaders at TC are accountable for reducing the gender gap in the program and therefore are a key stakeholder group of focus.

Criterion 2. Each interview participant has been a member of the TC's leadership team for at least two years. This criterion is used to ensure the TC leaders being interviewed understand both the organizational culture and the program specific interventions implemented to reduce the gender gap in CS.

Appendix B: Interview Protocol

Thank you for your time. If that's ok with you, first I would like to ask you questions about you.

Q: Tell me when and why you decided to pursue a career in computer science?

Q: What is your favorite programming language?

Q: When was the last time you compiled your own code? Was it work related or for fun?

Q: In your role as _____, what part of your job do you find to be most enjoyable? Why?

Q: Tell me about your typical day.

Q: When you were an undergraduate student, were there many female students in your computer science classes?

--If yes, in your opinion what are the reasons for gender gap in computing to widen?

--If no, in your opinion what causes the gender gap in computing to persist?

Q: Do you think the existence of the reducing gender gap in computing is an issue? If yes, in what sense?

Q: Has your personal perspective on women in computing been influenced in any way by your professional/academic experiences?

For the last decade the admission rate of female students at TC has exceeded the national averages. This is an incredibly impressive achievement. The next set of questions will focus on the TC's efforts in addressing the gender gap in computing:

Q: At TC, reducing the gender gap in computing has been a priority for many years. Why is it such a priority?

Q: How much effort is needed to maintain this high rate and do you think there is room for further improvement?

Q: Do you think all faculty share your view on the importance of gender diversity in computing?

Q: How does the school's cultural environment (e.g., university policies, allocation of resources, support from other TC departments) enhance or impede your ability to implement policies that reduce the gender gap in the program?

Q: In addition to admission policies that focus on the candidates' overall competencies, and not necessarily on the extent of the previous programming experience, what other factors contribute to the school's success in attracting female students?

(If necessary, can you tell me about your Dr. Matlock (pseudonym) role as a diversity program director?)

Q: How often does the topic of reducing gender gap in computing being discussed amongst senior leaders at TC?

Q: What role, if any, do program administrators play in reviewing and modifying the admission policies to the program?

(If necessary - Can you give me an example of a recent meeting or a discussion on the topic?)

There is an on-going debate on whether senior leaders in computer science programs consider themselves to be computing professionals first and then educators or vice versa.

Q: Can you tell me how you feel about this argument and how you would describe yourself on this spectrum?

Q: What is your level of interaction with computing industry leaders? With CS leaders at other higher education institutions?

Q: Do you feel leaders in computing industry/education community share/support your views on school's goal of achieving a more student gender-balanced program?

Q: Is there anything that I have missed and should have asked you about the school's efforts in addressing the gender gap but did not?

Thank you so much for your time again!

Appendix C: Credibility and Trustworthiness

The credibility and trustworthiness of the qualitative studies ultimately depends on the credibility and trustworthiness of the study authors (Merriam & Tisdell, 2016). Only when a researcher collects and analyzes data following the best ethical practices, meticulously reviews results, and relies on the evidence to explain any data discrepancies could the research study be considered credible and trustworthy (Maxwell, 2013). As discussed earlier, employing ethical practices during the study design, data collection, and analysis phases of the project is a critical step in ensuring that the study is both credible and trustworthy (Creswell, 2014; Maxwell, 2013; Merriam & Tisdell, 2016).

Researcher bias. Researcher is a primary instrument of data collection in qualitative studies (Merriam & Tisdell, 2016). Eliminating one's beliefs and perspective to achieve objectivity in a research study is extremely difficult, if not impossible (Maxwell, 2013). It is therefore critical for the researcher to reflect on his own feelings and document any biases that she or he may have during the entire course of the study (Creswell, 2014; Merriam & Tisdell, 2016). An earlier section of the manuscript, titled Role of Interviewer, describes potential concerns with how the researcher's extensive experience in the field of computing may influence data collection process. To further reduce the effects of the research bias, the study author has also reviewed each study finding while reflecting on his own views and beliefs with respect to the role of the program administrators in CS. As part of this mental exercise, the key question: "Is this finding skewed in any way by my perceptual lens?" was always considered.

