Spring 5-8-2020

First-Year Computer Science Students: Pathways and Perceptions in Introductory Computer Science Courses

Christina A. LeBlanc
University of Maine, christina.a.leblanc@maine.edu

FIRST-YEAR COMPUTER SCIENCE STUDENTS: PATHWAYS AND PERCEPTIONS IN INTRODUCTORY COMPUTER SCIENCE COURSES

By

Christina Anne LeBlanc

B. A. University of Maine, 2018

A THESIS

Submitting in Partial Fulfillment of the

Requirements for the Degree of

Master of Education

(in Student Development in Higher Education)

The Graduate School

The University of Maine

May 2020

Advisory Committee:

Leah Hakkola, Assistant Professor of Higher Education, Advisor

Kathleen Gillon, Assistant Professor of Higher Education

Elizabeth J. Allan, Professor of Higher Education

Penny Rheingans, Director & Professor of Computing and Information Sciences

FIRST-YEAR COMPUTER SCIENCE STUDENTS: PATHWAYS AND PERCEPTIONS IN INTRODUCTORY COMPUTER SCEINCE COURSES

By Christina A. LeBlanc

Thesis Advisor: Dr. Leah Hakkola

An Abstract of the Thesis Presented
In Partial Fulfillment of the Requirements for the
Degree of Master of Education
(in Student Development in Higher Education)
May 2020

This study examined student perceptions and experiences of an introductory Computer Science course at the University of Maine; COS 125: Introduction to Problem Solving Using Computer Programs. It also explored the pathways that students pursue after taking COS 125, depending on their success in the course, and their motivation to persist. Through characterizing student populations and their performance in their first semester in the Computer Science program, they can be placed into one of three categories that explain their path; a "continuer" (passed COS 125 and decided to stay in the major), a "persister" (did not pass COS 125 and decided to stay in the major), or a "withdrawer" (left the major regardless of their grade). After categorizing student populations based on their characteristics and chosen pathway, identifying behaviors of successful students will assist in making suggestions for future students to ensure their success. While there are current obstacles in the Computer Science field that affect student success (e.g. lack of preparation, self-efficacy, and family background), the creation of a model will help to predict student pathways and assist in the success and retention of future cohorts. Based on the findings, suggestions are provided to assess the actions and characteristics of students helps to create suggestions for students who need support in their pursuit to achieve a Computer Science degree.

ACKNOWLEDGEMENTS

I am grateful for my advisors and mentors and their endless support throughout this process. I am especially grateful for my advisor, Dr. Leah Hakkola, for her unwavering encouragement and patience during this process. Her great attention to detail has helped me become a better researcher and writer, and for that, I cannot thank her enough. I am also grateful for my mentor, Dr. Penny Rheingans, for giving me a chance to work alongside her, and helping me find my love for research and assessment. Her patience and infinite kindness will remain with me forever. I am also grateful for Dr. Kathleen Gillon and Dr. Elizabeth Allan, for their kind words, and continued support and encouragement throughout this process. I would also like to personally thank Dr. Brian Doore and Dr. Stacy Doore for assisting me during my entire graduate career. Without them, I would not have found the courage to continue my education, and for that, I am forever grateful.

In addition to the guidance I have received during my graduate career, I am also grateful for the wonderful friends I've met during my time at the University of Maine, who have provided me with nothing but endless support and the happiest of memories that I will cherish forever. I thank Zach Goulet for his patience and unwavering love during this process. Lastly, I would like to thank two important people most of all. The first is my mother Patty who is and will always be my role model in life. The second is my father Ron. Regardless of the circumstances during my graduate career, you have been nothing but a source of inspiration. Thank you for pushing me to be a better person and never letting me give up. You have taught me patience and strength through the years you were able to provide it, and even through the years that you weren't able to. The support I've received from the individuals in my life have helped me become the person I am today, and for that, I am endlessly grateful.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

STATEMENT OF THE PROBLEM

Computer Science is a flourishing field, and now, more than ever, the profession requires more qualified candidates to be ready for what the future holds. Though the demand for Computer Science degree-holders is high, drastic numbers across student populations are leaving the major, decreasing overall retention and completion rates for computing programs across the nation (NCES IPEDS Completions Survey, 2017). In 2018, approximately 112,300 jobs nationwide were characterized as computing and technology careers that required prospective candidates to have a degree in Computer Science (or similar) to be qualified. Within the next 10 years, as the nation catapults into a fast-growing future of technology, the Computer Science job market is projected to increase by 37% (Bureau of Labor Statistics, 2018). In order to match the pace of the ever-growing computing and technology field, more institutions must begin to understand what barriers are keeping students from being successful in their Computer Science majors and utilize this knowledge to predict and practice effective retention initiatives (Giannakos, Pappas, Jaccheri, & Sampson, 2017).

