UNIVERSITÉ DE SHERBROOKE

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Comment Encourager Plus de Femmes vers L'Informatique?

Women in Computer Science: How Can We Bring More on Board?

by

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DEDICATION

To my mother, my female role model, you are unconditional love.

My father, your strength and determined will, my motivation to never give up.

My sister, my sunshine, for always believing in me and inspiring me.

My husband, the smartest man I know in IT, for giving me space to grow wings, and

My two angels for their overwhelmingly gratifying love and support. I could not have

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ABSTRACT

Only a small minority of women are drawn to the field of Computer Science (CS). For many years, the ratio of female students at all the Cegeps/colleges in the province of Quebec attending and completing Computer Science programs has been much lower than the number of males. Women experience various challenges during the process of becoming computer scientists. Therefore, greater attention needs to be allocated to research that investigates the gender inequality phenomenon in the CS environment. This study looks at both female and male students who are currently attending a Computer Science program at the Cegep level at LaSalle College in Montreal. The purpose was to identify whether similarities or patterns exist at the social and/or affective levels that lead some female students to choose Computer Science as an academic program. The study also aims to identify the possible social and affective factors that are discouraging female students from registering in Computer Science. Such factors may be influencing their levels of confidence and interest, and consequently steering female students away from pursuing CS as an academic and career choice. Finally, we identify learning strategies that help those who pursue it to succeed in the program. A mixed research method was implemented. A quantitative study used the admissions records of all Cegeps in the province of Quebec, both English and French, in order to analyze and compare the number of applicants who have attended and completed a Computer Science specialization between 2005 and 2016. An exploratory qualitative study was carried out in the form of interviews with a participating sample of twenty-four students (F=12, M=12) currently attending LaSalle College in the field of Computer Science.

Keywords: *Women in Computing, bias, gender stereotypes, culture, career, coding, media, IT role models, diversity, equity* and *gender-gap.*

SUMMARY

Only a small minority of women are drawn to the field of CS. Several factors might be affecting their levels of confidence and interest and consequently steering them away from pursuing CS as an academic and career choice. This study examined the social and the affective factors that lead female students to choose Computer Science (CS) as an academic option at LaSalle College at the Cegep level.

A mixed research method employing quantitative and qualitative approaches was implemented in this study. Five research questions were addressed to measure whether any of the social or affective factors being investigated may have influenced female students' choice to pursue CS as an academic option or helped increase their self-confidence to succeed better in the program. First, we analyzed whether exposure of female students to female role models, leaders or mentors during their early or current studies had an effect. A second question dealt with the effect of negative preconceived misconceptions. Third, we looked into whether early exposure to computers while growing up played a role. Fourth, we looked at whether encouragement and support from their direct surrounding environment had an effect. Finally, a fifth question investigated whether having an interest and positive attitude towards CS resulted in choosing it and consequently increased self-confidence to successfully complete their program of studies.

A quantitative method was used to analyze the CS admissions records for all the Cegeps in the province of Quebec, comparing the number of male to female applicants who have attended and completed their programs for the ten-year period from 2005 to 2016. The results showed that a very small minority of female students attended CS programs across colleges in the province in comparison to a heavily male-populated environment.

A qualitative exploratory approach was implemented through one-on-one interviews with 24 participants (N=24, M=12, F=12) attending LaSalle College CS programs in both the DEC and AEC. The collected and analyzed responses from the interviews were used to answer all the research questions.

For the first question, none of the female participants had exposure to female role models while growing up; only two females indicated that they had male role models. However, this did not deter them from choosing CS. Once they joined the program, having the support and guidance of a mentor or peer became very crucial to stay motivated and learn. The male participants mostly looked up to male figures amongst friends, family, the industry or the media. The similarity here with the female participants is that they agreed that having a mentor is necessary especially in the first semester. Particularly, ongoing peer support is useful for constructing knowledge and sharing experience. Males differed from the females, who preferred female mentors because they felt more supported and understood. These mentors

were needed for both technical and emotional support. Many males still relied more on their male colleagues than their female colleagues for academic support.

For the second question, more than half of the participants, both male and female, had misconceptions that were cleared once they started the program. Therefore, it is apparent that these preconceived notions did not affect their decision to pursue CS.

The third question looked at their prior exposure and experience with computers. Again, we see that the male exposure was higher compared to that of the females. However, this did not deter the women from choosing to study CS. The obstacle for women is that they lack prior hands-on diversified technical knowledge that results in a steeper learning curve in order to get acquainted with many technologies they believe their male colleagues already are comfortable with. This lack of experience affected their self-confidence and often demotivated them. This was not an issue for the majority of the males as they always turned to online resources and peer support to advance their learning.

The fourth question dealt with encouragement and support from their direct surroundings. All the students seem to have made the decision to join CS out of their own will, with or without family support. Yet once enrolled in the program, they needed the understanding, guidance and support from family, peers, teachers and people in the industry. Further, they needed time to explore, experience and work on repeated tasks. Balancing life and school was a big challenge for females and seemed to only be an issue for a few males who have families or work long hours. Female participants felt there was a social and cultural expectation for them to still fulfill their tasks outside schoolwork, which put them at a time disadvantage.

For the fifth question, almost all the participants said that CS was not their first option before pursuing this program. The majority had background interest in math and science that helped develop their love for challenges and problem solving. Both males and females agreed that self-initiated practice and curiosity to learn is key for succeeding. The words "passion" and "interest to persist" in describing their attraction towards IT never came up from the female participants during our conversation. Yet it was a recurring theme for males. Females lacked self-confidence in their abilities even when they did well. That was not an issue for most males.

This research demonstrates that lack of self-confidence, prior background knowledge, sufficient female role models and mentors in addition to family, teacher and peer support during their studies all play a key role for female students in choosing to pursue CS. Further, an interest in math and science, love for problem solving and persistence to handle challenges may have also influenced students' decisions to pursue CS. A set of tested and successful learning strategies were shared including patience, applying one's self through repetitive practice, resourcefulness, and working on hands-on collaborative projects, which all seemed to pave the way for their success. The study includes a set of recommendations to help encourage more females into the CS domain.

RÉSUMÉ

Seule une petite minorité de femmes est attirée par le domaine de l'informatique. Les facteurs étudiés pourraient affecter leur niveau de confiance et d'intérêt et par conséquent les éloigner de choisir cette discipline en tant que cursus académique ou d'entreprendre une carrière professionnelle en informatique. Cette étude examine les facteurs sociaux et affectifs qui amènent les étudiantes à choisir l'informatique comme option académique au Collège LaSalle au niveau du Cégep.

Une méthode de recherche mixte utilisant des approches quantitatives et qualitatives a été mise en œuvre dans cette étude. Cinq pistes de réflexions ou questions ont été explorées pour mesurer si l'un des facteurs sociaux ou affectifs étudiés pouvait avoir influencé le choix des étudiantes à choisir l'informatique en tant qu'option académique ou contribué à augmenter leur confiance en soi pour mieux réussir dans le programme. Dans la première piste, nous avons analysé l'influence de l'exposition préalable des étudiantes au cours de leurs vies ou au cours de leurs études actuelles à des modèles féminins, de leaders ou de mentors sur le choix de l'informatique comme option. La seconde piste portait sur l'effet des préjugés et les idées préconçues sur la place de la femme dans ce secteur d'activité qui est l'informatique. En troisième lieu, nous avons examiné l'impact que pouvait avoir l'exposition précoce aux ordinateurs lors de la croissance alors que la quatrième piste consistait à examiner l'effet des encouragements et du soutien de l'environnement immédiat des femmes concernées. Enfin, une cinquième question a porté sur le fait de savoir si l'intérêt et l'attitude positive que portaient les femmes à l'égard de l'informatique avaient mené au choix de ce domaine et par conséquent, augmenté la confiance en soi pour mener à bien leur programme d'études.

Une méthode quantitative a été utilisée pour analyser les dossiers d'admission des programmes de l'informatique de tous les cégeps de la province de Québec, en comparant le nombre de candidats de sexe masculin qui ont suivi et complété leurs programmes pour les dix années s'étalant de 2005 à 2016. Les résultats montrent qu'une très petite minorité d'étudiantes ont fréquenté les programmes informatiques dans les collèges de la province comparativement à un milieu fortement dominés par les hommes.

Une approche exploratoire qualitative a été mise en œuvre dans le cadre d'une entrevue individuelle menée auprès de 24 participants (N = 24, M = 12, F = 12) participant aux programmes informatiques du Collège LaSalle au niveau du DEC qu'au niveau de l'AEC. Les réponses collectées et analysées à partir de ces entrevues ont permis de répondre à toutes les questions de recherche posées.

En ce qui concerne la première question, la compilation des résultats a montré que la majorité des participantes n'ont pas eu dans leur milieu de vie des modèles féminins ayant étudié ou œuvré dans le domaine de l'informatique alors que deux participantes ont connu des modèles masculins. Cependant, cela ne les a pas empêchés de choisir l'informatique comme choix académique ou professionnel.   Par

ailleurs, l'étude a montré qu'une fois engagées dans le programme et lorsqu'elles reçoivent du soutien et des conseils de la part d'un mentor ou d'un pair, cela devenait un facteur de motivation très important qui les poussait à poursuivre le cursus dans lequel elles étaient engagées.

Les participants masculins quant à eux ont surtout été influencé par des modèles masculins dans leur entourage immédiat famille et amis ainsi que par des icônes du monde industriel et médiatique. Le point commun entre les deux populations est que les participants sont d'accord sur le fait que la présence d'un mentor est nécessaire surtout pendant le premier semestre du parcours scolaire. Ils insistent aussi sur le fait que le soutien par les pairs est très utile pour bâtir des connaissances et partager des expériences. Cependant, les participant masculins différaient de leurs homologues féminins qui ont dit préférer des femmes comme mentors parce qu'elles se sentaient plus soutenues et comprises et donc plus en confiance. Ces mentors étaient nécessaires pour un soutien technique et émotionnel. Beaucoup d'hommes comptaient encore plus sur leurs collègues masculins que sur leurs collègues féminins pour le soutien scolaire.

En ce qui concerne la seconde question, l'étude a révélé que plus de la moitié des participants hommes et femmes, avaient des idées fausses ou préconçues sur l'implication des femmes dans le mode de l'informatique, idées qui ont été rapidement effacées une fois qu'ils ont commencé le programme. Par conséquent, il est évident que ces notions préconçues n'ont pas affecté la décision des participantes de poursuivre dans le domaine de l'informatique.

La troisième question portait sur leur exposition antérieure et leur expérience avec les ordinateurs. Encore une fois, les résultats de l'étude ont montré que l'exposition des hommes aux ordinateurs et au matériel informatique était plus élevée que celle des femmes. Cependant, cela n'a pas dissuadés les femmes de choisir d'étudier en informatique. L'obstacle principal que les femmes ont souligné était le manque de connaissances techniques et de pratique qui se traduisent par un processus d'apprentissage plus ardu afin de se familiariser avec les nombreuses technologies et dont elles croient que leurs collègues masculins sont déjà à l'aise avec. Ce manque d'expérience a affecté leur confiance en soi et les a souvent démotivés, alors que ce n'était pas un problème majeur pour la majorité des hommes qui se référaient très souvent vers les ressources en ligne et le soutien par les pairs pour progresser dans leur apprentissage.

La quatrième question portait sur l'effet de l'encouragement et le soutien de leur entourage immédiat. L'analyse des résultats a montré que tous les étudiants semblent avoir décidé de rejoindre un des programmes informatiques de leur plein gré, avec ou sans le soutien familial. Pourtant, une fois inscrits dans le programme, ils ont révélé qu'ils avaient besoin de la compréhension, des conseils et du soutien des membres de la famille, des camarades de classe, des enseignants et des gens de l'industrie. De plus, ils avaient besoin de plus de temps pour explorer, expérimenter et travailler sur des tâches répétitives. Par ailleurs, trouver un équilibre entre la vie

familiale et l'école représentait un très grand défi pour les femmes alors qu'il semblait en être un pour quelques hommes seulement principalement ceux qui avaient des familles ou qui travaillaient de longues heures. Les participantes estiment qu'il existe toujours une attente sociale et culturelle pour qu'elles continuent à accomplir leurs tâches en dehors du travail scolaire, ce qui représente un désavantage certain pour elles.

En ce qui concerne la cinquième question de la recherche, presque tous les participants ont révélé que l'informatique n'était pas leur première option avant de poursuivre dans ce programme. La majorité des étudiants possédaient un intérêt de base pour les mathématiques et pour les sciences ce qui les a aidés à développer leur amour pour les défis et la résolution de problèmes. Les hommes et les femmes sont d'accord sur le fait que la pratique auto-initiée et la curiosité d'apprendre sont la clé de la réussite. Dans la description de leur passion pour l'informatique, les mots «passion» et «intérêt de persévérer» n'ont jamais été soulevés par les participantes au cours de notre conversation, alors que cela représentait un thème récurrent pour les hommes. Les femmes ont révélé qu'elles manquaient toujours de confiance en elles-mêmes et dans leurs capacités et cela même lorsqu'elles réussissaient bien. Ce qui n'était pas un problème pour la plupart des homes

Cette recherche démontre que le manque de confiance en soi, l'absence de connaissances préalables, le nombres de modèles féminins insuffisant, l'absence de mentors en plus du manque de soutien de la famille, des enseignants et des camarades pendant leurs études sont des facteurs qui jouent tous un rôle clé dans le choix de l'informatique pour les étudiantes. En outre, l'intérêt pour les mathématiques et pour les sciences, l'amour de la résolution de problèmes et la persévérance pour gérer les défis ont peut-être également influencé les décisions des étudiants de poursuivre dans le domaine de l'informatique. Un ensemble de stratégies d'apprentissage éprouvées et réussies ont été partagées, incluant la patience, l'application de soi par la pratique répétitive, la débrouillardise et le travail sur un projet collaboratif pratique, tous combinés semblaient paver la voie à leur succès. L'étude comprend un ensemble de recommandations pour aider à encourager plus de femmes à s'impliquer davantage dans le domaine de l'informatique.