Triangulation. Cross-checking data for consistency using various methods of data collection is a sound strategy for enhancing credibility of the research (Creswell, 2014; Merriam & Tisdell, 2016). For the purposes of this study, data collected from the interviews was compared to the

internal documents provided by the CS administration team and publicly available information, such as studies published by the school. Uniformity of data collected further contributed to the credibility of the study.

Peer review. A peer review is a process that allows a person with significant knowledge of the topic or with deep experience in research methodology to independently review the research as it is being conducted (Creswell, 2014; Merriam & Tisdell, 2016). To ensure that study findings accurately reflect data being collected, the author of this study has asked a researcher, not connected to this study and with significant experience conducting investigations, to provide an independent review. Coded data, which preserves the anonymity of participants and all other aspects of the study, was reviewed to confirm the study findings.

Appendix D: Validity and Reliability

In qualitative studies, researchers focus on understanding how study participants interpret their experiences and assign meaning to them (Merriam & Tisdell, 2016). As a result, some researchers believe that concepts of validity and reliability are not relevant in qualitative studies and are more attuned to the quantitative studies (Creswell, 2014). Other researchers, however, disagree. Unlike the concepts of credibility and trustworthiness, which ensure the researchers' findings are supported by the underlying data, this group of researchers view validity and reliability in qualitative studies primarily focusing on whether study participants consistently interpret their experiences (Seidman, 2013). In interview-based studies, validity and reliability play a primary role in ensuring that participants reconstruct their experiences and assigns meaning to them independently of who the interviewer is, a context of the interview protocol, or the interview settings (Seidman, 2013). Checking consistency of interview responses to specific events at different times is a common approach to increasing validity and reliability in qualitative studies. During the TC campus visit, two of the study participants were met more than once. In addition to formal interviewing sessions, they were met in a more casual setting. Although not part of the formal interviewing process, discussions focused on the factors contributing to the gender gap in CS and the role of the leaders at school to achieve a more gender-balanced environment. Not surprisingly, both study participants were consistent in describing their experiences in addressing the gender gap in the computer science program at TC. Due to schedule conflicts no other follow-up discussions were set up. Despite the limitation, even these additional interactions with two interviewees increased the level of validity and reliability associated with the study.

Appendix E: Ethics

Ethical considerations and integrity of the researchers play a central role in qualitative studies (Merriam & Tisdell, 2016; Maxwell, 2013). As the researchers are the primary instrument used in the qualitative studies, it is their trustworthiness and ethical approach to study design and data collection and analysis that determine the credibility of the study (Creswell, 2014; Merriam & Tisdell, 2016). Ethical considerations need to be part of every component of the research design (Creswell, 2014). However, given that most of the data collection in qualitative studies is performed through interaction with study participants, it is vital that vigilance to the ethical standards pertaining to the researcher-participant relationship is sustained (Glesne, 2011; Merriam & Tisdell, 2016).

There are several guidelines that are considered universal in defining ethicality in qualitative studies (Glesne, 2011; Merriam & Tisdell, 2016). The 'no harm' provision mandates that interviewees should not feel pressured or exploited during the interviewing process, and subsequent to the study being published, be exposed to legal or financial hardship (Krueger & Casey, 2009; Rubin & Rubin, 2012). The study participant's anonymity needs to be preserved at all times, and any data collected during the interviews must be kept confidential and secured (Glesne, 2011). A consent form, outlining the participant's voluntary participation, the right to withdraw, and the right to privacy, needs to be written in a jargon-free language, and be reviewed and signed by the interviewees prior to any interviews taking place. Study investigators also need to reciprocate participants for their contribution to the study (Creswell, 2014; Glesne, 2011). As Maxwell (2013) points out, it is important to show to participants that their contribution to the study has been a worthwhile effort.

To ensure that ethical standards are adhered to, the study investigator developed a written plan of study, as suggested by Krueger and Casey (2009), and submitted it to the Institutional Review Board (IRB) at the University of Southern California (USC). The IRB's feedback was incorporated prior to the on-site interaction with program administrators at TC. Also, at the inaugural meeting the purposefully selected members of the TC administration team were informed of their right to privacy assuring them that any data collected would be kept confidential. Permission to audio record was solicited prior to any interviews being conducted. Finally, the TC program administrators selected for the study were asked to sign an informed consent form. Throughout the study the program administrators were reminded that their participation is voluntary and they have an option to withdraw from the study at any time. Once the study has been concluded, as a token of appreciation for their time and contribution, all study participants at TC were sent a photo book capturing the natural beauty of the five national parks in Utah.