Recent research explains the prevalent dropout period for Computer Science students, which occurs within the first two years of entering the major (Giannakos, et al., 2017). Similar to the findings in this study, historic data on previous and current Computer Science students from the University of Maine tells the same story. While reasons for leaving the major vary based on student characteristics, demographics, and experiences, all populations have a number of students who are discouraged early on in the discipline. This can be caused by the widespread misunderstanding of the major itself (Carter, 2006), and what can be done with a Computer Science degree upon graduation (Biggers, Brauer, & Yilmaz, 2008). As the literature suggests, it is critical to be aware of the point at which issues arise for students during their college career, what causes students to make the decision to leave, and what can be done to increase student retention. This study aims to examine reasons why students to leave the Computer Science major, and what can be done to prevent them from feeling discouraged. Through the lens of Tinto's (1993) schema for departure, student pathways are analyzed to understand how they decide to stay or leave, and what can be done to create the most positive and effective outcome for each student population.

Chapter 2

REVIEW OF THE LITERATURE

The review of literature is organized through the lens of Tinto's "Conceptual Schema for Dropout from College" (1993), discussing each step of the pathway he states that a student takes when making the decision to stay in their major, switch to another major, or leave the institution completely. These steps include providing evidence of pre-entry attributes, goals and commitments, and institutional experiences that the literature suggests Computer Science students have endured at postsecondary institutions. At the end of this review, I discuss how this present thesis builds on previous research done within this field, as well as how Tinto's model was utilized to supplement the model created through this study, and why it fit the present study appropriately.

Pre-Entry Attributes

Adequate Preparation

According to Biggers et al. (2008), retention in the Computer Science major depends greatly on having previous experience and knowledge of computing and technology. Their study was done with students from Georgia Tech, and focused on the different characteristics of students who were "stayers," those who continued on to graduate within the major, and those who were "leavers," those who left the major without graduating. One of the questions asked students about their preparation for the major, finding that students who had adequate previous experience before enrolling in computing courses at their institution, such as previous high school computing courses or independently learned skills, were statistically significantly more likely to stay within the major and graduate (Biggers et al., 2008). Similarly, students who successfully stayed in the Computer Science major described they “liked a challenge,” as they were prepared for the rigor of the course because they already had the foundational skills necessary to be successful and take on more work. Alternatively, students who were ill-prepared were found to have experience with “lighter workloads” in high school, making it difficult for them to perform to the rigor of the program (Biggers et al., 2008).

While there are a number of students who had adequate experience in computing and technology previous to the start of their college career, there are still many students who entered the computer science major that had little to no experience in the discipline. Stakeholders are looking to bridge the gap between students who already have foundational knowledge of Computer Science, and students who have no experience at all, by suggesting a separation of the student populations in introductory courses (Ott, Bettin, & Ureel, 2018). Initiatives such as these have been shown to increase motivation and positive self-efficacy in students who are more likely to leave the Computer Science major (e.g., female students, first-generation students). This study expressed that students who had less experience showed greater persistence when they were in separate classes from students who had previous experience in computing (Ott et al., 2018). The focus of this recent research is centered around understanding what measures can be taken to assist students who are at a high-risk of withdrawing from the Computer Science major and what preventative measures can be taken to aid students who do not possess previous knowledge of computing.

Students who are not prepared for Computer Science courses at their institutions not only lack foundational experience, but also the confidence in their ability to complete the program, resulting in the potential withdrawal from the major (Biggers et al., 2008). Additionally, having a high self-efficacy and a sense of belonging are both positive predictors of retention (Blaney & Stout, 2017), and can be difficult to achieve when a student feels inadequate amongst their peers. A feeling of deficiency has been reported amongst various student populations, such as first-generation and female students. Through Blaney and Stout's study, they discovered that first-generation female students were less likely to interact with faculty members outside of class, which decreased their sense of belonging in the course. Suggestions have been made to "increase the frequency of interaction" between student and faculty to create a connectedness between the professor and their students, regardless of their background or demographic (Blaney & Stout, 2017). This can increase student confidence as they practice good communication, creating allies throughout their college career.

With varying student populations entering the Computer Science major, whether they have previous experience or not, scholars are suggesting that professors should understand their students' differences and plan their curriculums, interactions, and course discussions around these differences. This ensures an environment of inclusion rather than discouraging students from becoming Computer Scientists at the beginning of their college career. (Leaper, 2015). On a similar note, Barker, O'Neill, and Kazim (2009) specifically discuss the negative effects of "weeder" courses in their study on framing classroom climates to being supportive environments. "Weeder" courses are typically defined as entry-level courses that siphon out students who are ill-prepared to take on the material, resulting in them either withdrawing from the course or switching to a different major entirely. These so-called "weeder" courses have been notorious for being the deciding factors for students, and whether they will do well in the major or not. The stigma behind such courses leaves students anxious and decreases their confidence in doing well in the major and in similar majors (Blaney & Stout, 2017). Regardless of a student's interest in the major, or pursuing a career in that field, a lack of confidence and support can directly decrease their motivation to enter a Computer Science program. These issues lead to the following inquiry: what kinds of initiatives can assist different student populations to find confidence in their abilities, and to increase student interest in this ever-growing field?