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LIST OF ABBREVIATIONS, INITIALISMS AND ACRONYMS

CS	Computer Science
STEM	Science, Technology, Engineering and Mathematics
CEGEP	Collège d'enseignement général et professionnel
IT	Information Technology
DEC	Diplôme d'études collégiales
AEC	Attestation d d'études collégiales
F	Female
M	Male
NGO	Non Governmental Organization
INT	Innovators iN Technology
WINT	Women Innovators iN Technology

INTRODUCTION

For so long, the lack of female students and faculty presence in the Computer Science department at LaSalle College has been remarkable. The problem is persistent and appears to be universal. According to a group of studies published by Statistics Canada in 2011, results show that female students dominate the percentage of university graduates aged 25 to 34 with a 59 % ratio (Hango, 2013). Yet only 39 % of those female graduates specialize in Engineering, Mathematics or Computer Science, compared to 72 % of male graduates (Hango, 2013). Although for the past few years there has been a general decline in the number of students, both male and female, who are interested in pursuing Computer Science (CS) as an academic choice, more specifically, the industry has witnessed another steep decline in the number of women candidates since the early 2000s (Pearl et al., 2002). Yet the need for Science and Mathematical labour workers due to shortages in these demanding and advancing arenas continue to grow. The Information Technology (IT) industry continues to be male-populated. There are two reasons why the underrepresentation of women in Computer Science is worrisome and alarming. First, it gives the impression that CS creates barriers for women to integrate. Second, recent trends and statistics show a significant decline in males entering college thus leading to an overall decline in people in the field in general (Pearl et al., 2002). Therefore, we need to figure out how we can support the inclusion of females into this industry to fill that shortage in order to achieve balance and diversity.

There are many job positions related to CS or more globally to the field of Information Technology (IT) where we would expect a female presence, yet the reality is that there is a huge lack of it. The misconception that Computer Science is for geeks or people who must be handy with hardware might create a barrier (Clayton, von Hellens & Nielsen, 2009). According to Pau et al. (2011), the term "geek" as defined in the Oxford English Dictionary refers to a knowledgeable and obsessive enthusiast who is socially incompetent. Computer scientists are generally portrayed as male geeks who spend countless hours in front of the machine (Clayton,

von Hellens & Nielsen, 2009). This image does not seem to attract women towards a career in IT, as they are more socially inclined (Markus & Kitayama, 1991). Yet, CS is vast and is not restricted only to coding.

Women view Information Technology as very logical and technically oriented where programming, building computers and setting up hardware devices are the main tasks in the field (Pretorius & de Villers, 2009). In addition to the technical jobs that women can occupy in the field as programmers, network administrators and developers in web, mobile, database, desktop and gaming, there are the more non-technical positions such as digital solutions consultants, business analysts, technical writers, team leaders, and graphic designers.

This current study looks at the possible impeding factors in order to find out whether female students are interested in computers and technology from a young age and whether or not those interests got disrupted or discouraged along the way. It is important to identify whether social surroundings including families, friends, media, IT companies, and educational institutions are taking the necessary steps to welcome and encourage women to pursue an eventual career in Computer Science or they are unintentionally creating barriers instead (Patitsas, 2016). Those issues represent social factors.

Previous research has looked at social factors in the form of misconceptions, media influence, and family support, apprenticeship, assistantship, internships as well as interesting career opportunities yet never investigated all of them in the same study. Similarly, lack of interest, motivation and self-confidence may lead girls and women to steer away from this demanding male-saturated field. These affective factors might play a critical role for a young female student to choose IT as an academic and career option. Theories of educational psychology provide us with supporting evidence that young female students can acquire the necessary knowledge and skills to succeed in the field through mentorship and support, as long as they have interest and motivation (Elprana et al., 2015). Given the existing demand and opportunities, it is worth investigating whether it is a social or an affective problem

that discourages females from pursuing CS. In addition, we need to identify whether there exists a similar profile of a typical female student who chooses IT and whether that profile is different from the male Computer Science student.

Chapter one puts the problem and its influencing factors in context. Then, in chapter two, the purpose of the research is identified and the relevant learning theories are integrated. The third chapter then references previous literature and empirical studies that motivated this thesis. The main social and affective factors are investigated and described along with all their relevant themes and concepts. Chapter four details the research methodology, data collection instruments, and operational variables. Chapter five presents the results and links the purpose of the study with the findings. Finally, chapter six provides a summary, limitations and recommendations towards more positive action to be implemented by academic institutions and the industry as a whole towards building a more inclusive environment.

CHAPTER 1: PROBLEM STATEMENT

The world we live in today is very technologically dependent. Therefore for a society to gain a competitive edge to survive in a global market, it is critical for its economic growth to encourage more graduates in the fields of science and technology. Higher education prepares students for such a career, yet CS is one of the sole science and engineering fields where women represent the least number of graduates when compared to their male counterparts (Palma, 2001). We need to identify the barriers that might be challenging them to choose and complete CS programs.

It is troublesome that there are still ongoing misconceptions about the domain of Computer Science that might turn female students away from the field. Computer scientists in various media outlets (television, movies, internet search and magazine images) are constantly portrayed as male geeks who spend countless hours in front of the machine thus making it an unattractive career option for the majority of the female population (Clayton, von Hellens & Nielsen, 2009).

Due to the misconception about the "nerdy" image and the anti-social labels attached to IT along with the perception that working in the field requires long intensive amount of dedicated hours with machines, research findings suggest that this stereotyped representation seem to conflict with the family plans that many women envision for their future (Clayton, von Hellens & Nielsen, 2009). This misconception is important to investigate as it can play a critical role.

We see a big presence of women in acting, modeling, nursing, teaching and business careers, but there are few positive role models for women in Computer Science, whether in society as leaders and role models, in schools as teachers and scholars, in the classrooms as fellow students or in media and film. Generally, the role-played by the media and its various outlets needs to be investigated to establish whether they have helped promote or clarify misconceptions about female role models and their leadership roles. Therefore, it is worth finding out whether the

female students who have chosen CS have had misconceptions and if so, define what they are and why they have not prohibited them from pursuing the field.

In gaining a better understanding of the gender imbalance, we aim to identify whether prior knowledge and hands-on experience in manipulating hardware and software could have a positive impact towards choosing CS. In addition, we also look at whether early exposure to mentorship, apprenticeship programs, active participation in computer summer camps, or related after-school activities might encourage more female presence in CS.

Research suggests that female students tend to lack self-efficacy when compared to their male colleagues within the Maths, Engineering and Computer Science fields (Palma, 2001). They tend to be shy in class, to not speak out or ask questions, and they make remarks and behave as if their male colleagues are better in programming. We don't know whether there is encouragement and support from parents, faculty and peers towards females to choose Computer Science for academic or professional goals. Some female students are not encouraged; yet make the decision, so here it is worth looking into whether those who do choose CS have a higher level of self-efficacy and determination to pursue this interest. The possible variables that help those who persist and successfully complete their studies are investigated.

In addition, there could be prejudice in academic cultures or in the Information Technology industry that is making women feel unwelcome. Today, only 24 % of the computing work force consists of women and there are predictions that those numbers will continue to drop. We need to look into whether the industry itself, as well as educators and professionals, are making an effort to open doors for these girls to be motivated to pursue a career in Computer Science (Patitsas, 2016). We investigate those issues in order to identify whether or not we would need to design special Computer Science curriculums and classroom environments in order to incorporate and accommodate female students (Jensen et al., 2007). We need to

explore how the current student population (males and females) are succeeding in CS programs with its current implementation.

Therefore, the misconceptions and fears that might prohibit women from making CS an academic choice need to be identified. This might help us identify whether there is a profile of a female student who chooses CS, and whether that profile is different or similar from that of the male Computer Science student. All of these issues and questions are relevant and present a real problem in education. Various social and affective factors seem to play a role, the question is what those factors are and to what extent are they relevant.

CHAPTER 2: CONCEPTUAL FRAMEWORK

Higher education is supposed to prepare students for a career, especially in a technical program. In CS programs, women receive fewer diplomas than men (Pearl et al., 2002). What is special or different about CS that creates this shortage of females when compared to other science-related fields? (Pearl et al., 2002). I have always been curious, as a teacher as well as an IT specialist, about the lack of the female interest and presence in computer and information technology. I aim to identify whether the early social experience of girls in combination with various affective factors plays a role towards making CS their academic choice. Social factors include stereotypes, prior knowledge, exposure to role models, and encouragement. Affective factors include interest, motivation, and determination.

It is worrisome if young female students make future decisions about the IT community based on preconceived misconceptions such as stereotyping, discipline difficulty, gender-related issues and lack of diversity in job options (Penner, 2008). I will be looking to see whether the misconception that people in the field work in isolation creates a barrier for females who are more socially inclined and prefer to learn within a group setting with peer support, mentorship and apprenticeship (Townsend, 1996; Klawe & Leveson, 1995).

Some research suggests that the CS discipline's criteria and demands pose a great challenge in general (Jenkins, 2002). An important factor to consider is their exposure and direct hands-on experience with computers and whether that helped them gain more self-confidence. Computer confidence refers to the level of self-efficacy one possesses in evaluating existing knowledge and aptitude towards computers (Beyer et al., 2003). Women with low computer confidence exhibit adverse behavioural consequences. This may decrease the likelihood that they will choose to major in CS and increase the likelihood that they will drop out of CS. This means that women miss the opportunity to enter into a highly paid field with excellent career advancement potential. Therefore, it is of utmost importance to CS educators, family, friends, peers, school-teachers and the community to help increase

female CS students' computer-related confidence and interest. Female students need encouragement to direct them to internships, teaching or lab assistantships, and other opportunities that can boost their confidence in their skills are crucial (Beyer et al., 2003).

This takes us to the importance of measuring the female students' intrinsic motivation and positive attitude toward choosing CS as an academic choice and persisting in the program towards its completion. They seem to lack motivation, engagement and relatedness to topics ranging from PC troubleshooting to video gaming. Curiosity, self-initiated learning, determination, ambition, love for challenges and not shying from seeking help are skills that are important to succeed in CS. Therefore it is worth investigating whether female students in CS already possess those skills, or support from their peers and teachers helped build them.

Vygotsky's social constructivist theory can help clarify the advantages of social learning towards achieving the learners' success (Powell & Kalina, 2009). The theory outlines that social collaboration and guided instruction helps enhance the learning process. Learners construct knowledge by continuously adapting their logical structures and creating new conceptual models. The role of teachers is to scaffold and facilitate opportunities for deep learning to be attained as students work together, reflect and get feedback to make necessary corrections. Teachers achieve this by constructing activities that require group and peer-based project learning, problem-based learning, and goal-based orientations. Research shows that making connections between Computer Science and its application in the real world helps retain the female student population (Zhang et al., 2007).

Studies as early as 1992 have shown that the inability to connect computer science with the learner's real world leads to students' lack of motivation and interest in pursuing fields of science (Zhang et al., 2007). The self-determination theory can help identify the effect of motivation and interest in augmenting a female student's development of self-confidence and self-efficacy. The theory is based on three human needs: competence, autonomy and relatedness. When the learner feels they have the

capacity and confidence in his/her own abilities, this attributes to promoting their interest in learning, valuing the education they are receiving and consequently resulting in higher quality learning (Deci, Vallerand, Pelletier & Ryan, 1991; Niemic & Ryan, 2009; Ryan & Deci, 2000). This eventually results in personal growth and understanding as the best outcomes manifest themselves while being motivated.

I aimed to identify the social and affective factors that lead female students to choose Computer Science and to successfully complete their programs. The findings from this research study can help guide the development of solutions for a more inclusive environment for everyone in CS.

CHAPTER 3: LITERATURE REVIEW

1. INTRODUCTION

Women are a minority in the Computer Science field in most industrialized countries. Since 1995, data shows that men earned twice as many Math and Computer Science degrees as women in countries such as Canada, Germany, Japan, Spain and the United States, and three times as many as women in Australia, New Zealand, Norway and the UK (Pearl et al., 2002). Women have not been included in the advancement and integration of technology in the social and culture professional areas. The lack of presence of women in information and communication technology reinforces gender stereotyping, which causes younger women to stay away from technological practice and research (Revelles-Benavente, Prieto & Bosch, 2015). Why is their lack of presence a concern? There is a growth in the need for science and mathematical workers due to shortages in those demanding and growing fields. The industry has an urgent need to increase the availability of high quality students who share a diversity of viewpoints, while promoting gender equality to occupy those vacant positions (Cohoon, 2003; Pearl et al., 2002). The Association for Computing Machinery (ACM) committee on Scientific Freedom and Human Rights reported that women experience various challenges during the process of becoming computer scientists (Pearl et al., 2002). Therefore, more attention needs to be allocated to research investigating the gender inequality phenomenon in both the CS academic and professional environment.

Many children use computer-based technologies such as cell phones or video games, but most never end up studying CS formally (Pearl et al., 2002). This problem starts from grade school and goes all the way to university graduate level (Klawe & Leveson, 1995). Most previous research has looked into two main areas, the social and genetic factors, in trying to shed light on this issue. There is considerable international variation in computer scientists' intelligence performance that makes the effect of the social factors more worthy of looking into (Penner, 2008; Revelles-

Benavente, Prieto & Bosch, 2015). The social factors contain indirect and direct aspects that may influence young female students' decision about pursuing Computer Science as an academic choice. In the indirect social aspects, role models, stereotyping, misconceptions, and the media seem to have had the highest impact on women (Penner, 2008). Also, indirectly, academic institutions and their faculty members along with the Information Technology (IT) industry and the way they operate can create barriers. Amongst the direct social aspects, parents, family members, close friends and peers perceptions and behaviours along with individual prior exposure to computers can contribute to the decision-making (Revelles-Benavente, Prieto & Bosch, 2015). The affective domain focuses on girls' self-confidence, interest and attitude and how it affects their perceptions about their readiness and capability to succeed in the IT industry and whether they are capable of pursuing it as a career or not (Revelles-Benavente, Prieto & Bosch, 2015; Cheryan, Plaut & Handron, 2013). Through media, television and advertising, society has promoted misconceptions and stereotypes about the image of a Computer scientist (Pearl et al, 2002).

2. ROLE MODELS

According to a Taulbee Survey, the lack of presence of women in IT is described as pipeline shrinkage where, as women move along the academic pipeline, their presence starts to shrink over time, hence the lack of female faculty in higher education (Pearl et al., 2002). This problem could be attributed to the lack of female role models for women who are in the process of becoming computer scientists. When there are not enough women studying Computer Science, this translates into few women working in the IT industry as well as being readily available in the academic world (Pearl et al., 2002). If there are not enough female faculty members, then guest speakers can come often to encourage students through talks, conferences, workshops and interactions (Pearl et al., 2002).