Appendix F: Integrated Implementation and Evaluation Plan

Implementation and evaluations section suggests a practical approach to designing and measuring the efficacy of a program used to implement recommendations. As many components of this program are already in place at TC, the value of this section is to develop a comprehensive approach that is effective, clear, and measurable. The New World Kirkpatrick Model (New Model) is used to implement and evaluate the effectiveness of program in support of the organizational goals (Kirkpatrick & Kirkpatrick, 2016a). The four levels of the New Model aid in clarifying the organizational goals (Level 4), support the monitoring and reinforcement of the critical behaviors needed to achieve these goals (Level 3), and identify the appropriate KMO based learning practices (Level 2) based on the levels of engagement and perceived relevance expressed by the CS administrators (Level 1).

Implementation and Evaluation Framework

Based on the original work by Dr. Don Kirkpatrick, the New Model still retains the four levels of the original implementation and evaluation framework: Reaction (Level 1), Learning (Level 2), Behavior (Level 3), and Results (Level 4). Yet, the primary purpose of the New Model is to emphasize the business values that implementation and evaluation plan delivers as well as to highlight the importance of the Behavior and Results levels of the framework (Kirkpatrick & Kirkpatrick, 2016a). As a result, the New Model presents the four levels in reverse, i.e., initially focusing on the results the organization is looking to attain in Level 4, and then identifying the behaviors stakeholders need to demonstrate for achieving these results in Level 3. Learning and Reaction, Levels 2 and 1 respectively, are then presented in support of critical behaviors in Level 3. By following this approach, the New Model improves the effectiveness of the framework and further clarifies the purpose of each level (Kirkpatrick & Kirkpatrick, 2016b).

Level 4: Results and Leading Indicators

A variety of benchmarks and outcomes are used by educational leaders to measure organizational performance and to identify areas needing further investment (Dowd, 2005). Performance enhancing initiatives are then implemented and evaluated to ensure the aspired organizational goals are being achieved (Kirkpatrick & Kirkpatrick, 2016a). Table F1 identifies internal and external outcomes, used as key performance indicators by CS administration team at TC, to assess the progress in reducing the gender gap in computer science program.

Table F1

Outcomes, Metrics, and Methods for External and Internal Outcomes

Outcome	Metric(s)	Method(s)
Internal Outcomes		
Increase number of female applicants being selected for admission in computer science program at TC.	KPI – Annual college admission report breakdown by gender	Annual review of student admission criteria for computer science program with Office of Admissions personnel.
Increase number of female undergraduate students graduating from computer science program at TC.	KPI – Annual college graduation report breakdown by gender	Annual assessment of diversity focused initiatives that provide academic and social support to female students.
Improve organizational sentiment regarding the importance of reducing the gender gap in computer science program at TC.	Annual assessment of computer science faculty engagement in diversity focused initiatives.	Monthly meetings with small group of faculty to reinforce and encourage support for the gender diversity focused initiatives at TC.

Increase number of female faculty being hired in computer science program at TC.	KPI – Annual college hiring report breakdown by gender.	Assign diversity champions to the computer science program Faculty Hiring Committee at TC.
External Outcomes		
Increase awareness external stakeholders have of the gender focused initiatives being supported at TC.	Annual level of corporate support for diversity focused initiatives.	Monthly meetings with small group of industry stakeholders to communicate school's diversity focused priorities and to provide progress updates.

The number of female applicants to CS program at TC indicates both the school's ability to attract a broad spectrum of students as well as its ability to market the success of diversity focused initiatives in the program. The number of female students graduating from CS program measures whether school's cultural environment is equally conducive to female and male students dealing with a rigor of the academic curriculum. The number of faculty involved with diversity focused initiatives, especially those focusing on the gender diversity, indicates the organizational sentiment towards achieving a more diverse computer science program at school. Finally, an interaction with and support from the external stakeholders allows CS administrators to account for the program's achievements as well as to solicit additional feedback and recommendations.