Goals and Commitments

Initial Goals

Before entering an institution, students must first determine what major they want to apply for, and why they might be interested in this major. For Computer Science majors, there can be many factors leading up to their decision to enter the major. Through research done by Guzdial et al. (2018), students were found to have differing responses when asked for a reason why they chose to enroll in a computing major. While the majority of the students replied that they simply "enjoy working with computers" or they are "interested in solving problems with computers," others declared that having a degree in Computing "provides good financial opportunities after" or that it "offers diverse and broad opportunities" (Guzdial et al., 2018) Adversely, in past experiments, researchers have found that students might decide not to choose a Computer Science major because of their lack of understanding of what they can do with a Computer Science major (Carter, 2006). Even in this less-recent study, students still mentioned that they were interested in the financial benefits of having a Computing degree, however, they assumed that being a Computer Scientist meant sitting at a computer all day and having little social interaction. Since then stakeholders have attempted to create more interactive curriculums for students in the Computer Science major, allowing for more collaboration and project-based work (Carver, Henderson, He, Hodges, & Reese, 2007). The decision to become a Computer Science major is based on a student's current and future goals, as well as other motivators that influence their decisions, such as intrinsic, personal reasons to choose the major, and extrinsic, outside individuals affecting their decision, motivators.

Later Goals

While students choose their college major based on a number of factors, students must have some form of interpersonal values that coincide with their major in order for them to stay (Leaper, 2015). In addition to the reasons that students choose to enroll in a Computer Science major, their goals and values must be met in order for them to continue to persist within the major. If students do not feel that their intrinsic values are supported by faculty members within the program, it is difficult for them to find purpose in the work they must do to graduate from the major. In order for programs to successfully affirm their students' values, they must adhere to the diverse student population and their values. An example of value affirmation can be seen through research done on the differing perceptions of male and female students in computer science done by Funke, Berges, and Hubwieser (2016). This experiment depicts the differences in male and female values within the major, and how these values can be ignored depending on the mission and values of an institution's curriculum and faculty. According to this study, male students are more likely to have technology-focused values, such as logistical issues and mathematics, while female students have values directed toward the communication and creativity aspects of the discipline (Funke et al., 2016). Without adhering to the values of each student population, it can be difficult for students to find interest and importance in the work that they produce within the program (Leaper, 2015), leading to their decision to either continue in the major, or leave entirely.

In order to increase retention, as well as close the gender gap within Computer Science, scholars have suggested an increase in value affirmation for both male and female students, making sure all student interests and needs are being met (Miyake, Kost-Smith, & Finkelstein, 2010). Through this study on reducing the gap in gender achievement, scholars look to validate the values and interests that students have outside of Computer Science major and allow for students to exercise these values within the Computer Science program (Miyake et al., 2010). This, in turn, allows for students to create a hybrid learning environment as they combine like-interests into their personal curriculum. As faculty members attempt to support student values, this can increase the visibility of student self-worth, and can aid them in becoming successful learners in their Computer Science programs (Giannakos et al., 2017).

Institutional Experience

Self-Efficacy

Student perceptions of themselves within the Computer Science major can be positively or negatively affected by their self-efficacy, which can be triggered by internal and external factors. According to Lewis, Yasuhara, and Anderson's (2011) study on student self-assessments of their own abilities, students based their decision to leave or stay on their academic ability in Computer Science, their enjoyment in the major, and how their values fit with the values of the program. Negatively speaking, self-efficacy can be affected when student values are "devalued" by their peers and professors. This can, in turn, leave a student with a lowered "sense of well-being." Additionally, this can trigger anxiety, and can lead to the expectation of being rejected in their future endeavors within the major or when applying for computing jobs (Mendoza-Denton, Downey, Purdie, Davis, & Pietrzak, 2002). Similarly, students are concerned about "weed-out" courses, as Lewis, Yasuhara, and Anderson (2011) examine, which can increase competition between students, and, in turn, creates a culture of isolation within the major which can then decrease positive interactions with peers and faculty. Without a positive social connectedness with both peers and faculty (Mendoza-Denton et al., 2002), individuals in Computer Science programs cannot begin to perceive the benefits in receiving a degree in a discipline such as this.