Role models are very important, even at the pre-college level where high school girls might choose not to do their math and science courses early on, which

will eventually limit their academic choices in sciences and engineering once they reach higher education. The Social Role Theory (SRT) offers a thorough framework on how labour division leads to gender role beliefs and discrimination about gender-specific attributes (Chan and Drasgow, 2015). According to the SRT, we create gender role beliefs through observations of men and women performing their tasks. In turn, Lockwood & Kunda (1997) and Tesser (1986) as cited by Elprana et al. (2015) claim that we compare ourselves to role models who can become a source of inspiration to us. It allows the observer to foresee that they can accomplish tasks; there is hope so they are more motivated to achieve, and expand academic aspirations (Lockwood & Kunda, 1997).

2.1 Use of Media for Role Models

During the 1995 annual SIGSCE meeting coinciding with DePauw's Institute for Girls in Science (DIGS) weekend, a research study was designed to screen two videos that described the lives of two female students attending the Computer Science program (Townsend, 1996). The study included two random groups made up of 12 high school girls each. The experimental group viewed a video and then completed an attitude survey. The control group filled the attitude questionnaire and then viewed the video. The attitude survey included questions about their existing perceptions towards CS and the usefulness of studying it. Results indicated that high school girls showed a statistically significant positive change in their attitudes towards Computer Science after viewing videos of slightly more mature women who appear the same as them (White, Hispanic and/or African-American) and hearing them talk about their success stories. The limitation of the study is that it did not extend to other age groups and women attending college studies. It would be interesting to try to compare the influence of having live interactive interviews with female CS students that capture the personalities and life stories of young women as they relate them to Computer Science, in helping improve the attitude of young girls interest towards CS (Townsend, 1996). We need to clear misconceptions and change the attitude of young grade school girls towards Computer Science so that later when it is time to go to

college, they see CS as a possible choice. Mentors can play a key role in clearing those misconceptions.

3. MENTORSHIP

There is a shortage of mentors who play an effective role for young students who follow this career path. Female Computer Science professionals can serve as mentors for undergraduate women in Computer Science by sharing insights from personal undergraduate experience and experience in a Computer Science career (Howell, 1993). One program that proved successful at both Stanford University and the University of Michigan was pairing female graduate students with female undergraduates (Pearl et al., 2002). The result was an increased level of self-confidence in the undergraduates as the graduates were able to offer guidance, supports and career path advice to the undergraduates through sharing similar experiences and clarifying misconceptions. Through this experience, female graduate students can normalize women working this field as a regular phenomenon. It gives the undergraduates exposure to a female role model who can be a living evidence of success as well.

4. FACULTY ROLE

Jacquelynne Eccles, in her research study, has videotaped the behaviours of many teachers who have claimed they react fairly and justly to female students in class as they do towards boys, but the proof has showed the opposite (Klawe & Leveson, 1995). The tapes document the fact that female students are not encouraged to participate and engage in classroom activities. Professors unconsciously ask men more challenging questions, call them more for answering, as well as remember their names better (Klawe & Leveson, 1995).

The professor's classroom conduct, expectations, and structure of assignments and assessments have a major impact on shaping the culture and experience of the Computer Science student. Sensitivity to the styles, goals, and needs of the female student population could help to shape a more supportive and comfortable learning

environment that encourages more students to succeed (Howell, 1993). Drawing connections between Computer Science and its application in the real world helps retain the female student population (Zhang et al., 2007). Also giving constructive and timely feedback is very important to the female student where they need more objective feedback regarding the type of expectations required from them to succeed. Female students in CS prefer to work on real life projects through contextual learning (Zhang et al., 2013). The support of their teachers and staff can help clear misconceptions, provide encouragement and trigger interest.

5. STEREOTYPING

Name labels such as wizard, hacker and geek are given to those who are knowledgeable about computers. People profile them with certain expected characteristics, ways of talking, and behaviours. The image of a geek and his intimate relationship with the computer is something that discourages women from becoming involved with computing (Beaubouef & Mcdowell, 2008; Pau et al., 2011). This image leads to perceptions of a career in Computer Science as hours spent in front of a computer screen doing programming. In a magazine article, an anonymous computer scientist equated the task of writing a program to bench-pressing 250 pounds, insinuating that only a man can do it. When females trying to choose this career path read such material, it would create fear and barriers of the already unknown (Cohoon, 2003).

Computer Science students in general are stereotyped as being "nerds" and "geeks" with a lack of interpersonal capabilities. This is contradictory with the view of women as being social beings with strong interpersonal skills (Markus & Kitayama, 1991). Social stereotyping discourages girls from pursuing sciences and mathematics; for example, violence in video gaming does not take into account that these types of games do not interest the majority of the female population (Klawe & Leveson, 1995). People draw an image of an unattractive, thin and spectacled male when asked to describe a computer scientist (Mercier et al., 2006). There is a huge misconception that to be a highly skilled programmer, it demands enjoyment in

tampering with hardware and electronics (Cheryan, Plaut & Handron, 2013). "Project Implicit", is a study that took place with approximately 350 000 self-selected participants from 66 nations surveyed online in order to identify the implicit and explicit gender stereotyping that is present about science in society (Nosek et al. 2009). Participants had to rate on a 5 or 7-point scale how they associated science with males or females from strongly male to strongly female. Results showed that from all 66 nations 77 % of the participants believed that sciences are more associated with men than women even in countries where women occupy half of their nation's science majors and specialists. These stereotypes negatively impact women and their achievement in Science, Technology, Engineering and Mathematics (STEM) fields (Miller et al., 2015).

Beyer et al. (2003) present five major misconceptions about the field of CS that can create social barriers. The first misconception is that Computer Science is machine- and technology-oriented rather than people-oriented. That might cause many women to steer away from it as they would perceive it as a male field and be less interested. The second stereotype is that computer scientists are obsessed with the machine and spend endless hours coding to the point of neglecting all other interests. The third stereotype is that computer scientists are socially awkward and lack interpersonal skills. This stereotype, if evident, is more present amongst the male scientists compared to the females. The fourth stereotype is that computer scientists are perceived as genius geeks, nerds or hackers. The issue is that this is how they are constantly portrayed in the media. Both male and female students perceive male students in CS as having higher GPAs than females in the field (Beyer et al., 2003; Cheryan, Plaut & Handron, 2013). Another stereotype is that computer scientists like science fiction and playing video games for leisure (Cheryan, Plaut & Handron, 2013). Stereotyping of women in CS has gone as far as categorizing those amongst them who do succeed as being exceptional (Beyer et al., 2003). The media plays a negative role when they always show computer scientists as young men and as geeks.

5.1 Media Role in Misconceptions

The media has a preference to show men who occupy programming and technical support related jobs as leading lives that revolve around computers. It is an unattractive image for smart females; they choose to avoid it intentionally (Cheryan, Plaut & Handron, 2013; Cohoon, 2003; Penner, 2008). A study examined the stereotypes that undergraduates established about people in Computer Science, and whether the use of the media can clarify people's perception and change women's interest in Computer Science (Cheryan, Plaut & Handron, 2013). In the first study, a sample (N=293) of college students at two U.S. West Coast universities provided their assumptions regarding Computer Science majors. Those descriptions were coded, and the results showed that perceptions of the traits of computer scientists, such as lacking interpersonal skills and focusing solely on computers, are incompatible with the female gender role. In the second study, a sample (N=54) of college students at two U.S. West Coast universities were asked to read fabricated newspaper articles about computer scientists. The articles framed computer scientists either as fitting within the existing stereotypes or no longer fitting these stereotypes. Women who read articles describing computer scientists as unfitting of the currently believed stereotypes expressed more interest in Computer Science than those who read that computer scientists fit those stereotypes. On the other hand, neither article affected men's interest in Computer Science. These studies suggest that stereotypes of academic fields influence women's decision to participate. Media must play a more constructive role in helping recruit more women into Computer Science and change how computer scientists are represented (Cheryan, Plaut & Handron, 2013; Revelles-Benavente, Prieto & Bosch, 2015).

The media's representation through its various outlets, including broadcasting (television, film), internet (websites, blogs), and print media (newspapers and magazines), influences people's perception of a given social group, depending on whether it is presented in a positive or negative way. For example, undergraduate women who watched gender-stereotypical advertisements where women focused   on

their physical appearance later did not display interest in technical careers (Davies et al. 2002). In another study, women who watched biographies done about female engineers expressed a more positive attitude towards math compared to those who saw biographies about male engineers (Stout et al., 2011). The popular Big Bang Theory comedy show, currently in its eleventh season, further strengthens those stereotypes about computer scientists and engineers. The show has two lead female characters as scientists. They are portrayed in a very geeky fashion and are socially awkward. This can have a negative effect knowing that a majority of young males and females draw conclusions about what scientists are like based on television, movies, and magazines representations. A few networks started campaigns to change those perceptions with shows like SciGirls. Other efforts by the industry include launching their own campaigns through online projects that promote technology and make it more accessible to young females such as The Dot Diva project and Picture Me in Computing. The goal of these sorts of projects is to present a more fun and dynamic image of girls in IT (Cheryan, Plaut & Handron, 2013). Although those little seeds of change have been planted, female students need role models in their day-to-day life to counteract the stereotypes from media representation.

6. EXISTING CULTURE OF THE IT COMMUNITY

A community should reflect the image it likes to portray. There is a lack of female presence in places like technical boards, technical journals, Computer Science program committees, technical conferences and guest speakers (Pearl et al., 2002). It should be noted that some of this discrimination is not intentional; nonetheless it exists, and it creates a barrier to the new comers. The misconception that programming requires endless hours of programming may not appeal to many women and men alike. When women don't have a clear idea about what programming or CS is as a discipline, and with no encouragement from someone with technical expertise, they will perceive it as being difficult and steer away from it. Students need to get the message that a career in Computer Science is more than just programming.

Women need to hear the message just as strongly as men concerning the importance of understanding how to use and control computing technology (Howell, 1993).

It has been documented over the years that many women experience alienation when they are asked to establish a relationship with the computer (Clayton, von Hellens & Nielsen, 2009). The reason is that women are raised to approach relationships in a negotiating style, emphasizing the importance of conversational communication and valuing the ambiguity of human relationships (Howell, 1993). Men, on the other hand, are raised to value abstraction, imposition of will, clarity, and risk taking — the perspective and approach rewarded by the vast majority of experiences in Computer Science education (Howell, 1993).

7. EXPOSURE TO TECHNOLOGY/PREVIOUS EXPERIENCE

It is noticed that early on in their lives, boys prefer using computers and attending summer camps that are technology-related over girls (Pearl et al., 2002). For many boys, exposure to computers comes simply through playing individual and online games. This early exposure provides boys with prior knowledge and experience that gives them a head start compared to girls (Khan & Luxton-Reilly, 2016; Hamilton et al., 2016). Even the computer games that target adults identify more with the male culture (Pearl et al., 2002). Most computer games have principle and common themes of war, battles, crimes, destruction, and traditionally male-oriented sports and hobbies (Klawe & Leveson, 1995). They are made to appeal more to males than females. Boys also play more video games and for longer periods than girls (Papastergiou, 2009; Cheryan, Plaut & Handron, 2013). Boys make faster progress in performance at different levels in game playing. More boys than girls concentrate on completing the game, developing strategies to share information, and successfully recognizing the embedded mathematics (Papastergiou, 2009). Yet, when using games for learning purposes, the learning gains achieved at the end for both boys and girls were not different. So, gender does not influence the learning effectiveness and motivation through using the game (Papastergiou, 2009). This shows that it is not the girls' aptitude that is the problem but rather it is social

indicators that are sending the wrong messages. Women have limited experience with computers compared to men, which can cause them fear and anxiety (Pretorius & de Villers, 2009; Hamilton et al., 2016). Men are much more likely than women to have self-initiated interactions with technology prior to college experience with computers (Howell, 1993).

Computing does not represent the mere act of using computers for word-processing, web browsing or social media interaction. The term computing refers to using technology (hardware and software) in order to assemble or disassemble computer parts, troubleshoot hardware or software, and write programs. More opportunities must be provided for women to have positive experiences with computing. These valuable positive experiences help women succeed in undergraduate Computer Science courses. Women need to have opportunities to be involved with computing in settings and contexts that are currently not available to them. In addition, this involvement feeds into the opportunity of improving their perceived self-efficacy and comfort level with computers (Howell, 1993). The pre-college exposure to Computer Science is a very important factor for success of student candidates in CS (Cohoon, 2003; Klawe & Leveson, 1995; Townsend, 1996). There are many recent efforts in Canada to encourage young girls to code through funded programs such as Technovation, girlswhocode, Canadian Women in Technology and so forth. The participation is still low, and the programs efforts are not well networked. Therefore for a female student to pursue CS, would extra efforts through family encouragement make a difference?

8. FAMILIES, PARENTS AND TEACHERS SUPPORT

Parents play a key role in encouraging their daughters and boosting their self-confidence (Klawe & Leveson, 1995; Khan & Luxton-Reilly, 2016; Pretorius & de Villers, 2009). Parents seem to provide their sons, more than their daughters, with opportunities to better their computer skills with exposure to PCs at home or in camps (Cohoon, 2003). Jacquelynne Eccles at the University of Colorado has published multiple studies showing how the student, teacher and parental attitudes   can

discourage girls from pursuing science and math even though their grades might be better than their male counterparts (Klawe & Leveson, 1995). In classrooms, female students were not called on to answer questions, they were not encouraged to participate in class or engage in discussions and they were not expected to be able to answer hard questions. What matters most is encouragement, not whether this encouragement was from someone with technical expertise. This is particularly important given that young women are half as likely as young men to receive that encouragement (in any form). Therefore, parents and family members play a key role in encouraging their daughters to pursue Computer Science and experiment with the use of technology from an early age. The responsibility is not solely on the parents; one of the most-used coping strategies by students for surviving CS is peer support. Success in Computer Science is not dependent on an individualistic competitive style of learning or through a highly structured approach to programming. Professors within the IT culture need to recognize that students differ in their approaches to studying CS (Howell, 1993). Therefore, faculty members in educational institutions have an important influence on the culture of Computer Science education and must take those differences into consideration (Howell, 1993). The pre-existing knowledge and experience that female students possess prior to college education needs to be taken into consideration.