Level 3: Behavior

Critical behaviors. As stewards of the program, the CS leadership team is responsible for achieving organizational goals, such as diversity and inclusion. According to Kirkpatrick and

Kirkpatrick (2016a), critical behaviors are specific actions that when performed consistently ensure the organizational goals defined in Level 4 are achieved. Schein (2010) further adds that individuals who are unable to consistently exhibit critical behaviors needed to support organizational goals will negatively impact organizational performance. Table F2 shows critical behaviors that CS leadership team needs to demonstrate to achieve the espoused outcomes described in Level 4.

Table F2

Critical Behaviors, Metrics, Methods, and Timing for Evaluation

Critical Behavior	Metric(s)	Method(s)	Timing
1). CS administration team at TC to promote gender diversity focused initiatives and collect feedback from internal and external stakeholders on progress being made.	Number of internal and external meetings where topics related to improving the gender diversity are included on the agenda and discussed.	Group discussions to monitor and reinforce importance of achieving a gender balanced environment in computer science program at TC.	Monthly
2). Members of the CS administration team at TC to sponsor or co-sponsor a gender diversity focused initiative.	All top priority diversity focused initiatives to have a diversity champion who is a member of CS administration team.	Reinforce the importance of gender diversity in computer science program to the rest of the organization by becoming a diversity champion.	Annual process for CS administrators to champion a gender diversity focused initiative.

3). CS administration team to allocate financial and human capital resources to the initiatives supporting the gender diversity in computer science program at TC.	Itemized dollar investment by TC in gender diversity focused initiatives.	Reinforce the importance of gender diversity in computer science program to the rest of the organization by providing budget allocation to prioritized diversity focused initiatives.	Annual budgeting process

The CS administration team needs to promote gender diversity as a critical element leading to the program's academic excellence. Also, by personally leading initiatives that promote gender diversity and by allocating resources to such initiatives, CS administrators signal to the rest of the organization the value being placed on achieving diversity in the computer science program.

Required drivers. Support of critical behaviors in Level 3 is facilitated through the processes or drivers that reinforce, encourage, and monitor espoused performance (Kirkpatrick & Kirkpatrick, 2016a). Table F3 identifies key drivers, their relationship to critical behaviors, and the timing of each driver that facilitate the gender diversity focused initiatives in computer science program.

Table F3

Required Drivers to Support Critical Behaviors

Method(s)	Timing	Critical Behaviors Supported
Reinforcing		
Enable CS administrators to conduct internal information campaign about the academic and social benefits of gender diversity in the computer science program.	Monthly	1, 2
Allow CS administrators to enhance admission policies that extend the pool of candidates being considered for admission	Annually	1, 2
Encouraging		
Support CS administrators' efforts to sponsor and allocate resources to initiatives that reduce the gender gap in computer science programs.	Annually	1, 2, 3
Provide CS administrators with opportunities to engage in diversity focused discussions with educators in other college STEM disciplines where gender parity has been achieved.	Quarterly	1, 3
Monitoring		

Evaluate impact of gender diversity focused initiatives with respect to achieving organizational performance goals	Semiannually	1, 2, 3
Monitor CS administrator's engagement with internal and external stakeholders who advocate for a greater gender diversity in computer science program.	Quarterly	1

Critical behaviors are reinforced by the on-going diversity efforts to promote and support initiatives that reduce the gender gap. Enhancing admission policies to include non-traditional candidates, such as those with little or no programming experience, can also reinforce the importance of having student diversity in the program. Sponsoring and personally leading initiatives to reduce the gender gap in CS could encourage other internal stakeholders to follow. Encouraging meetings with educators from other STEM fields where gender parity has been achieved can incentivize CS faculty and staff to adapt best practices in their professional work. Finally, actively monitoring faculty's involvement and support of the diversity focused initiatives and regularly assessing impact of such initiatives can be a significant contributor to attaining critical behaviors needed to reduce the gender gap in CS program.