In order for students to have confidence in their ability to succeed in Computer Science, they must first perceive their individual ability as worthy of success (Höhne & Zander, 2019). While students continue to compare themselves to their peers, says Höhne and Zander (2019), their perceived academic and affective exclusion increases, specifically students who approach the major with little to no experience. Exclusion and rejection from social norms within the major can result in decrease self-worth and anxiety over potential future rejections (Mendoza-Denton et al., 2002). To reverse the effects of perceived exclusion, Lewis, Yasuhara, and Anderson (2011) suggest that students identify factors that made them decide to major in Computer Science, such as enjoyment, ability, and personal fit. Through positive self-efficacy, students are able to find more purpose, creativity, and support within their learning environment (Giannakos et al., 2017). This, in turn, allows their motivation to become a larger asset in their academic career, increasing their chances of staying and thriving within the major.

Sense of Belonging

According to a study done by Campbell Leaper (2015), alienation for students can occur not just in the Computer Science discipline, but throughout the realm of STEM. Lacking a sense of belonging can be a contributing factor to a student's decision to withdraw from their major entirely or their institution entirely. Leaper (2015) suggests that this can specifically affect female students and their decision to stay in STEM majors altogether. Female student decisions to leave the major can stem from, according to Sax, Lehman, Jacobs, Kanny, Lim, Monje-Paulson, and

Zimmerman (2017), the gender gap in both equity and "self-rated ability," especially in subjects such as mathematics and physics. Regardless of gender, feeling a sense of belonging in one's major creates comradery in peer to peer and peer to faculty relationships.

As "belonging uncertainty" can negatively impact student academic performance (Höhne & Zander, 2019), scholars focus on how peer to peer and faculty to peer interactions can increase student self-efficacy and positive perceptions of the Computer Science classroom climate (Barker et al., 2009). Increased peer interactions and collaboration not only helps to build relationships between cohorts, but also provides opportunities for less-prepared students to gain another academic resource to improve their skills. Current tools strategies are striving to increase this collaboration, specifically in introductory courses within the major. One example of collaborative strategies was studied by Carver, Henderson, He, Hodges, and Reese (2007) who suggested paired programming as a source of interactive relationships for students of all abilities. This strategy has been proven to help successfully retain students in Computer Science programs than courses that did not offer paired programming, creating an environment of social interaction, as most programming projects are completed independently. As the topic of belonging in Computer Science and other disciplines in STEM has become an area of interest for many (Biggers et al., 2008; Leaper, 2015), scholars are looking to increase meaningful interactions and relationships with students and faculty alike to create supportive and inclusive environments that are attractive and achievable to all student populations. While the transition into college is difficult on its own, the benefit of an accepting major can be the deciding factor whether a student feels comfortable and welcomed in their chosen major.

Additional Student Barriers

Gender Gap

At many institutions across the nation, female students seeking a Computer Science degree are typically greeted by the gender gap, as only 18% of graduates in computing and technology programs are women (National Science Foundation, 2018). A number of scholars have found that women in Computer Science have felt a gender bias in their courses (Kapoor & Gardner-McCune, 2018), and more specifically, there is a stigma of male students exceling in similar disciplines such as math and science over their female counterparts (Corbett & Hill, 2015; Milesi, Perez-Felkner, Brown, & Schneider, 2017). This, in turn, decreases female willingness to achieve in their science courses. Through a study done by Milesi et al. (2017), they found that when faced with challenging material in Computer Science, male students tend to double their efforts to complete the task, while female students are more likely to perceive their skills as inadequate and put less effort into their work. While self-efficacy is a general predictor of retention, research shows that students must also feel a sense of belonging in their program to feel fully supported; something that has shown to be lacking for female students in computing majors (Blaney & Stout, 2017).

Increasing female retention in Computer Science programs requires more attention to the needs of female students, rather than the needs of the general student population. This can be achieved by hiring more female professors at institutions, or by increasing the frequency of interactions that female students have with their current professors (Blaney & Stout, 2017). The percentage of female students cannot increase unless there is more support for the values of current female students in these computing majors. As female students in Computer Science are twice as likely to leave the major than their male counterparts (Kapoor & Gardner-McCune, 2018), research suggests that more preventative measures must be taken in order to support them in their academic and career aspirations.

Summary

Regardless of the breadth of research that has been done to date on student retention in Computer Science, the claims made in the literature reinforce this current study. Specifically, Biggers et al. (2008) research titled “student perceptions of computer science: a retention study comparing graduating seniors with cs leavers” provides a similar methodology to this study, by comparing the reasons “leavers” had for leaving the major or the institution entirely with the reasons “stayers” had for continuing and expecting to graduate in the program. While Biggers et al.’s study provides an important analysis on the rationale students have when deciding to stay or leave the Computer Science major, there is a gap in the differentiation between student persistence and continuation. For this present study, a distinction is made between the motivation that “persisters” (failing a Computer Science course and deciding to retake the course to stay in the major) and “continuers” (successfully passing their Computer Science courses and staying in the major) have. Providing this distinction in this study will add another layer of categorization, focusing not only on student populations based on their demographics and background, but the level of motivation they have to be successful in their Computer Science courses, and whether their motivation is intrinsic or extrinsic. This is also in line with Tinto’s (1993) research on student departure outcomes, as it describes the different factors that can hinder or enhance a student’s interest or ability to continue in their major or at the institution entirely. Analyzing student experiences in an introductory Computer Science course at the University of Maine will help to model areas of success and struggle and will begin the process of making suggestions toward improving student performance and retention within the major.