9. PEER SUPPORT

A focus group including 178 undergraduates in 16 CS departments found that asking a classmate for help was essential to success (Cohoon, 2003; Rheingans et al., 2011). The study offered two recommendations. First, enrol enough same-sex students who can offer peer support, and second, have supportive faculty to guide and encourage female students to persist in their studies (Cohoon, 2003). Peer support is still relied on more than faculty's aid (Cohoon, 2003). When female students are already a minority in CS programs, the peer support they will get will most likely be from male students. Mostly, women are comfortable reaching out to another woman, as they do not want to appear less knowledgeable in front of a male colleague

(Cohoon, 2003; Pearl et al., 2002). Some females report that they are afraid that their inquiry for help might insinuate to a male colleague that they are interested in him, and they decide to therefore avoid asking all together. Here it is worth mentioning that peer support could be beneficial for both men and women, as the respect they get from their peers helps in creating positive satisfaction with their educational experience. On the other hand, there have been no documented studies that evaluate men's performance in relation to their surrounding climate and their interactions with other males or females as role models (Rheingans et al., 2011). The challenge to this solution is the absence of female faculty to start with. What are the factors, content, and contexts of undergraduate Computer Science education that influence women's decisions to choose and persist (or not persist) in completing a Computer Science major (Howell, 1993)?

10. INTEREST

Even during those times when the demand for women in Computer Science is skyrocketing, there still is a very small number of women who are interested in studying it (Cohoon, 2003). Women's experiences vary culturally from country to country, so it is valid to investigate the reasons why women in general don't give Computer Science first preference (Cohoon, 2003). Motivation, interest and persistence seem to play a role (Howell, 1993; Pearl et al., 2002; Chan and Drasgow, 2015). Elprana et al. (2015) discuss that in order to improve gender equality, and create interest for females in gender-stereotyped roles, we need to implement three strategies (Elprana et al., 2015). The first strategy, permission and support for integration, allows for clarification of gender-based stereotypes that are causing discrimination and creating obstacles for females in certain roles. The second strategy, increasing the can-do factors, means equipping and empowering females with better education and skills. The final strategy is increasing their want-to factors by focusing on motivation through encouraging persistence and effort for goal achievement.

Motivation is enhanced through positive emotions that are linked to leadership. Self-enhancement and confidence transcend to a positive feeling of pride and well being that eventually decreases negative cognitions and feelings of insecurity (Elprana et al., 2015; Revelles-Benavente, Prieto & Bosch, 2015). The factors that can create interest in females towards CS need to be investigated. Same-sex role models are especially influential in empowering attitudes, and raising interest and self-confidence since, for example, a female role model reduces the anxiety brought from negative female stereotyping (Marx & Roman, 2002). An effort must be put forward to increase awareness about gender inequality, especially for young women thinking about how their career fits within their future family plans (Elprana et al., 2015).

The technological culture is built around a male-dominant model where intense working days and full availability are making time management more difficult for women who are looking to reconcile family and work (Revelles-Benavente, Prieto & Bosch, 2015). Computer Science is a very demanding field. It relies on technology that is constantly changing and evolving. Anyone looking to pursue this field, as an academic choice, needs to dedicate time and effort to constantly balance the demand for updating their knowledge along with hectic working hours. This might conflict with seeking to start a family. CS requires time and energy. This fact might create a barrier of fear for those with other interests outside the scope of computers as they might think the two issues would conflict together. This struggle might be challenging for both men and women. Here cultural and social expectations play a factor to the extent of responsibilities women have towards their families. The helpmate-in-the-background model explains how many males who have successfully created a prosperous career for themselves in IT, have done so with the support of their wives and partners, "the helpmate" (Pearl et al., 2002). We can argue the same holds true for women as well. Yet women, for the longest time, were viewed as helpmates, but do they have helpmates of their own to help support them during the process of studying CS? In their preparation for college

and university education, women tend to question their ability to do things and the types of strategies to apply in order to succeed (Pearl et al., 2002).

11. SELF-EFFICACY AND CONFIDENCE

Research suggests that women in CS generally have less confidence than men (Cheryan, Plaut & Handron, 2013). Compared to men, women have different perceptions about college and university training. They also have a harder time dealing with criticism. They feel less comfortable speaking up in class and a high percentage of them fear intimidation and looking stupid saying the wrong thing when either asking questions in class or simply participating in discussions (Klawe & Leveson, 1995). A study that followed 80 high school valedictorians in Illinois (46 women and 34 men) through their college years noted that as women advanced in their college years, their self-confidence decreased dramatically compared to the men whose overall self-confidence increased (Pearl et al., 2002; Klawe & Leveson, 1995). Self-esteem can be a factor deciding the kind of academic choice that a woman makes; she might not feel like pursuing a career that she does not feel adequately qualified for (Pearl et al., 2002). A study following doctoral students showed that even when both the male and female students had similar achievement scores in their studies, the female students felt less comfortable, less confident, and less successful than their fellow male colleagues (Pearl et al., 2002). In addition, both men and women in CS believe that the males' GPA is higher than the females', a presumption that is not always true (Beyer et al., 2003; Cheryan, Plaut & Handron, 2013).

Treating women like they are less qualified or committed than men is considered gender discrimination. It can take place consciously or unconsciously by male students or faculty members. The impact can cause female students to switch majors, hence damaging their self-confidence and their academic choices. A number of studies found males to be more confident than females in personal abilities (Lips & Temple, 1990; Miura, 1987). The lack of confidence then becomes a significant factor in the decision-making of many women as to whether or not to persist with a Computer Science major (Beyer et al., 2003; Elprana et al., 2015; Lips & Temple,

1990; Hamilton et al., 2016; Pau et al., 2011). Other studies also show that men tend to have a stronger sense of self-efficacy in dealing with computers and computer programming than women (Miura, 1987; Hamilton et al., 2016). Albert Bandura (1994) defines self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives". Comfort and feelings of self-efficacy are found to be important factors in women's decisions to study computing (Howell, 1993; Lips & Temple, 1990; Bernstein, 1991). Women tend to develop comfort with computers through positive experiences (Bernstein, 1991). When faced with failure, women tend to blame a lack of ability, while men blame poor teaching or difficult material (Ware, Steckler & Leserman, 1985). Are the female students resourceful and equipped with proper learning strategies to succeed in CS?

12. SUCCESSFUL LEARNING STRATEGIES

Computer Science students need to be equipped with lifelong knowledge and transferable skills, as they need to constantly adapt to advancing and changing technologies (De Raadt et al., 2004). Common emerging themes from various literature emphasizes how constructivism, cognitive development, problem-based and situated learning all play an effective role in knowledge construction for computer scientists as they move from being novice learners to experts in the field. The role of teachers here is crucial for scaffolding, mentoring and modeling. Teachers must present and explain to their students, in an active learning environment, step-by-step logical models to follow. They need to provide them with repetitive hands-on application and practice situations where those schemas get reinforced, tested and adapted to help them move from being novice programmers to becoming experts in the field (Ben-Ari, 1998; De Raadt et al., 2004; Machanick, 2007). There is no evidence that prior mathematical ability and aptitude in problem-solving lead to better programming skills (Jenkins, 2002). In addition, Jenkins (2002) argues that there is no demographic factor affecting the ability of a learner to learn problem-solving skills, which means that problem solving for building better programmers can be

taught. Problem solving is also used for resolving technical problems and issues. Students might already have a logical model for dealing with technical difficulties or writing programming languages. This depends on their background experience with computers. The existing model or schema might be either a viable or a faulty one that they build on. Therefore, it is the teacher's role to make sure that students start with an effective cognitive schema in order to construct new mental learning models to apply when coding and problem solving (Ben-Ari, 1998).

Piaget's constructivism is viewed as the most popular educational theoretical approach in Computer Science (Machanick, 2007). The theory claims that students construct knowledge through active participation where they build on knowledge they already have. Because of that, each student might build their own version of this knowledge including misconceptions (Ben-Ari, 1998). Therefore the student must learn in an active environment where they construct knowledge through direction and guidance from an expert source, such as a teacher, with feedback and assistance from a peer. So, students in CS cannot construct knowledge in isolation; hence cognitive apprenticeship and mentorship are very effective where learners are able to construct knowledge through collaboration and feedback (Bareiss & Radley, 2010; Ben-Ari, 1998; Machanick, 2007). Teachers need to construct teaching/learning activities that would help students attain a strong cognitive foundation for problem solving through hands-on practice with concrete real-life exercises (Alharbi, 2011; Ben-Ari, 1998; De Raadt et al., 2004; Jenkins, 2002). To do that, teachers need to learn more about their students' incoming knowledge, to link and draw connections between various models of abstract concepts, to offer guidance to students by addressing their misunderstandings, and to allow students to reflect on and evaluate their own work with feedback through social interaction. When students develop interest towards what they are learning, and they like it, they are willing to invest time to improve their knowledge of it (Jenkins, 2002). It seems that the implementation of a more integrative learning environment where female students get support from their teachers and peers, to help them with lack of self-confidence to get over challenges

and develop a more professional sense of self-efficacy is very crucial towards their success in CS (Tan et al., 2016).

13. REQUIRED ACTION

For more than twenty years, various efforts have been put into place to increase the gender equity in universities and colleges around the world to support the integration of more female students in Computer Science (Hamilton et al., 2016). It started back as early as December of 1989, where various governmental and industrial programs created the National Task Force for women and minorities to train them in sciences, engineering and technology (Pearl et al., 2002). Yet all those efforts still seem to not be enough. Some programs have had success integrating more female students yet others are still struggling (Hamilton et al., 2016; Guthrie, Yakura & Soe, 2011). Programs that have integrated an interdisciplinary approach to Computer Science seem to be more successful (Guthrie, Yakura & Soe, 2011). It allows female students to connect their social values and interests with the use of technology (Guthrie, Yakura & Soe, 2011; Hamilton et al., 2016). All the efforts and their impact are still not visible enough, as the number of female computer scientists is still not witnessing a significant increase (Hamilton et al., 2016). Therefore, much more still needs to be done.

14. CONCLUSION

The absence of female faculty in CS leads to a lack of role models for future female students (Pearl et al., 2002). Faculty support is very important, especially from those who are willing to mentor, encourage, and integrate female students to overcome their challenges (Cohoon, 2003).

Various research studies have shown that factors such as stereotyping, lack of early exposure and access to technology, along with flawed preconceived perceptions prior to college Computer Science curriculum can discourage young female students from entering CS programs (Cohoon, 2003; Cheryan, Plaut & Handron, 2013;

Howell, 1993; Klawe & Leveson, 1995; Penner, 2008). Low self-confidence is another major reason why women are not attracted to pursue CS (Beyer et al., 2003).

14.1 Current Research Study

A mixed quantitative and qualitative research was designed to describe how the above-discussed factors that shape the culture of Computer Science have influenced the individual students' responses. The research included the experience of both male and female students. The study aimed to investigate how the major social and affective factors have impacted the decision of young female students, with diverse backgrounds and experiences, to pursue Computer Science as an academic choice.

CHAPTER 4: RESEARCH METHODOLOGY

In this chapter I describe the research questions and the research methods, including the participants' sample utilized, implemented instruments, procedures, data collection and analysis in addition to ethical considerations.

1. RESEARCH QUESTIONS

The following question was the main research aim, which will then be examined by addressing five research questions below:

What are the social and affective factors that lead young female students to choose Computer Science as an academic option?

➢ RQ1: Does exposure to a female role model, leader or mentor who young female students can relate to in the field (IV1) influence decisions to pursue Computer Science as an academic choice (DV1) and consequently complete the program (DV2)?
IV1: Female role models can come in any of the following forms:

- In school: as a teacher or faculty
- In the media: TV shows, movies, magazines, newspapers, TV, and the industry
- In the family: parent, relative or close friend

➢ RQ2: Do preconceived misconceptions about the IT community (IV2) influence young female students to choose Computer Science as an academic option (DV1)?
IV2: Preconceived misconceptions. Those misconceptions include:

- Stereotyping: in schools, society, media outlets, magazines, TV shows, and movies,
- IT viewed as a difficult career
- IT is a male-oriented field
- Pre-established ideas about the job description (IT involves only coding and lack of diversity of jobs in its community)

➢ RQ3: Does the female student's exposure and direct experience with computers (Personal Computers including Laptops) while growing up (IV3)

encourage her to choose Computer Science as an academic path (DV1), and to gain more self-confidence (DV3)?

IV3: exposure and experience with computers growing up can come in the form of:

- Hardware: installing, fixing or using machines
- Software: installing and using various applications and operating systems
- Gaming: PC or console game playing and the types of games they play.

➢ RQ4: Does encouragement and support from their family and teachers (IV4) influence young female students decision to pursue Computer Science as an academic option (DV1), and gaining more self-confidence (DV3)?

IV4: encouragement and support can come from: parents, family, teachers, faculty or peers.

➢ RQ5: Does the possession of intrinsic motivation in young female students (IV5) and inclination/positive attitude (IV6) towards CS play a role in choosing Computer Science as an academic path (DV1), helping them complete the program (DV2), and gaining more self-confidence (DV3)?

IV5: Intrinsic motivation:

- Intrinsic Interest in CS
- First program of choice
- Self-initiated learners for IT related material
- Eager and curious to learn

IV6: Inclination / positive attitude toward CS:

- Persistent (not to give up)
- Focused and ambitious
- Look for solutions (including asking for help)
- Love the challenge

2. RESEARCH DESIGN

A mixed research method that integrates qualitative and quantitative research design methods was implemented. Although the admission rates were examined for

all Colleges in Quebec, a more specific analysis on a sample from one college, LaSalle College was used for the interviews. For the quantitative component, ten years' worth of admissions records dating from 2006 to 2015 were analyzed. The goal was to determine and compare the number of admitted, attending and graduating students (males versus females) in the DEC (3-year) programs in Computer Science including programming and/or networking specializations across all colleges in the province of Quebec. The instruments used here were the admissions files provided by the Dean's office at LaSalle College.

The qualitative component of the study was exploratory. The instrumentation involved a single one-on-one interview process with both open and closed ended questions. The purpose of the interview was to survey both female and male students who are currently in the program. Utilizing interviews for data collection was effective for this sort of research as it provided a valid and reliable way to gain a better understanding of the participants' ideas, past experiences, personal qualities, present experiences and existing challenges in Computer Science.