Organizational support. Organizational goals of higher education institutions are based on the cultural values and beliefs of that institution (Kezar, 2001). Since diversity is one of the core institutional pillars at TC, college leaders need to provide guidance, support, and resources to the CS program administration team's efforts to reduce the gender gap in computer science. First, institutional leaders need to ensure that diversity and inclusion remain a priority across all disciplines and all programs taught at the school. Gender diversity focused initiatives in the CS program and their success need not only to be acknowledged by the institutional leaders at TC, but also exemplified to other programs in the school. Second, TC leaders need to permit CS

administrators to implement policies and procedures the team feels are important to achieving student diversity in the program. Having confidence in members of the CS administration team empowers them to implement novel and innovative solutions without fear of being censured if any specific gender diversity initiatives fail to produce expected results. Institutional leaders at TC also need to support CS administration's diversity focused efforts by providing resources needed to develop, implement, and evaluate initiatives that reduce the gender gap in CS. Consistently allocating budget to diversity focused initiatives is imperative for such initiatives to succeed.

Level 2: Learning

Learning goals. All learning goals need to be clear, specific, and relevant to the organizational objectives (Clark & Estes, 2008). To be effective these goals also need to facilitate development of the critical behaviors of Level 3 (Kirkpatrick & Kirkpatrick, 2016a). By implementing the recommended solutions discussed earlier, CS administrators at TC will continue to pursue the following learning goals that have contributed to the program's success in reducing the gender gap in computer science:

1. Recognize the social and cultural factors that contribute to the gender gap in computer science programs (Declarative)
2. Learn how to develop a plan for implementing diversity focused initiatives that improve gender parity in computer science program (Procedural)
3. Recognize own attitudes and potential biases towards women pursuing degrees in computing science (Metacognitive)
4. Develop confidence in own abilities to develop and implement diversity focused initiatives to reduce the gender gap in computer science program (Self-efficacy)

5. Value the achievement of reducing the gender gap in computer science program (Value)

Program. Computer science administrators at TC need to participate in diversity focused learning program to continue supporting initiatives that reduce the gender gap in computer science program. According to Kezar (2001), continual learning is often needed to sustain organizational changes in higher education institutions. Advancing diversity focused knowledge, skills, and motivational factors of the CS administrators can be accomplished through a combination of formal training and informal learning methods. Formal training includes both online and live sessions focused on improving gender diversity and inclusion in the computer science program. Training, such as effects of implicit biases, already offered at TC is an example of formal training. Informal learning refers to the training where individuals determine the content of interest, resources used for learning, and their time commitment (Kirkpatrick & Kirkpatrick, 2016a). Reading scholarly articles, watching educational videos, and having diversity focused discussions with colleagues and external program stakeholders are just some of the examples of the informal learning. It is expected that informal learning will constitute a significant portion of the diversity focused training incurred by the members of the CS administration team at TC.

Evaluation of the Components of learning. Kirkpatrick and Kirkpatrick (2016a) have identified five elements needed to develop critical behaviors supporting the attainment of the organizational goals. These are knowledge, skills, attitude, confidence, and commitment. Table F4 identifies recommended evaluation method for each of these components of learning.

Table F4

Evaluation of the Components of Learning for the Program.

Method(s) or Activity(ies)	Timing
Declarative Knowledge "I know it."	
Group discussions focusing on social and cultural factors contributing to the gender gap in computer science programs.	During diversity training (Formative) During management meetings (Summative)
Procedural Knowledge "I can do it right now."	
Structure social environment to provide support for students with no prior programming experience.	During Undergraduate Review Committee During management meetings
Attitude "I believe this is worthwhile."	
Group discussions on the importance the external stakeholders place on achieving the gender parity in computer science education	During diversity training (Formative) During management meetings (Summative)

Confidence "I think I can do it on the job."	
Group discussions highlighting school's diversity focused initiatives contributing to recent success in attracting and graduating female students without sacrificing academic rigor in the program.	During management meetings
Discussions with educators from other STEM disciplines where gender parity has been achieved.	Individual ad hoc meetings
Commitment "I will do it on the job."	
Individually developed action plan to champion diversity focused initiatives.	Annual performance review

Level 1: Reaction

Reaction of the participants to the performance improvement program plays a critical role in measuring program effectiveness (Clark & Estes, 2008). According to Kirkpatrick and Kirkpatrick (2016a), there are three components of Level 1 that need to be evaluated. They are the level of engagement by participants, relevance of the material presented to the one's functional role, and the overall level of satisfaction derived by the participants from the performance improvement program. Table F5 below identifies methods used to assess the reaction of CS administrators as well as their level of engagement during the group sessions and individual discussions emphasizing the importance of diversity in computer science education.