Conceptual Framework

In order to achieve a broad perspective on success and decision-making that can be utilized for all student populations, Tinto's (1993) institutional model provides a map of reasons why students 'dropout' from their program or institution. While the model is a "Conceptual Schema for Dropout from College" (1993), it acts as a model of student decision-making as a whole, describing environmental, motivational, and success factors that contribute to their persistence. Tinto's model (see Figure 1), a Conceptual Schema for Dropout from College (1993), depicts potential predictors of departure based on socio-economic status, psychosocial, and student success variables. As the model represents a horizontal movement of decision-making and occurrences, it indicates that the preceding experiences impact the succeeding experiences and commitments that students are involved with in the future. This particular model has been utilized to frame other predictive models throughout higher education (Elkins, Braxton, & James, 2000; Sass, Castro-Villareal, Wilkerson, Guerra, & Sullivan, 2018), guiding research based on postsecondary student self-efficacy and persistence. This model is helpful in this study because of how it expresses student pathways based on internal and external factors. Specifically, it allows me to analyze the student decision-making process through the lens of Tinto's model of departure, which will be explained in the sections below.

Pre-Entry Attributes

Pre-entry attributes can be critical when entering an institution and deciding on a major. As Tinto discusses, there are a few factors that can contribute to a student's ability to be successful in their major, but also factors that can hinder their success as well. One of the pre-entry attributes that can affect a student's performance is their family background. In some instances, having family members that have experience in the major they have chosen is helpful for the student to receive more information about what kinds of occupations are available to them post-graduation. This can, in turn, help them to have a better idea of what careers they would be interested in pursuing later on, or, adversely, that this major is not right for them. Similarly, to family background, it may be challenging for students to perform well in their courses if they are first-generation college students. The opposite of students with family members that work in similar fields to the major they are in; first-generation students might lack the preparation for their courses as well as college in general.

Another pre-entry attribute that can affect student performance is their previous experience with content relevant to their major. In the case of Computer Science students, it is common for students to learn computing skills either on their own or in a formal course. Having these skills and learning computing languages before taking computing courses helps students already have a grasp of what is taught during the introductory courses. On the other hand, students who do not have experience either have difficulty in the introductory courses or have a lack of confidence when comparing their skills to those of seasoned computing students. Tinto's model can help to understand how various characteristics can affect a student's ability to be successful during their experience in Computer Science.

Goals and Commitments

Regardless if a student is enrolled in Computer Science or not, if they do not embody a sense of purpose and value within their chosen major, their chances of persisting within that major are extremely low. This is where student motivation is important, and where intrinsic and extrinsic factors can either help or hinder their ability to continue in the major. Intrinsic factors can be described as any internal motivations that a student has to do the work necessary to complete their major. On the other hand, extrinsic motivation comes from external factors such as stakeholders in a student's life that persuade them to choose a certain major, or a student choosing a major because they are following in the footsteps of someone they know. As the second step of his pathway to departure model, Tinto describes student characteristics and values as important factors that allow them to be successful in their desired major. After students have worked within their major and have gained experience in the major and at the institution itself, students are then tasked with revisiting their values, which assist in the decision-making process to stay or leave. The revisiting of goals and commitments happens after students are faced factors such as faculty-student interactions and student-student interactions, which can either hinder or enhance their motivation to persist in the major. Their decision to stay in or leave the major can also depend on their willingness to participate in these interactions. A student's lack of effort to fully immerse themselves in their major can show their lack of interest or perhaps their inability to succeed.

Institutional Experience

As the third element of Tinto's model, Institutional Experience discusses the impact that individuals in a student's life can have on their decision-making process. These interactions can be described as a student taking advantage of professor and teaching assistant office hours, creating study groups with students in their cohort, or utilizing additional lab assistance, if applicable. In addition to student interactions with these individuals, Tinto also emphasizes the benefit of a student's willingness to be involved on campus, whether it is through a job, extracurricular activities such as clubs and intramurals, or through volunteering at the institution or in the community. Overall, a student's sense of belonging and self-efficacy across their academic and social interactions can be deciding factors of retention in their major and their extracurricular activities, as well as their decision to stay at the institution.