The interview process also allowed the participants to ask questions when unclear. They were able to provide longer answers than was possible through a survey. It was an authentic way to find out about their opinions (Alshenqeeti, 2014). The interview method allowed the researcher to make discoveries and understand issues from the participants' point of view by using their ideas (Alshenqeeti, 2014). It allowed me to collect in-depth information and go beyond a single word answer. It was held more as a conversation/dialogue where at times I asked them to elaborate on their answers. The interview questions were the same for all participants with the exception of open-ended questions that sometimes led to other questions to understand the participant ideas.

The sample size included a total of 24 students. Given that my population is small, the motivation and purpose behind the interview was to identify whether there exist patterns of similarities or differences in perceptions and experiences.

3. PARTICIPANTS

LaSalle College's Computer Science department is heavily populated with international students majoring in one of three specializations, Programming, Networking or Gaming. Gaming was just added this past year 2017-2018 where at the time of the research we had our first cohort with first semester students. No students from this program had agreed to participate in this research. Hence the majority of participants come from the DEC with a small proportion from the AEC programs. In addition, the department is heavily populated with male presence both at the student as well as faculty levels.

The College dean's office has access to the admission records of all colleges in Quebec. I was given access to the admissions records dating from 2006 to 2015, as approved by the Ethics committee of LaSalle College in 2017. Those records were compared and analyzed in order to identify the number of female and male students who have attended and completed various specializations in the field of Computer Science in both the English and French sectors in the province of Quebec as a whole and at LaSalle College particularly. This comprised the quantitative analysis performed during this research project.

The target population for the qualitative part of the study was female and male students who were attending LaSalle College in Montreal, Quebec in the field of Computer Science at the time of the data collection. The sample size included a total of 24 students (N=24; F=12 and M=12). Information about their backgrounds, interest in IT, the kind of cultural and social factors that they were surrounded with while growing up, as well as their perceptions of IT as a future career were investigated. The questions revolved around their demographics, social status, background, attitudes, personalities, habits, family background, academic choices, math aptitude, technology usage, prior computer experience, as well as assumed similarities and differences. Both closed-ended (yes/no) as well as open-ended questions were asked during the interview. In December of 2017 through January 2018, the 24 students were interviewed. Twenty-two students belonged to the DEC

(3-year diploma) out of which twenty specialized in Programming and two in networking. Two participants were attending the AEC (1-year) intensive specialization certification in Programming. I use the term CS to refer all the students regardless of program specialization or length. Twenty-two students (83 %) of the participants (M=10, F=10) were from the DEC programming, two (8 %) were DEC networking (M=1, F=1) and two (8 %) were AEC programming (M=1, F=1). From the 83 % DEC programming students, 50 % (M=4, F=8) were senior students in the last year of their studies, 21 % in their second year (M=5, F=0) and 17 % first year (M=1, F=2). In the DEC networking there was one female participant from first year and one senior male participant. As for the AEC there were only students from the programming specialization, both seniors (M=1, F=1). Emails were sent to students from both cohorts in Programming and Networking in years 1, 2 and 3 encouraging them to participate. Some teachers were asked to encourage their students' participation. All in all, the final respondents were the only students who expressed interest in participating, so this was a voluntary sample.

Having students from the first, second and third year cohorts allowed me to see if there were differences in their opinions in term of struggles and perceptions, as well as whether they had similar struggles and views on what it is like to specialize in CS.

4. INSTRUMENTS

There were two instruments used in this research study, the registrar's reports for all Cegeps, and the interviews.

The purpose of the registrar's reports was to compare the female to the male ratio for students pursuing CS. LaSalle College provided me with four reports containing data that helped me identify:

- The number of male and female applicants in CS in all Cegeps in Quebec
- The number of males and females registered per Computer Science program per semester in both the English and French sectors

- The number of students (M and F) who have graduated
- The number of students (M and F) who have quit or failed the program

The interviews were audio recorded and notes were taken. It was crucial as it helped assure understanding of meanings, for themes creation and authentic use of the data. It was preferred not to use video recordings as they might cause distractions. The voice recorder can more easily be forgotten during the interview. Interviews took place on LaSalle College's campus privately where the time ranged from 20 minutes to 45 minutes. Students were informed of the purpose, goal and procedure to follow for the study. Their right to anonymity was respected and hence, pseudonyms were assigned to reference all participants once I started the transcribing process. All recordings were saved with titles using those pseudonyms. My data analysis was conducted using the pseudonyms as well. I used male and female superhero names by taking the first initial from a student's name and assigning a corresponding hero name. The interview findings were coded in order to determine commonalities and variations. The coding process is later described. Please refer to Appendix 4 for a sample of the questions that were asked during the interview.

5. PROCEDURES

5.1 Quantitative Research

I was provided four pdf files for the admissions records of students majoring in Computer Science in the DEC program all across the province of Quebec in both the English and French sectors. The data was separated by gender. Given that the files were in pdf format, I had to transfer all the data to a separate Excel spreadsheet. The data contained numbers related to students attending and completing their studies in all the colleges of Quebec and compared them to those of LaSalle College.

5.2 Qualitative Research

I sent an email to both male and female students in both programming and networking fields from first, second and third year English cohorts inviting them to participate in the study. The consent form was then emailed to students who expressed interest in participating. They were able to read the forms to gain a better understanding of their rights. They were then required to sign a hard copy of the consent form upon presenting for the actual interview. I clarified that they were permitted to withdraw at any time. None of the participants withdrew from the study. The interviews took place in a reserved teacher-student room at LaSalle College. All participants seemed to be comfortable to share their points of view and answer the questions. They were all curious about the results as they find this an intriguing topic that hits close to home. This research received ethical approval from the Université de Sherbrooke Ethics Board.

Given that the majority of the participants were international students with a high variability in accents and expressions, I personally performed the transcription manually using MS Word. In addition, due to the fact that interviews were semi-structured, it resulted in a lot of data to be transcribed. The transcribed interviews left me with 35 relevant pages of themes and ideas to decode to identify common as well as unexpected themes. I created two Excel spreadsheets. The first, called "Research statistics" contained all my Excel sheet tabs. Each tab represented a sheet per question so in total I ended up with nineteen sheets. One extra sheet belonged to the statistics from the admission records data and analysis. The second spreadsheet, called "Research Results Tables", was created to have the results of the analysis and the presented tables. The data was organized using pseudonyms with their corresponding genders and then coded and linked to other components. Every sheet in the "Research Statistics" spreadsheet had corresponding columns for the pseudonyms, participant gender and their related answer for a given question. Every sentence in the participant's answer was given a number so the answers were presented in a cell in list format under the row dedicated for the participant's

contribution. Then I went back to my research questions and linked the interview questions that were related to the corresponding RQ.

6.   DATA COLLECTION & ANALYSIS

I conducted a comprehensive data analysis method where I analyzed the content from both instruments and tried to form relations and patterns of behaviour. In doing the qualitative analysis, I went through every question and started breaking down the participants' phrases and their recurrence across the different answers to identify themes. Participants' responses were verified through the audio recording. After identifying common themes and ideas, I highlighted related quotes that reinforce those themes. I first analyzed all the closed-ended questions to organize results categorized by gender. Then based on a research question, starting with RQ1, I started analyzing all the related questions to that RQ and writing up my findings in a Word document that I called "Research Writing". I categorized all my results by RQ and the analyzed answers to the questions related to it.

The data analysis was truly the most time-consuming part, and finding common themes and categorizing them was the most challenging. Several themes repeated across different research questions on issues such as prior exposure, knowledge construction, challenges and learning strategies. It should be noted that participants were more authentic and comfortable in answering the questions as the interview progressed. For example, at the beginning of the interview for a close-ended (yes/no) questions, a female participant would say that she does not find the specialization difficult yet later on, in an open-ended question about dealing with program difficulties, she would express how she struggled often with understanding concepts right away and applying them. It is possible that in some cases, the language barrier in understanding the scope of the questions or a fear of being judged may have influenced some responses.

7. ETHICAL CONSIDERATIONS

The participants clearly understood the purpose of the study and the importance of their contribution. They were informed of how the results would be used and stored. They were assured that the information would be treated with confidentiality.

At the beginning of the interview, participants were asked to sign a voluntary informed consent –a copy is attached in Appendix 1- to which they understood and agreed to participate willingly to take part of the research. The participants received the form to look at prior to the interview. The approval from the Ethics Board Committee of LaSalle College is included in Appendix 2. Also, the approval from the Ethics Board of the Université de Sherbrooke is included in Appendix 3.

All female and male students were included with no prejudice. Any participant who would have wished to withdraw from the study would have their request treated with professionalism and respect with compliance and no need for explanation or justification for their withdrawal. Participants were not led on to make certain conclusions or draw certain connections. If a student chose to drop from the study, they would have been replaced with someone of the same gender.

There are no sponsors for the project. There were no risks or benefits involved other than the risks of daily living and attending the college on a daily basis. The participants were free to withdraw at any time. They were assured that their acceptance and/or refusal to take part of the study would not affect their treatment in any of their classes and they would continue to receive high quality education. The information they provide was not shared either with colleagues or teachers internally or externally.

The interview audio recordings took place in digital format and were saved on an external hard drive that will be stored in a locked cabinet on LaSalle college's grounds in the Dean's assistant's office for five years after which it will be destroyed and disposed of. The hard drive was encrypted with password access. All written

notes taken during the interview will be stored in the same location in a closed envelope. The written documents will be shredded after five years.

The data and findings were not altered or misrepresented in any way to suit my goals. Names of the participants remain anonymous and unidentified in the final research results. At the end of the research project, a copy of the final thesis report will be placed in the College's library for the participants to view. A digital copy will also be placed on the college's intranet under the active learning committee page for all the teachers' and administrator's review.

CHAPTER 5: RESULTS AND DISCUSSION

In this chapter, I discuss the results of the data analysis from both the quantitative and the qualitative research. I will start with the quantitative results.

1. QUANTITATIVE RESULTS

The results from both the admissions records and the participants interview findings related to their demographics are compiled in this following section.

1.1 Admissions Records

In colleges in the province of Quebec, between 2006 and 2015, 14 177 students registered in CS, yet only seven percent (986) of these were women. That showed a strong presence of 93 % male students (13 191) as shown in Table 1 below. Out of that 14 177 total number of students admitted, 12 570 (M and F) completed the program successfully. Females accounted for six percent of all graduates (759 out of 12 570). In addition, only 88.7 % of the total number of students admitted to a CS program complete their program of study. There are far fewer women who register in CS. But once they are there, they are also significantly less likely to graduate than the men. In fact 77 % of the registered women completed the program, while 89.5 % of the men who register do complete the program. This is significantly higher than the 77 % completion rate of the girls.

During that same period, LaSalle College's Computer Science program admissions records show that 77 out of 230 registered students successfully completed their DEC and graduated (see Table 2 below). Six females have graduated between 2005 and 2016 from the DEC in CS while 21 have quit. It should be noted that these numbers comprise only the DEC students. LaSalle College has AEC specializations in CS that have female presence as well, but they are not documented in the admissions records provided.

Table 1: Admissions Records for DEC Specializations in CS for Quebec

Gender	Registered	Quit	Completed
Female	986 (7 % of total registered)	227	759 (77 % completion rate)
Male	13 191 (93 % of total registered)	1 380	11 811 (89.5 % completion rate)
Total	14 177	1 607	12 570 (88.6 % completion rate)

Table 2: Admissions Records for LaSalle College

Gender	Registered	Quit	Completed
Female	27 (12 %)	21	6 (22 % completion rate)
Male	203 (88 %)	132	71 (35 % completion rate)
Total	230	153	77 (33.5 % completion rate)

1.2 Participants' Demographics Results

The sample population of the participants from LaSalle College included students from the DEC and AEC in specializations in Programming and Networking (see Table 3 below). I decided to present the results in separate tables in order to keep the integrity and anonymity of the data without direct reference to the actual participants. The College's population in general is heavily international as was reflected in the twenty-four participants who took part in the research study. They came from twelve different countries with only one Canadian-born student (please see Table 4 below). Eight students were South-American (Brazil, Columbia, Mexico and Guatemala), ten students were Asian (China, India, Iran, and Pakistan), two were African (Tunisia and Rwanda), two were European (Bulgaria) and one was Russian.

For 88 % of the participants, English is not their first language. They reported difficulties in their first semester adapting to learning and understanding in English.

For some, this was an obstacle that did not help them advance technically in the program when they first started. They cited that if their English was strong initially, their focus would be on concepts rather than trying to make meaning of things.

Table 3: Participants Programs

Program	DEC		AEC	
	Programming	Networking	Programming	Networking
M	10	1	1	0
F	10	1	1	0

Table 4: Country of Origin

Country of Origin	Female	Male
India	2	0
Bulgaria	2	0
Iran	3	1
Columbia	1	0
Brazil	1	4
China	2	1
Rwanda	1	0
Mexico	0	1
Pakistan	0	1
Tunisia	0	1
Canada	0	1
Russia	0	1

Ten of the female participants had previous college or university degrees from various specializations compared to seven of the male participants. Only one male student came from a Computer Science background. The various specializations include Engineering, Biology, Physics, Tourism, Business, Education, Literature and Architecture (please see Table 5 below for previous education and Table 6 for Higher Education Specializations).

Table 5: Previous Education (Highest Level Achieved)

Education	Male	Female
High School	1	3
Cegep or Technical College	3	0
Associate degree	1	0
Bachelor's degree	5	5
Bachelor -Unfinished	1	1
Master's degree	1	3

Table 6: College and University Specializations

Specializations	Male	Female
Science	1	2
Business	1	4
Arts and Literature	2	1
Computer Science and Engineering	3	1
Architecture	0	1
Tourism and Communication	2	0
Totals	9	9

Four have master's degrees (M=1, F=3). Four participants came directly from High School to do the DEC in CS. The age groups show that the greatest proportion of students are between the ages of 20 to 29 and that makes up 58 % of the participants (see Table 7 below). Thirty-three percent of the participants are between the age of 30 and 39. The two students who belonged to the AEC specialization were between the ages of 45 and 54.

Table 7: Age groups

Age	Male	Female
20-24	4	4
25-29	2	4
30-34	5	1
35-39	0	2
40-44	0	0
45-49	0	1
50-54	1	0

Fourteen of the participants are single (M=6, F=8), five are married with no children (M=2, F=3) and four are married with children (M=3, F=1). One student (M=1) is engaged (see Table 8).