Table F5

Components to Measure Reactions to the Program.

Method(s) or Tool(s)	Timing
Engagement	
Training instructor's observations	On-going
Meeting leader's observations	On-going
Relevance	
Diversity training assessment survey	Post training
School's diversity initiatives rating survey	Annual
Customer Satisfaction	
Diversity training assessment survey	Post training
School's diversity initiatives rating survey	Annual

Evaluation Tools

Evaluation tools are a key component of assessing performance of the learning programs. The type of the learning program and the timing of evaluation determine what components of the program can be evaluated and which evaluation tools are appropriate to use (Kirkpatrick & Kirkpatrick, 2016a). For in-class training, surveys focusing on Level 1 (Reaction) and Level 2 (Learning) are typically done immediately following the learning program since impact of Level 3 (Behavior) and Level 4 (Results) takes time to take effect. For informal learning, evaluation tools are typically based on the measurement of the key performance indicators of the organizational effectiveness and are typically reviewed on the semi-annual or annual basis (Kirkpatrick & Kirkpatrick, 2016a).

Immediately following the program implementation. Formal diversity training at TC is strongly advised to all new and current members of the CS faculty and administration. It has been cited by all members of the CS administration participating in this study as an important resource for positively influencing their diversity knowledge and motivational factors. Diversity Training Assessment Survey, similar to the one shown in Figure F1, can be used to evaluate Level 1 as well as Level 2 components of the New Model immediately following the diversity training session.

Figure F1. Diversity Training Assessment Survey

Instructions: Please indicate your level of agreement with the statements listed below.

	Strongly Disagree						Strongly Agree
1. Topics included in this diversity training program were interesting to me.	1	2	3	4	5	6	7
2. Topics focused on the gender gap in computer science were easy for me to follow.	1	2	3	4	5	6	7
3. Topics focused on the gender gap in computer science will help me do my job better.	1	2	3	4	5	6	7
4. After each diversity topic in the program we discussed how to apply what was learned.	1	2	3	4	5	6	7
5. I am committed to applying newly acquired diversity focused knowledge and skills in my current role at TC.	1	2	3	4	5	6	7
6. I feel more confident in being able to lead the diversity focused initiatives at TC.	1	2	3	4	5	6	7
7. I believe this diversity training program will be useful in reducing the gender gap in computer science at TC.	1	2	3	4	5	6	7
8. I would recommend this diversity training program to my colleagues at TC.	1	2	3	4	5	6	7

Delayed for a period after the program implementation. Delayed evaluation is comprised of two separate components, depending on whether the diversity focused training was done in-class

or performed individually on the informal basis. Approximately six weeks after the formal, in-class training is completed, an evaluation survey similar to the one shown in Figure F2 can be distributed to the class participants.

Figure F2. Diversity Training Evaluation Survey

- What did you like most about this diversity training? _____
- What aspects of the diversity training could be improved? _____
- Were topics covered in this training relevant to your work? _____
- How do you hope to change your practice because of this training? _____
- What additional diversity training to help you with your practice would you like to have in the future? _____

Evaluation of Levels 3 and 4 of the New Model, which measures whether the transfer of learning to the participants' professional practice is taking place and organizational outcomes are being attained, is the primary focus of the survey (Kirkpatrick & Kirkpatrick, 2016a).

Informal learning typically lacks formal learning objectives. It takes place over a period of time, and usually occurs unconsciously (Kirkpatrick & Kirkpatrick, 2016a). As such, assessment of the informal learning is to be performed annually, as part of the employee review process. Diversity Initiatives Survey, Figure F3, can be used to evaluate four levels of the informal diversity learning process.

Figure F3. Diversity Initiatives Survey

Do you feel informal learning is an appropriate way to advance one's skills and knowledge needed to lead gender diversity focused initiatives at TC? (Y/N). Please explain.

In the last 12 months, have you used informal learning resources to study topics on gender diversity? (Y/N)

***If no, please select all that apply from the list below:

- Not interested in informal learning methods
- Informal learning does not work for me
- I have no need to study diversity related topics
- I am too busy during work hours to focus on informal learning
- I have not found any diversity focused topics of interest
- Other. Please specify _____

***If yes, from the list below, in order of priority please identify resources that you use to further your diversity and inclusion focused knowledge

- Reading a scholarly article/book
- Watching an educational program/video
- Interacting with other CS administrators at TC
- Interacting with faculty at TC
- Interacting with students at TC
- Interaction with external (non-TC affiliated) stakeholders
- Other. Please specify _____

If applicable, what were some of the major gender diversity related concepts you learned from the informal learning sources in the last 12 months? Please specify.