As stated in the model and supplemented by Levin and Levin (1991) in their work on at-risk students, pre-college attributes, such as family background and socio-economic status (e.g. first-generation status), can contribute to motivation and success, or lack thereof, in their future endeavors at the institution. While family history is unavoidable for students as they begin their transition process to college, students are responsible for painting their path at a postsecondary institution. This, as Tinto portrays, requires motivation in order to be committed to achieving goals and connectedness during their integration into the institution. Goal achievement (Martinez, 1997) and connectedness with professors and peers in the program can also be affected by student motivation, whether it's intrinsic or extrinsic. Further, student motivation can be affected by student self-efficacy (Al-Harthy, Was, & Isaacson, 2010), believing in their ability to achieve. Without these contributing factors that assist students in their success, without successful performance within the major, it is impossible to visualize self-worth and accomplishment, leading to student departure from their program or institution entirely.

In addition to Tinto's dropout schema (1993), his further research depicts not only what factors contribute to students leaving, but also what can be done to help them stay (Tinto, 2006). This statement is comparable to the work being done for the current thesis, as it strives to analyze student persistence, their decision to choose certain pathways, and how to assist them in their success in the Computer Science program at the University of Maine. As Tinto's model focuses on pre-college attributes, psychosocial factors, and success variables, the model presented in this thesis follows similar guidelines. This model considers student pathways, whether they decided to stay within the Computer Science major and whether they decided to leave and categorizes them based on their decision. Further, the model considers student characteristics (previous experience, self-efficacy, success) as part of their decision-making process, which can, in turn, act as a predictive model for student outcomes in future cohorts.

As Tinto's model was originally utilized to identify potential reasons students decide to leave an institution, his model has been used in this study to understand student persistence in the introductory courses of their major. Because of the differences in usage of this model, it is important to express reasons for choosing an institutional model for a persistence study, as well as what limitations have risen during the process.

Justification

Tinto's Conceptual Schema for Dropout from College (1993) was originally created to understand the linear student pathway that students take through their college experience, and the decision that they make to either stay and graduate at their institution or leave entirely. Regardless if this model has been used over the years to understand institutional departure, it was helpful in this present study to understand student persistence in their majors. Firstly, Tinto's model expresses a linear pathway that students followed, which matched the layout of the model that I originally wanted to create for the present study. I wanted to create a basic linear expression of student pathways in Computer Science to have a preliminary understanding of movement and decision-making in introductory courses within the major. The linearity not only depicts the most common pathways that students take within the Computer Science major, but it also helps to understand what can positively and negatively affect their ability to successfully reach the end of the semester, pass the course, and their decision to continue on to the next semester of courses.

In addition to the linearity being a helpful component of this model of departure, the key factors within the model were particularly similar to the results from the present study, which lead to my decision to choose this model. Specifically, Tinto expresses that a student's background has great importance to how well they do in college, both academically and socially. This was also important to the present study, as a number of scholars in Computer Science (i.e., Biggers et al., 2008; Ott et al., 2018) insisted that a student's success is greatly determined by their previous computing experience. As this present study merely uses Tinto's model for inspiration, the factors that affect student decision-making will be altered to better fit the factors that specifically affect Computer Science students based on previous research and the results from this student sample set.

Limitations and Critiques

Through the years, Tinto worked to develop his Institutional Departure Model to further understand the factors that affect student persistence at their institution. Like many retention models, there are limitations to its ability to fully understand student pathways. For instance, Tinto's model of departure generalizes student pathways and persistence, which leaves no room for deviation from this linear model. Because of this generalization, the model does not leave room for nontraditional or diverse student populations but provides a model for the "traditionally" aged white student at American residential institutions. Critiques of Tinto's work include discussion on how he lacks "explanatory power in commuter colleges and universities" (Braxton, Hirschy, & McClendon, 2004; Braxton, 2019). This critique speaks to the limited population to which the departure model can provide guidance (residential, traditionally aged students), and the number of students that it leaves out (commuter, non-traditional students). Further, neglecting to understand diverse populations in this model indirectly creates factors of oppression, which can, in turn, affect persistence of students in these underrepresented populations. While Tinto's model can be helpful in understanding basic pathways of residential students at post-secondary institutions, it does not assist in fully grasping additional factors that can contribute to student success or failure. With that in mind, this model does not consider any transitions, expected or not, in a student's college career that could affect their ability to reach their goals. Further, retention models such as Tinto's must leave room for experiences that put student pathways at a standstill, disallowing them to continue for any number of reasons. A death in the family, needing to work full time to support family, or raising a child are few of the many reasons that can halt the linear pathway, and depict why many students' lives cannot be expressed by one linear pathway.

Another factor that Tinto's model overlooks is the future goals of the student. Tinto discovered in his earlier depictions of his work (1975) that he did not adequately discuss the differences in departure; whether a student transferred from their original institution or if they withdrew from the Higher Education system altogether. This makes it difficult to truly understand student motivation for leaving the institution, and what their goals are in the future. Without understanding a student's future goals, it is difficult to fully define their specific pathway leading up to their decision to stay or leave.