Table 8: Social Status

Gender	Single	Engaged	Married with no children	Married with children
M	6	1	2	3
F	8	0	3	1

Fifty-eight percent of the male students have parents (mothers and fathers) who have gone through the higher education system compared to 75 % of females who have had both parents complete higher education degrees (please see below Table 9).

Table 9: Parents' Education (Highest Level Achieved)

Participants Parents' background	Male		Female	
Parents education	Mother	Father	Mother	Father
Elementary	3	3	1	1
High School	2	1	3	3
College	1	1	1	1
Bachelor's degree	6	7	7	7
Master	0	0	1	1

Nineteen out of the twenty-two participants showed interest in sciences and mathematics while growing up, and that number is almost divided equally amongst males and females (please see below Table 10). Only three females were not interested in sciences while growing up as compared to two males.

Table 10: Previous Interest in Sciences and Math

Gender	Interested in Science	Not Interested in Science	Total
M	9	3	12
F	10	2	12
Total	19	5	24

Tables 11 and 12 below show the list of pseudonyms and program specializations of both the male and female participants.

Table 11: Male Participants Pseudonyms and Specializations

Pseudonyms	Gender	DEC/AEC	Specialization	Semester
Anthony	M	DEC	Programming	6
Adam	M	DEC	Programming	4
Alfred	M	DEC	Programming	4
Dash	M	DEC	Networking	6
El	M	DEC	Programming	6
Johnny	M	DEC	Programming	4
Murdock	M	DEC	Programming	6
Max	M	DEC	Programming	2
Steve	M	DEC	Programming	6
Warren	M	AEC	Programming	4
Wolf	M	DEC	Programming	4
Yuki	M	DEC	Programming	4

Table 12: Female Participants Pseudonyms and Specializations

Pseudonyms	Gender	DEC/AEC	Specialization	Semester
Aurora	F	DEC	Programming	6
Lois	F	DEC	Programming	6
Faora	F	DEC	Programming	6
Jubilee	F	DEC	Programming	6
Louise	F	DEC	Programming	6
Lana	F	DEC	Programming	2
Marvel	F	DEC	Programming	6
Natasha	F	DEC	Programming	6
Raven	F	DEC	Programming	2
Selina	F	AEC	Programming	4
Valerie	F	DEC	Networking	2
Zalia	F	DEC	Programming	6

2. QUALITATIVE RESULTS

The following section will present all the important and relevant findings from the interviews held with the participants. In sharing the participants' results, I need to make note that any direct quotes were maintained in terms of grammatical errors for participant response integrity.

2.1 RQ1 Role Models

Does exposure to a female role model, leader or mentor who young female students can relate to in the field (IV1) influence decisions to pursue Computer Science as an academic choice (DV1) and consequently complete the program (DV2)?

It was important to understand whether the participants had role models in IT as they were growing up who might have ignited interest in the field because this was found to be an important factor in the literature review. Having role models while growing up helps us understand whether it played a role into making their decision to choose CS.

2.1.1   Role Models, Mentorship and Peer Support

The role models or mentors can be from school, the media, the industry, their family, friends or peers. None of the female participants seemed to look up to someone from the industry yet 60 % had a teacher or a peer internally from the college as their role model while the other 40 % had their mentors in the form of family and friends outside of the school. That same 60 % wanted to have a "female" specifically as a role model compared to five female students who said it did not matter if the mentor was male or a female.

2.1.1.1 School, Teacher and Peer Role Models/Mentors

The majority of the female and male participants did not have a role model or a mentor figure at school while they were growing up. None of their teachers, male or female, came up as aspiring leaders who have left a mark or made a difference in the CS domain. However once in the CS program, female participants had encountered

role models in the form of female teachers. Several female participants referenced a female teacher they acknowledged as their role model who shared experiences of balancing career and family to make it look like it is a goal possible to attain. Zalia thought it very important to see female role models in female teachers," I can see that I can build a family, be confident and successful when I look at [her]…" Aurora, Jubilee, Marvel, and Lois to name a few said, "I want to be like [her]…" , referencing a female teacher as their current role model in CS. Two female students in their first year expressed that they were trying to figure things out and that made them feel lost. Valerie, a first semester student in networking said, "I feel I am on my own now, but having advanced mentors in the field who can support me, and we can ask questions and guide us can really help". Raven also said "I need a female role model to show me the way to find balance and succeed both in my career and family life". Jubilee mentioned that for her, as a female, "I need a female mentor or role model in IT, for when I look at a male developer, I see a career-oriented person but when I look at a female, I see the combination of career, family, social life and friends". Lois who has heard it was just "a place for guys" emphasized, "The teacher in the classroom, especially if female, makes all the difference to make female students feel welcome, comfortable and supported". Female participants preferred to also ask their classmates or peers for help once they were comfortable with them. Faora preferred to ask classmates as she mentioned "classmates who just learnt it like me can explain it better", and Lois preferred to ask peers because "some teachers don't like to be asked".

As for the male participants, they preferred having mentors from the first semester to help guide the learning process, more than later in the program when they become more autonomous and resourceful. El mentioned, "now that I am in my last semester, I have my own formula to follow and it is not important for me to have a role model". Wolf said that for various skills, teachers could be great role models, "some for their patience and kindness and others for other types of skills".

2.1.1.2 Media and Industry Role Models/Mentors

The media seems to have played no role for women yet helped shape the experience for male participants due to key male figures in the industry such as "the Google guy, Larry Page" as Yuki referred to him, "Elon Musk" for Dash and "guys like Bill Gates and Mark Zuckerberg" for Anthony.

Movies like "The Matrix" along with other shows and media, gave a wrong impression for many participants on what being an IT professional is really like. Whether in programming or networking, people seem to think that magic happens when you click a few keys on the keyboard. None of the males had any female role models in the field while growing up to influence their attitude towards IT.

2.1.1.3 Family and Friends Support

In families, close relations such as a father, a sibling, an uncle, or a cousin might have played a role in igniting interest towards the world of computers. The majority were male figures for both males and females. Six females had had people in their lives who worked in IT who they admired but did not necessarily aspire to be like. They also all happened to be males such as their fathers, brothers or a close friend. Jubilee's father brought her along to work in the computer servers' room often while she was growing up. Aurora and Raven learnt a lot about computers through their male siblings. For Faora, it was "a very close friend who worked with computers". She had a male colleague at university in CS who she viewed as a "genius, and aspired to be like and learn from". As for the males all their role models from family and friends were also male figures. Murdock has an uncle who worked in IT, and said, "my brother and I always found a way to break the PC, I was so impressed by what he does to fix it, seeing the inside of the box lighting up, I cared to learn and loved building stuff, it got me intrigued by how things are built step by step". Adam's father had a computer store while Johnny, Alfred and Steve all had male friends who worked in IT who were very inspiring.

2.2 RQ2 Preconceived Misconceptions

Do preconceived misconceptions about the IT community (IV2) influence young female students to choose Computer Science as an academic option (DV1)?

Interestingly, the number of students that had preconceived negative ideas or misconceptions about Computer Science was evenly split between males and females. Only six (M=3, F=3) out of the 24 students claimed that they had a good understanding of the world of IT prior to starting the program. This was due to either having come in contact with IT in the past or from someone they knew who worked in the industry. Preconceived misconceptions did not affect either males or females who were in the program from pursuing it as an academic or a career option. It is noteworthy to consider whether this factor prohibited those who did not register. Upon examining comments made by the participants, it was evident that many had negative preconceived notions including stereotypes about social life, the "nerdy" character traits, gender discrimination, and the job expectations.

2.2.1   Social Life and Long Hours

Sixteen out of the twenty-four students (M=10, F=6) believed that computer scientists use computers all day long and have no social life or healthy life style. Jubilee thought, "I had to spend 90 % of my time on the computer". She was worried that all she should like and enjoy in life should only be related to computer activities. Faora, a third-year female participant in Programming, speaks with concern that due to existing social stereotypes that portray computer scientists as anti-social, she still had insecurity as a female studying CS. She added "when I introduce myself to people as a programmer, I feel the need to add but I am pretty social and not on computers all day". The stereotypes of a lack of social life and the long hours did not seem to be important factors in influencing participating females in choosing CS. Dash, a third-year male participant from networking, brought up an important misconception where he thought that CS consisted mostly of guys "...who don't take care about themselves and don't care about anything else except computers and the

online world". He continued "there is that image of a fat guy sitting all day on the PC...."

2.2.2 Nerds and Geeks

Six out of the nine males were under the impression that professionals in Computer Science are "geniuses", "nerds", that they all "know how to hack" and "know everything there is to know about computers, networks and various technologies" and are "gamers". Adam expressed how when people found out he was in CS, they would say, "You must be a genius". Steve said, "people in CS are all geeks and know everything about computer hardware and software, they are always expected to have all answers to IT questions". A senior female participant, Jubilee, was under the impression that you had to be a gamer. In spite of those stereotypes, female participants believed that they had what it takes to survive the program.

2.2.3 Gender Discrimination

Another misconception that was evident with both male and female participants was that CS is for males. Lois shared "I thought I was going to be the only female but then saw there is a female professor and six female students in the group of twenty-five" and Lana's friends told her "as a girl you will not be interested, programming is not for girls and it is too boring". "I really like the logic" was a common response I got when asking them why they pursued CS as an academic choice. Therefore, the misconception that CS is for males did not deter them. As for the males' perception, most of them were surprised at the underrepresentation of females in CS. Adam, a second year student from the Middle East mentioned that he was surprised by the lack of women in the industry, as back in his country there is an equal male and female presence.

2.2.4 Job Expectations

From the male participants' comments it was clear that they had created unrealistic job expectations based on the media representation and encouragement of certain stereotypes. Yuki was under the impression that "a true programmer never

uses the mouse", he added, "TV shows and movies show a male sitting in front of a black screen typing endless white characters for hours and things start happening". Both El and Dash expressed that they thought they would become expert hackers. None of the female participants' expected that they would learn everything they needed to know about the world of IT during the academic program.

The female participants were worried that their "expected family responsibilities" would prohibit future advancement in their careers. They had to balance life in and outside of school during their studies and they realized that this was an ever-evolving and advancing career where the learning never ends. Female participants were concerned that males had the luxury of pursuing their careers whereas social and cultural expectations put pressure on the female to fulfill her family responsibilities before her career.

In general, it was clear that there was a misrepresentation of the image of males and females who pursue CS but that did not seem to deter the male or female participants from choosing CS as an academic choice.

2.3 RQ3 Exposure and Prior Experience

Does the female student's exposure and direct experience with computers (Personal Computers including Laptops) while growing up (IV3) encourage her to choose Computer Science as an academic path (DV1), and to gain more self-confidence (DV3)?

Findings suggest that prior exposure to computers while growing up can help start an interest in the field but is not a requirement for males or females in choosing CS as a program of study. Most of the female students mentioned that they experienced a steep learning curve, compared to males. It took time for the females to get acquainted with many hardware as well as software utilities to get to the same level as most of their male colleagues who were a lot more comfortable experimenting. Louise shared, "I do not know enough about the different technologies and that puts me at a disadvantage". Raven, a first semester student believed that "those with prior technical-related knowledge make me nervous because

they make me more self-conscious that if I ask a question, they would think it is stupid and that I am not smart". Jubilee said, "I feel the pressure, guys find the answers faster". Findings revolved around three main ideas including early exposure to computers hardware and software, encouragement from their surroundings, gaming and online resources.

2.3.1 Early Exposure to Computer Hardware and Software

Male participants explored PCs beyond desktop applications and software editing. They also had parents or family members who allowed and encouraged them to explore and discover without fear. Approximately 60 % of males (seven out of 12) had taught themselves to use computers, to program, develop websites and set up various technologies, while only 17 % of females (two out of 12) had had the opportunity or the interest to do the same. In addition, 75 % (nine out of 12) of male students had autonomously fixed computer hardware/software and/or programmed applications or websites while growing up. Anthony said, "In my surrounding I was the only one who knew how computers work, it increased my self-confidence. I learnt HTML and started creating websites by myself". Dash learned how to build servers by reading documentation online and following forums. He was 14 when he created his first dedicated server. "I saw my father open/assemble PCs and I learnt by watching basic stuff from the Internet". Two of the females participated in school clubs where they used computers for extracurricular activities compared to zero males. Natasha joined a special program that allowed her to learn Visual Basic, a popular programming language back in the 90s.

2.3.2 Encouragement from Surrounding Environment

Not many of the female participants had encouragement to discover and learn. Both Faora and Aurora shared that they had PCs at home that belonged to their brothers and they were allowed to use them. Raven added that they had a PC at home for her older brother who would hide cables from her and set passwords out of fear "she would mess things up after one incident where she deleted his stuff during an

exploration and curiosity session". Marvel said, "I liked computers but was not curious about them".

2.3.3   Gaming

Another interesting finding was that 60 % of males used computers at home for gaming while only 33 % of females were interested in gaming while growing up. Jubilee said, "we had a computer at home and I used it to play games and do school research". For the female participants, playing games was just an activity; the gaming device used in and of itself did not matter. For the male participants, gaming created an intrigue to want to know more about the machine, build computer systems and understand how they function. Many male participants became self-taught learners from a young age and experimented with computers. They would break their machines, but that did scare them away from experimenting further. For some females, fear of breaking things created a barrier to their advancement and those who were accused of breaking their families' computers developed a lack of interest in the machine.

2.3.4   Online Resources

Female participants believed that male students had been exposed to resources such as online forums and communities and were bolder to experiment and try things without fear of consequences. In their opinion, the limited knowledge they possessed due to lack of prior experience created a barrier or fear of not knowing what certain actions would do to the machine or how to manage finding relevant information, especially considering that technologies were always changing.

2.4   RQ4 Encouragement and Support

Does encouragement and support from their family and teachers (IV4) influence young female students' decision to pursue Computer Science as an academic option (DV1), and gaining more self-confidence (DV3)?

Encouragement and support from parents, family members or friends did not matter for female students who decided to pursue CS as an academic choice. The love

of the challenge and wanting a career that had options made them believe they were capable. However, once they were in the program, the support from their partners or spouses became crucial as the learning curve and the required effort was difficult. Balancing life responsibilities with jobs, full schedules and finding time to study and practice outside of school became a big challenge.