Based on your informal learning experience, do you feel that you are better prepared to lead initiatives that further reduce the gender gap in computer science at TC? Please explain.

Please list gender diversity focused initiatives at TC or outside activities you have personally been involved with in the last 12 months.

Please specify diversity related topics you intend to learn more about in the upcoming period.

Data Analysis and Reporting

Data analysis and reporting is an important step in guiding educational decision-making (Marsh, 2012). It monitors progress of the performance improvement training programs and supports leadership efforts in attaining organizational goals (Kirkpatrick & Kirkpatrick, 2016a). Internal and external outcomes discussed in Level 4 of the New Model can only be achieved when there is evidence that newly acquired knowledge and motivational factors are contributing to behavioral changes that improve organizational results (Clark & Estes, 2008; Kirkpatrick & Kirkpatrick, 2016a). To measure progress in reducing the gender gap in the computer science program and to assess the effectiveness of the training interventions at TC, a data analysis and reporting approach similar to the Equity Scorecard discussed by Down and Bensimon (2014) can be implemented. The scorecard at TC can be compiled and reviewed on the annual basis during

the budgeting and strategic planning discussions. It would provide a comparison of the number of undergraduate applications to the program, students' progress for each year, and the graduation rates for female and male students. It would also the diversity focused faculty recruiting efforts in the program as well as the summarizes student feedback from the individual and group discussions held throughout the year. This approach would allow CS administrators to focus on the areas that need additional investments. For example, if the number of applications from female candidates is low in comparison to male applicants, additional information session to highlight the program's student diversity could be set up. If there is an increase in female student dropout rate, a comprehensive analysis of the academic and social environment by the members of the TC administration team could be initiated. An example of the management report that would enable TC administrators to measure progress in reducing the gender gap in CS shown in Figure F4.

Figure F4. Diversity Scorecard at TC

Result	2018		2017		% YoY Change		Self-Assessment Score (1 - Need Focus; 2 - Meets Expectations; 3 - Exceeds Expectations
	F	M	F	M	F	M	
Student Academic Progress							
# of CS Program Applicants							
%age of Acceptances							
%age of 1st Yr Students --> 2nd Yr							
1st Year Student dropout rate							
%age of 2nd Yr Students --> 3rd Yr							
2nd Year Student dropout rate							
%age of 3rd Yr Students --> 4th Yr							
3rd Yr Student dropout rate							
# of 4th Yr Students Graduating							
# of 4th Yr Students --> 5th Yr							
Student Feedback							
# of Student Responses Collected							
Increase in Student Satisfaction (Academic							
Increase in Student Satisfaction (Social							
Increase in Student Satisfaction (Faculty							
Faculty Hiring							
Number of Research Faculty Hired							
Number of Teaching Faculty							

Summary

New World Kirkpatrick Model guides implementation and evaluation planning of the study's recommendations. It provides a framework that (a) enables leadership teams to develop programs to address any knowledge and motivational gaps within their organization, (b) ensures critical behaviors needed to achieve organizational goals are sustained, and (c) assesses the effectiveness of the program (Kirkpatrick & Kirkpatrick, 2016a). Level 1 of the New Model evaluates the level of engagement, relevance, and satisfaction and is helpful in developing and enhancing the diversity focused learning programs at TC. Level 2 relies on the KMO type of analysis to identify the knowledge and motivational gaps that need to be addressed to improve the gender balance in computer science program. Critical behaviors of Level 3, when perform consistently, ensure that the gender diversity focused outcomes of the program are achieved. Level 4 lists aspired outcomes and indicates whether the expected results of the diversity focused learning programs have been achieved. Evaluating the return on expectations (ROE) is an important measure of success supported by the New Model. ROE indicates how well the program results match the set expectations and ultimately determine the effectiveness of the learning program. Only those diversity focused initiatives that meet or exceed expected outcomes receive further investment and support from the CS program leaders.