While Tinto's model provides a linear pathway analysis for students who decide to dropout, the thematic concepts within the model can be altered to discuss other pathways that students can take throughout their college career. Since there are also limitations and critiques of Tinto's model (i.e., Braxton et al., 2004; Braxton, 2019), it is important to be aware of these, and how they can affect the capabilities of this model, and any model inspired by it. This particular thesis examines the socio-economic, psychosocial, and success factors that affect student perceptions and performance within the Computer Science major at the University of Maine and categorizes their chosen pathways into three possible directions; continue in the program, persist in the program, or withdraw at any point in time. Similar to Tinto's more recent research on student retention (2006), this thesis examines not only what causes students to leave their program, but preventative measures and strategies that can be implemented to help students to stay and achieve their goals in Computer Science, or to assist them in making an informed decision on what pathway works best for them.

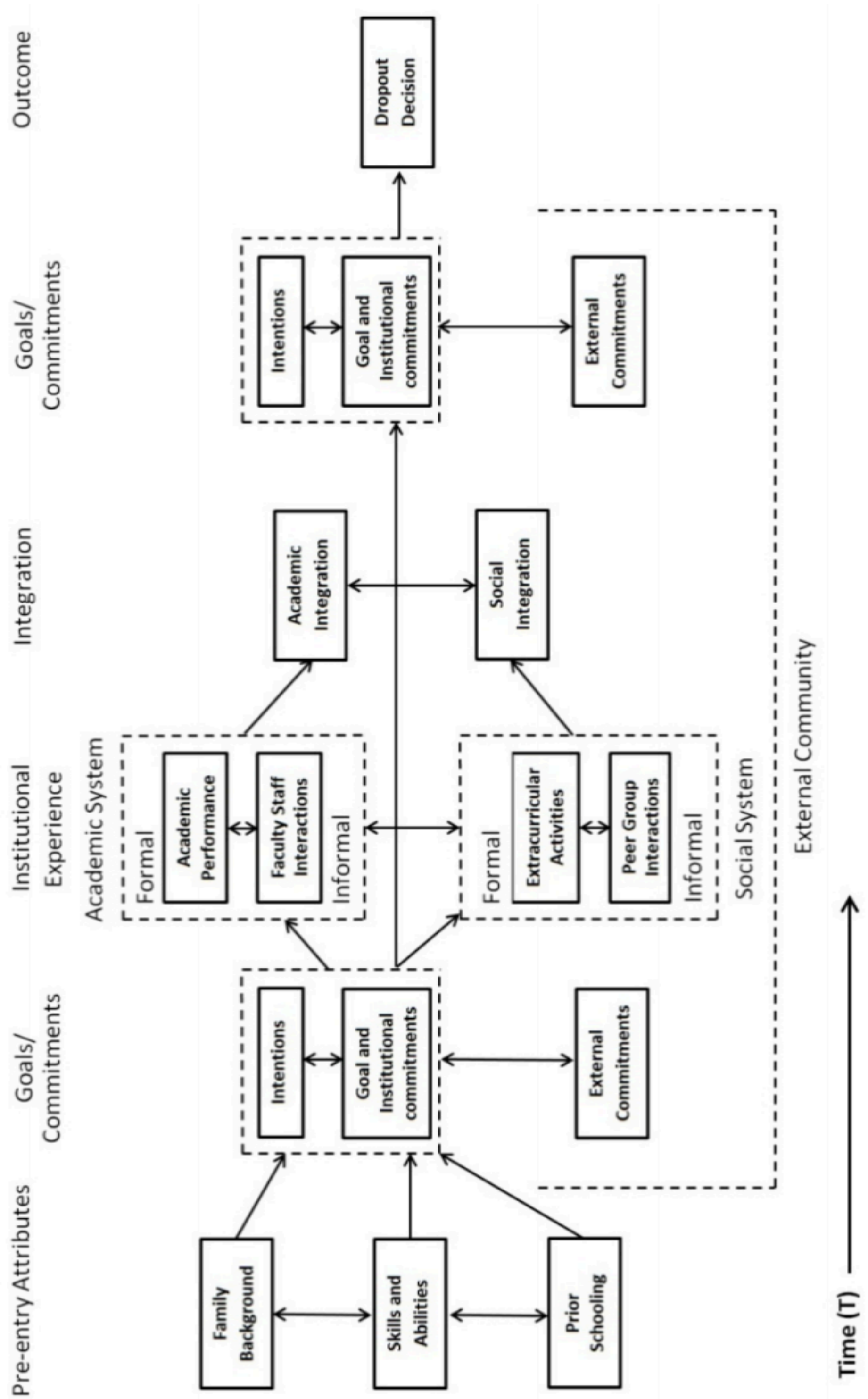

Figure 1. Tinto's Institutional Departure Model (1993).