2.4.1 Making the Decision

Eight out of the 12 males said they had encouragement from parents, siblings, or partners to go to school and specialize in Computer Science, while only two had discouragement from parents. On the other hand, five female participants had encouragement from parents, partners or family to pursue CS while friends had discouraged three from pursuing the program. In general, most students commented that regardless of the feedback from others, the decision was theirs to make out of belief in themselves, curiosity about the field and the love for a challenge. Many males and females equally voiced, "it was my choice". In addition, many expressed that their families or friends didn't quite understand the scope of what a computer scientist consists of.

2.4.2 Need For Academic Support

Once they got into the program, support and encouragement to complete it was just as important. From the female participants' comments, there seemed to be a pattern, as they needed support both academically and emotionally. Academically they needed answers, clarifications, guidance and resources. Marvel, Lana, Raven, and Selina explained, "First I ask teachers". It was not always like that for the female participants in the first year. "I don't feel comfortable asking teachers or colleagues questions or clarifications in the first semester" was a recurring theme for most females. Emotionally, they seemed to need encouragement to keep on going, in addition to receiving help from their partners and family with day-to-day responsibilities. They were afraid of being judged or viewed as not being smart enough when they were still not comfortable in the classroom environment. As they

warmed up to the teacher and to their classmates, asking the person sitting next to them became the first thing to do. They used tutorials and videos to understand concepts but preferred asking peers or teachers for help when they got stuck.

Eleven out of twelve males liked to find the answers on their own as a first option. Following either lack of resources, knowledge, or time, male students started seeking the proper solutions to resolve the problem by using online tools or requesting the help of a friend or classmate and as a last resort, going to a teacher.

All participants equally expressed the need for initial guidance and support for knowledge construction to take place. All students realized they must invest time in repetition and practice to acquire the knowledge and experience necessary for constructing a learning logical model - schema to go back to and build on as they develop more skills and more knowledge building blocks. This helped them feel more confident about their own skills and abilities. None of the participants thought of quitting and giving up.

2.5 RQ5 Motivation and Interest

Does the possession of motivation in young female students (IV5) and inclination/positive attitude (IV6) towards CS play a role in choosing Computer Science as an academic path (DV1), helping them complete the program (DV2), and gaining more self-confidence (DV3)?

Research portrays women as social beings with strong interpersonal skills (Markus & Kitayama, 1991). Most of the female participants matched this generalization. For them to be interested and motivated to work for long hours with a computer machine, they preferred working hands-on through social collaboration on real projects that allowed them to draw connections between Computer Science and its application in the real world (Zhang et al., 2007). That is absolutely true for the female participants. They had to push themselves to keep going. The majority were learning new concepts in a challenging and difficult discipline amongst male students whom they perceived to be better than them. They were a minority. It took a lot of self-affirmation, commitment and intrapersonal strength to succeed.

Motivation and interest are two important factors for success in a program like CS. These two factors are enhanced through positive emotions such as encouragement, reinforcement and enjoyment in doing computing tasks, which could lead the observer to a more positive feeling of self-efficacy (Elprana et al., 2015; Howell, 1993; Cohoon, 2003; Revelles – Benavente, Prieto & Bosch, 2015). Therefore, motivation and interest seem to be a recurring theme in the literature as well as during my conversations with the participants. Given that 75 % had negative preconceived ideas about the profession, and 21 % had no prior interest in maths and sciences, it was necessary to understand the motivation and interest that led them to pursue CS.

2.5.1 Choosing CS

Males and females chose CS due to a liking to technology-related interests such as programming, networking and problem solving. Lana said, "I was interested in IT and computers and wanted to learn new skills". Lois also enjoyed gaining better understanding of programming but eventually preferred working on applications design. Anthony mentioned, "I was into gaming and computers so the decision to go into CS came naturally". Murdock said that he appreciated the fact that "there is more to CS than just programming and coding" as he preferred graphical design. Males equally attributed their decision to go into CS to technology being the career of the future. Dash saw it as "the future of humanity" and Johnny, who came from a tourism background, said that "there is no need for tourism agents, people find everything online, I had to choose a field with options". Other findings for participants' interest in CS were attributed to enhancing IT skills related to their prior jobs. A few mentioned family influence.

2.5.2 Attitude

All participants seemed to agree with the fact that they felt an overwhelming amount of joy when their problem was resolved, or their code worked. Aurora said, " when it works, I feel like I am on another planet, I feel happy and very energetic".

Louise agreed, "it is very rewarding at the end when you created something and it is working, the feeling is amazing, it happens every time". Dash from networking said, "when I get the answer I am looking for using online forums such as Stack overflow or YouTube, it feels good, it feels awesome; there are more experienced people in forums than colleagues in class". Yuki said, "when it works, it feels great and it boosts my self-confidence, when it doesn't work, I lose my self-confidence". Wolf mentioned how "amazing it feels when you hit the compile button and there are no errors, it is like watching your child born". All students agreed that to succeed, you needed hard practice and commitment. From the male participants' feedback, it seemed they spent countless hours on their computers and they attributed their commitment to passion, interest and curiosity.

2.5.3   Self Confidence

Self -confidence seems to be the biggest obstacle for female participants and a threat to their success, but not for the male participants. Seven out of the female participants expressed that self-confidence and motivation to put in the extra hours and effort were the things they struggled with the most. They had the impression that males were simply better in CS than they were. Male participants did not seem to struggle with self-confidence and if they did, they turned to a peer for support or they would research strategies to find solutions for their problems.

The female participants mentioned that only when they felt more resourceful did their self-esteem and confidence increase. "Now that I am more confident, I can ask anyone, if I need help, I got to ask", Lois says. Raven said about the females in her classes, "I know the girls, we were together, they had the same problems, when they get stuck, and couldn't continue, I don't think guys in the class hit the same road block when stuck".

Females were also under the impression that males were not shy like they were, and that they always found a solution faster and easier. They mentioned that even when their performance was better, they would always question their

capabilities. Marvel was curious as to why "guys have really good level, I don't know why". Natasha believed that "the logic of how we solve is different males to females also for the knowledge skills and technical tools, males are better, I don't think I am smart as a female compared to guys, they are just smarter, they have better logic than females in general". They reported low levels of self-efficacy. Eleven out of the twelve female participants made a point that "males are better", attributing that males' logic was better, or they just get it faster. Only Zalia viewed it differently and thought:

> "The difference with males is they have a certain amount of background knowledge they count on it and do something with it and they show it. If we have that same amount of knowledge, we pay attention to all the other stuff we don't know and don't have, that is why they are faster and succeed better. Lack of self-confidence affects performance of female students, even when they know, they think they are not good."

In addition to the factors identified in the previous five research questions, the interviewees shared some of the difficulties and struggles they faced while studying Computer Science. The following two sections are dedicated to focus on the participants' acknowledged difficulties in the CS discipline and the learning strategies they have applied to help them succeed.

2.6 Difficulty and Struggles of Studying CS

The discussion of the difficulties is vital to this conversation as it helps us understand how, in spite of the hardships they encounter, the participants managed to find ways to complete the program and succeed. The difficulties were attributed to various reasons and they differed for from females versus males. Eight of the female participants compared to three of the males expressed that they found the CS discipline difficult. The struggles faced by the participants included: quantity of information, managing time and stress, and dedicated practice.

2.6.1 Quantity of Information

Male participants expressed that there were always new things to learn and lots of programming languages to explore in addition to school projects. Dash explained, "there was so much information" and Anthony mentioned that "CS is not in itself difficult, but it has a difficult learning curve, as there is so much to learn and constantly update your knowledge on". On struggling with too much information, Max stressed that the active role of a teacher is vital in helping students handle the amount of learning to be done. If the teacher did not explain well, then that added to the students' workload where, after a long day of classes, they still needed to watch videos to learn concepts before they could start applying their knowledge and practicing.

2.6.2 Time Management and Family Obligations

Female participants expressed difficulty with time management. Lois wished "I had more time to watch YouTube videos to improve". Faora felt stressed and exhausted due to running out of time and having to juggle many things. Then feeling stress due to lack of practice, she "feels stuck and can't move forward". Female participants do not have time to practice. Marvel mentioned that "it requires a lot of time on my own and I am always lacking behind with too many programming languages and too many ongoing school projects, I listen to TED talks to encourage myself and get motivated and my dad's advice".

Balancing social life with work, family and school was a constant struggle for both male and female students as 42 % in each group mentioned that they were always fighting for more time. The male participants did not bring up family-related emotional struggles. Most of the female students who were married felt they had to juggle family and school. Louise, amongst other female participants, viewed it as unfair as she felt male students were more prepared and got things done faster because they spent time at home preparing and viewing tutorials, while women had to go home and take care of "cleaning, cooking and family responsibilities". "Females

don't have the advantage of time" seems to be a recurring theme among many of the female participants.

The males who complained about time always related it to work and never mentioned that they had to clean and cook, versus the females who did work and still had to take care of those extra chores. Louise said regarding the comparison of male to female performance

> "If by grades, I think my grades are better than my colleagues as I spend much time studying and practicing, I know many people don't spend as much time as I do, not because I am better, I just feel the male students find the answers faster, they are more prepared than the females, I think they spend time at home preparing and taking courses. Females go home to take care of their partners and clean and cook. I don't have as much time as men".

2.6.3 Dedicated Practice

Female participants found it challenging to practice and work harder on a regular basis, though collaborating with other peers made it more interesting. Faora said, "it is more motivating when working through team learning, I need interaction by asking questions. When the teacher asks us to do something on our own, I am lost". Male participants praised having interest and passion towards computers as the motivator to spend endless hours finding solutions to their problems. El, a senior male that many participants referred to in the study as being one of the strongest candidates in their group, said

> "I hardly ever get a concept from the first time the teacher explains it, I don't get it right away …I need to go home, look online what others say, write it down, understand it and apply it, try to produce it myself and then need to self-reflect to get them".

2.7 Recommended Learning Strategies

All participants seemed to agree that "dedicating time in and outside of the classroom" in addition to "practicing and repeating" as well as "becoming resourceful on how to search for required information" were all key learning strategies for

success. The most important finding for me was that none of the female participants mentioned that they expected "to hit walls and struggle" compared to half of the male participants who were expecting to struggle with problem solving. Another difference between male and female perception was that half of the males brought up the importance of being eager and passionate about the knowledge compared to only one female participant who mentioned it. El recommended that writing things down, "although seemingly strange coming from an IT professional," was one of the best strategies as it forced him to understand and explain technical concepts. It solidified the knowledge and "it has become [his] hobby". Students advised on the importance of two approaches to learning: independently to construct knowledge, and through peer collaboration. Wolf advised that one of the first skills to help you succeed was to learn to study by yourself, as it was a required skill in CS to be autonomous and self-taught. He said, "You constantly need to update your knowledge and you could not afford to always take courses or wait on someone to explain it to you". Sixteen out of the twenty-four participants believed that it is a collaborative working environment. They attributed their improvement to constructing knowledge on their own and through social collaboration. Adam added, "it is not collaborative from the first year but as we grew to know each other better, college schedules help groups stick together and form a support system". Valerie believed that building relationships with the group was conducive to collaboration.

CHAPTER 6 - CONCLUSION

1. SUMMARY OF FINDINGS

Twenty-four female and male students who were studying in a Computer Science program at LaSalle College in Montreal were interviewed to help uncover how individual students respond to the various social and affective factors during their academic experience. Interview findings showed that there were differences in attitudes and behaviours between the male and female participants specializing in CS where personal experiences and social obligations create distinct situations and expectations. There were common themes and similarities amongst the women participants' views about their limited prior knowledge, struggles with time management, lack of self-confidence and the need for female role models. There were also similar patterns and recurring themes in the answers provided by the male participants on the issues of learning independently and relying on online resources. Both males and females agreed on common obstacles such as lack of practice and balancing life and school. Most of the participants had an interest in math and science while growing up.

The admissions records for students attending the CS programs in the province of Quebec at the college level had shown that it is a heavily male-populated specialization. I believe that my research helped gain a better understanding of the social and affective factors influencing the female students' choice of specialization in Computer Science.

The lack of prior exposure to role models or mentors did not influence female students' decisions to pursue CS as an academic option. The need for female role models for female students arose and became necessary during their time of studies.

Eighteen out of the twenty-four participants had pre-established negative notions about CS, yet this did not stop them from joining. In general, students had expressed happiness that their preconceived notions of the "character traits" of a computer scientist turned out to be false.

Their interest in CS was attributed to the love for a challenge, puzzles and problem solving. The lack of technical exposure and experience with hardware and software while growing up affected the female students' self-confidence and learning. They felt they needed to invest a lot more time and energy to catch up to the knowledge and experience they perceived their male colleagues to be in possession of. That put them at a disadvantage and affected their level of self-confidence and productivity. Male participants seemed to be more active with online communities and were more self-taught learners.

Social and affective barriers have been discussed, however several steps can be taken to utilize the information gathered from this research to develop more action.

2. RECOMMENDATIONS

In order to address my research question of how can we bring more females on board, both male and female participants provided six relevant suggestions.

The first suggestion was to have more support for females from males in their families. Marvel was worried as she said, "I will not marry until I have a job and experience" as she was afraid that her family life will stop her from building a career. Aurora suggested that husbands should also be there more for the kids so females could have time to improve their skills.

The second suggestion pertained to companies having more encouraging and active initiatives. Louise thought that life circumstances made women slower or less resourceful than men and thought "women should not have this wall to deal with, employers should know women have more responsibilities at home, we just need equal chances and opportunities". She suggested that companies create social female events once every three months where women get to talk about issues and struggles and get "little gifts from various industries, not for their material value, but to show support and understanding".

The third suggestion pertained to having more female role models in CS. Lois suggested, "We need a hand when we start our career to show us the way, and to

know the tools to use". She gets her confidence when she sees that her final product works. She believed "We need to impress and do something for girls by girls" in order to prove that they can get the work done.

The fourth suggestion pertained to creating academic and social initiatives to strengthen females' technical background knowledge in CS. Valerie believed females' difficulties in CS stem from lack of background knowledge in IT. To increase female presence in IT, Anthony believed mentoring should start from elementary school. Alfred agreed "We groom boys and expose them to technologies and groom girls and give them dolls, then this becomes the truth". He also believed we need to clarify this social myth that CS was for males. Dash thought it would help if teachers curbed their expectations in the classroom, to avoid having students with self-confidence issues feel embarrassed to speak out and ask questions.

The fifth suggestion pertained to having mentors and creating on going group studies to allow students, both male and female, to work collaboratively and offer one another help and guidance. Zalia believed that "creating group studies for females is very effective, we cover each other's gaps and explain or watch someone explain. A third year can mentor a first year and coach them". Jubilee added that women need guidance on where to find more resources and get help so they can manage their time better and not add stress to work and family.

The final suggestion by the participants was for teachers to make the material interesting, and offer more diverse real life hands-on projects. Murdock attributes that people, both male and female, who left CS did so due to loss of interest. "Diversity in projects creates interest". His impression was that while the industry was changing, teachers were recycling the same projects repetitively, and the content stayed the same.

There should be increased efforts to have more female faculty from primary to higher education to teach IT-related courses. Both cultural and career shifts could occur. Governments should start programs for women in IT, or in careers that are

constantly changing, where they can integrate their training within their job hours. Otherwise, there has to be a shift in social expectations where there is an equal distribution of responsibilities within the household.

We cannot apply a one-solution-fits-all policy but rather must integrate various teaching/learning strategies to encourage diversity and inclusion. Even males as a majority group in Computer Science can benefit from those diverse methods to help accommodate their individual learning styles. The integration of team-based and problem-solving learning techniques allows for students to work together and hear each other's various perspectives and look at problems with different points of view. Students' interactions are very valuable towards building understanding and attitude change (Rheingans et al., 2011). Forming supportive relationships and getting help from others thus becomes essential for women's survival in Computer Science courses, careers, and for the accommodation of students with limited prior experience (Howell, 1993). Mentorship along with peer support and faculty's strong presence can help clarify existing fears and misconceptions. They can collaborate with the industry on publishing media material that can encourage women to pursue Computer Science.

The interview findings also produced a list of the best teaching/learning practices that helped students succeed in Computer Science, especially for the female population. The general consensus for both male and female students is that they need to take the time to understand concepts, read about them, apply them and reflect on their use. They must dedicate practice time on a daily basis. Curiosity, interest and motivation to learn and apply are very crucial. The results of this study align with what research shows about the integration of two strategies related to team-based and problem-solving techniques. Those findings show that along with mentorship, peer support and faculty guidance, the above two strategies can help students build better understanding, and clarify their fears and misconceptions (Rheingans et al., 2011). At the Cegep level, there are no graduate programs through which attending students can benefit from mentors; instead, the presence of a female mentor can be replicated

through alumni students who can visit, hold conferences and provide support to the female students attending the program. Also, more advanced students in the program, such as second or third year students can act as mentors to first year students. Funding for those kinds of projects is important to ensure success and effectiveness (Pearl et al., 2002). In addition, high school students can attend local college programs and connect with female scientists or faculty members in the field.

There are all these barriers for females, but they coped with them in the following ways. Some had to get over their shyness to gain the confidence to speak up and ask for help. Others realized that they needed to find ways to study on their own. Sharing, collaborating and experimenting were crucial to their success. Time and practice seemed to be the biggest challenge, yet their persistence, ambition and seeking help turned out to be their driving force. The coping strategies employed by the females were an important factor in pursuing and completing their studies in CS. I was very grateful for the stories they shared with me as it helped me to get to know them better and learn from their experiences.

3. FUTURE EFFORTS

Several universities have started a program through which they bring high school girls to their campuses for summer weekend workshops sponsored by faculty and CS students. Survey results show that those activities have brought awareness, interest, and enjoyment to young girls about the world of IT (Townsend, 1996).

Booklets and video interviews documenting the success of women in scientific careers are becoming more readily available. More educational software and games that appeal to girls are being produced and implemented (Hamilton et al., 2016). All those efforts and more need to take place at a global level through governments, educational institutions and non-governmental organizations (NGOs) to create gender equality opportunities in the fields of sciences and technologies. As for the industry, various known companies in IT, such as Google and Apple have made the inclusion of more female employees part of their future mission.

There are quite a few movements such as "Girls Who Code" and "Technovation Montreal" amongst others that are happening in Montreal in which students from LaSalle college took part to encourage young girls to learn how to program.

Previous research regarding this topic inspired me to create an initiative with the help of CS students, administrators and people in the industry, to create a Computer Science student association called INT (Innovators in Technology) with a sub-chapter for female students members (WINT-Women Innovators in Technology). Most of the students provided great feedback as to how being part of the association helped them gain confidence, knowledge and a sense of community. One of the projects of the association called "Humans Of IT" is meant to demystify the misconceptions about people in IT by publishing short videos showing Computer Science students playing music, doing sports, practicing hobbies, and living a life outside of coding. Being part of a bigger community that offers support and understanding is what those women and men equally need to lead great careers in IT. Lois confirmed that the student association made a huge difference for everyone as it helped them share their struggles and not be afraid to work on new projects and experiment with new technologies.

As for the suggestions or future directions for school administrators, we need to prepare students to be life-long autonomous learners. They should be encouraged to try and fail by experimenting with more hands-on applications with interesting projects. Another point is that, given that females already feel like a minority and struggle with self-confidence, teachers need to make an effort to avoid creating bias in the classroom and steer away from demanding quick solutions that discourage the students who need time and support.

4. LIMITATIONS OF THE STUDY

Given that the participants come from various backgrounds with different experiences, it is difficult to draw concrete conclusions. This research study examined

the patterns and suggested several factors that could contribute to the gender imbalance in CS. The small sample size was a legitimate limitation as it did not include a wider range of areas of students from Networking and Game development programs. Having access to only two AEC students and two networking students did not help me draw comparisons regarding whether the struggles were similar or different across various specializations within the same CS discipline. Although I got to know more about those who participated, I did not get to hear about the opinions of those who did not participate, as our female student community is already very small. Given that all my participants chose CS in spite of the misconceptions and challenges they heard of, I am unable to identify the factors that discouraged other females from choosing CS. In addition, even though LaSalle College is not limited to international students, most "Canadian-born" students opt for public colleges to relieve themselves from tuition fees, which meant that my sample consisted mostly of international students.

In response to the lack of female presence in the industry, a CS student association was implemented at LaSalle College following the concept of service learning. A big part of the senior participants took active roles in this association. It is possible that because some of the participants received extra preparations through workshops, seminars, and exposure to industry speakers, that this sample might not reflect an average CS student.

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Appendix 1 – Consent Form for Students

<center>**STUDENT CONSENT FORM**</center>

<center>**TITLE OF THE RESEARCH: WOMEN IN COMPUTER SCIENCE: HOW CAN WE BRING MORE ON BOARD?**</center>

Researcher:	Nariman Mansour	Tel:
Email address:	Nariman.Mansour@collegelasalle.com	
Department:	International School of Business and Technology – Computer Science Department	
Availability:	To be determined.	
Supervisor:	Marc Belanger	Tel:
Email address:		

Purpose of the research:

There are many Information Technology (IT) job positions where we would expect female presence, yet the reality is that there is a huge lack of it. IT has been viewed for so long as a male-oriented field. We can identify the misconceptions and fears that might prohibit women from making it an academic choice. Misrepresentation in the media and society and lack of encouragement might lead them to believe that either they are not good enough or that they are not welcome. I would like to identify the common factors (social and affective) that play a role directly or indirectly leading female students down the path of making Computer Science an academic choice. The purpose is really to identify why isn't computer science attractive to more young female students.

What is involved in participating?

STUDENTS: please check the appropriate box, sign, date and return.

☐ I have read and understood the information provided on the consent form, and I agree to participate in this study. I understand that I may ask questions in the future. I understand that my participation is voluntary, I may withdraw from participation at any time, and my academic standing will NOT be affected in any way by consenting or not consenting to participate in this study. I certify that I understand there are no risks and no benefits involved in participating.

☐ I do not consent to participate in the described study.

Student's name (print):	_____		
	First name, Last name		
Student's signature:	_____	Date:	_____
	signature		dd / mm / yyyy
Researcher's signature:	_____	Date:	_____
	signature		dd / mm / yyyy

There are no known harms or greater risk involved in participating other than that of general living and attending the college on daily basis. The benefits are the shared results and findings about the strategies that can help you succeed and enhance you learning experiences.

Confidentiality will be respected. No information that discloses your identity will be released or published without your specific consent. Participation in this research is voluntary. The interview will take place in a private space at LaSalle College where I will be reserving either a conference room or an empty meeting room for the purpose of the interview at your convenience and both our availabilities. The interview will take between 15 to 20 minutes per participant. The researcher does not anticipate any secondary uses for the data.

If you choose not to participate, you will continue to have access to quality education. If you choose to participate and later decide to change your mind, you can say no and stop the research at any time. Again, you will continue to have access to quality education.

There will be no way for anyone reading the results of this study to be able to link any data with your name or student number. PSEUDONYMS WILL ALWAYS BE USED in any publications that may result from this study, as well as in the stored data. If you withdraw from participation as a participant at a later date, all data of any kind will be erased and/or destroyed.

> Participation, or lack of participation in this research will NOT affect your grades in any way.
> Your participation is entirely voluntary and you may choose to withdraw at anytime.

Confidentiality means that no person, other than this researcher, at LaSalle College, or any other organization will have access to the materials collected and that they will be coded and stored in such as way as to make it impossible to identify them directly with any individual. All names will be changed in the stored data and resulting publications. Data will be stored on a password secured hard drive, and will be destroyed after 5 years. All other type of information (audio-tapes, cd's, paper copies) will be stored in a locked filing cabinet and will be erased and/or destroyed after 5 years. At the end of my research, after I submit my final thesis report, I intend to share the results of my research with the participants by leaving a copy of my thesis final report at the library and informing all the participants by email that they have access to it. I will share the results as well with all teachers at the college but more specifically in the computer science department. The administration will also have access to my research results for a copy of my thesis report will be deposited in the active learning committee page on the College's intranet page. In addition, as I am part of the active learning committee at LaSalle College, I am asked to present my findings eventually either during a pedagogical day activity or during a workshop.

IF STUDENT IS UNDER THE AGE OF 18, PLEASE FILL OUT THIS SECTION AS WELL:

☐ I have read and understood the information provided on the consent form, and I agree that my daughter or son may participate in this study. I understand that their participation is voluntary, they may withdraw from participation at any time, and their academic standing will NOT be affected in any way by consenting or not consenting to participate in this study. I understand there are no risks and no benefits involved in participating as outlined in the document.

☐ I do not consent for my daughter or son to participate in the described study.

Parent's or legal
guardian's name (print): _____
                                                    First name, Last name

Parent's or legal
guardian's signature: _____ Date: _____
                                    signature   dd / mm / yyyy

Researcher's signature: _____ Date: _____
                                    signature   dd / mm / yyyy

Appendix 2 – Consent College LaSalle

Collège LaSalle
Montréal

Montréal, le 27 avril 2017

Madame, Monsieur,

La direction des études a analysé l'énoncé de recherche de Madame Nariman Mansour intitulé « Women in Computer Science: How Can We Bring more on Board ». Nous approuvons donc la méthodologie présentée dans le document, puisqu'elle respecte le code d'éthique prévu dans le cadre de consultations auprès des étudiants du Collège.

Cordialement,

Mathieu Lépine
Directeur adjoint aux études

Appendix 3 – Consent U. de S. Ethics Committee

PERFORMA

ATTESTATION DE CONFORMITE ETHIQUE

LE SECTEUR PERFORMA-UNIVERSITÉ DE SHERBROOKE CERTIFIE AVOIR EXAMINÉ LE PROJET

DATE DU RAPPORT	NOM DU PROJET	NOM, PRENOM DE L'ETUDIANTE OU DE L'ETUDIANT
19 décembre 2017	WOMEN IN COMPUTER SC ENCE: HOW CAN WE BR NG MORE ON BOARD?	Mansour, Nariman

PROGRAMME

Maîtrise en enseignement au collégial (M.ed.)

ÉQUIPE DE DIRECTION DU PROJET D'ESSAI

	NOM	PRÉNOM
DIRECTRICE OU DIRECTEUR	Taylor	Stephen

PERFORMA ESTIME QUE LE PROJET PROPOSÉ EST CONFORME AUX PRINCIPES ÉTHIQUES ÉNONCÉS DANS LE DOCUMENT : *BALISES RELATIVES À UNE DEMANDE D'ATTESTATION FACULTAIRE DE CONFORMITÉ ÉTHIQUE*

CONFIRMATION DES INTERVENANTES ET INTERVENANTS

DIRECTRICE OU DIRECTEUR	Taylor	Stephen
EVALUATRICE OU EVALUATEUR	Lemay	
REPSONSABLE DE PROGRAMME	Lakhal	

LA RESPONSABLE DE PROGRAMME

SIGNATURE	DATE 19 DÉCEMBRE 2017

Sawsen Lakhal, professeure, responsable de la maîtrise en enseignement au collégial-volet anglophone

Appendix 4 – Interview Questions

Interview Questions

1. First there is a list of general questions about their country of origin, age, previous education or degrees, previous careers, status (single/married/with or without children), mother tongue, education of parents and their academic choices, current CS program.

2. Did you have special interests in Sciences or Mathematics growing up? (Yes/No answer)

3. Why did you decide to pursue CS?

4. Was CS your first option? (Yes/No answer)

5. Growing up, were there any male/female role models in CS that you looked up to in your direct environment or through the media (TV/movies)? If yes, who? Did that play a role in making your decision?

6. Growing up, what exposure did you have with computers?

7. Did you program or fix/install a PC before your Computer Science specialization? (Yes/No answer)

8. While growing up, were you into playing video games? (Yes/No answer)

9. Did anyone in your life encourage or discourage you from pursuing CS as a college option?

10. Now that you are in CS, did you have any pre-established misconceptions or stereotypes?

11. How do you find the difficulty level of studying CS? (Difficulty of the course material and work load)

12. Are there any impeding factors to your success? If so, have you felt you are struggling with and want to quit? When and what happened?

13. According to your opinion, do others experience the same challenges? (Yes/No answer)

14. How do you compare your success and advancement to others in your classes (males/females: is there a difference)?

15. What do you do when you experience difficulty in your courses? Do you ask questions to teachers, go to a colleague (male or female), read notes, and search for answers online?

16. What strategies or skills do you apply to succeed and get through the challenges?

17. Do you think according to your experience so far that there is a difference between males and females performance in CS? (Yes/No answer)

18. Do you find it a competitive field or collaborative? (Yes/No answer)

19. Do you have a male or female role model you look up to (senior student in the program, or fellow colleague or a teacher) who you view as an example for success that you look up to?