Chapter 3

METHODS

Through examining previous studies done on students and their abilities, or inabilities to succeed in computing majors, the work Biggers et al. (2008) has done on comparing Computer Science graduating seniors and students who have left the major has proved to be the study that would inform the design of this present study. Similar to their study, investigations of first-year student experiences in their COS 125 course were analyzed using a mixed methods process. Through this previous research, a number of reasons why students leave the Computer Science major were discovered. Knowing the reasons why students stay or leave, as well as what practices successful students utilize to supplement their academics will "be useful in developing high impact initiatives" (Biggers et al., 2008) that have the ability to increase student retention and completion in Computer Science programs.

While there has been research done on why students stay or leave the Computer Science major, there has yet to be a distinction between the ones who stay; whether they are "continuers" (students who passed their intro-level courses and have decided to stay in the major) or "persisters" (students who did not pass their intro-level course and have decided to stay in the major). This distinction between "continuers" and "persisters" separates the motivations that the populations might have from each other, which could result in suggesting different preventative measures for the individual student populations. To address this gap in the literature, this study focused on the follow research questions:

1) What factors affect a students' ability to succeed in their introductory Computer Science courses?

2) What specific student populations, if any, struggle more than others, and how can these be addressed?
3) What are the characteristics of students who either continue, persist, or withdraw from the Computer Science major?
4) What preventative measures can be taken to increase student retention and completion within the Computer Science major?

Through this methods section of the study, I will discuss the population included in the study as well as why I used Maine as my site, and more specifically, the University of Maine. I will also discuss the methodology utilized for this study, and why a mixed methods study was deemed most affective for the work done for this study. From there I will discuss the various components of the study, and how I analyzed the results from each.

Maine Justification

As discovered in the literature, there are factors in the realm of Computer Science specific to the state of Maine, and the University of Maine that require more attention. Speaking to the University of Maine, their Computer Science program has had a high rate of students who either receive a grade of a D, F, withdrew, or received an L (left) from the course (DFWL) from the course, especially in introductory Computer Science courses (University of Maine). In the past, COS 125 has produced as high as a 50% DFWL rate in recent cohorts, as the students who left the major either switched to another major or left the institution completely. With this percentage of unsuccessful and departing students, there calls for further investigation as to why many students are not staying in the Computer Science major, as it affects the state of Maine's standing in producing qualified computing professionals.

In the state of Maine, there is a lack of student preparedness and interest in pursuing a Computer Science degree at a post-secondary institution. While Maine had 981 computing and technology job postings (2.0 times the average demand) in the past year, only 119 qualified students graduated with a Computer Science degree from a Maine university (State of Computer Science Education, 2018). In this day and age, professionals in the Computer Science field are extremely valuable. In 2017, 67% of all new job postings in the nation were in computing, while only 10% of graduating STEM majors held Computer degrees (National Center for Education Statistics (NCES IPEDS Completions Survey, 2017). In order to increase the number of skilled professionals, the root of the problem must be addressed; when are programs losing their Computer Science students, who are they losing, and why are they losing them? This study examines the reasoning behind the pathways that students take and how institutions can increase retention and interest across all student populations. This study also suggests that there be necessary attention given to students in primary and secondary schools, as there is a general lack of computing opportunities in the state of Maine, which affects numbers in postsecondary institutions, and overall graduation rates.

Specifically, in the state of Maine, there is no dedicated state funding for computing programs, as well as no requirements (K-12 curriculum standards) for primary and secondary schools to offer Computer Science programs (National Center for Education Statistics, 2018). In 2018, only 30 Maine schools provided AP courses that taught Computer Science content (23% of these test-takers were women) (State of Computer Science Education, 2018). As the importance of computing knowledge grows, scholars are regarding this knowledge as foundational skillsets that most adolescent and young adults should acquire. Similar to the time needed to learn a new foreign language or multiplication tables, it takes time to learn algorithms and new coding languages, as studies suggest that having skills in Computer Science are equal in value to having skills in reading, writing, and math (CODE.org, 2019). Gaining computing skills at a younger age increases student intuition and potential interest in the field of Computer Science.

As this study specifically examines students enrolled in the Computer Science major at the University of Maine, it can begin to interpret why there is a lack of qualification for computing professions in the state of Maine, and where attention should be focused to increase retention. The state of Maine is unique compared to other states, as it has one of the most rural populations in the nation. This rurality can contribute to the lack of opportunities for students in the field of Computer Science and can affect the number of students with early onset interests in computing. To identify this problem, this study can begin the process of creating initiatives that can produce more qualified graduates to take on these jobs in the state of Maine, and hopefully start the initiative to include more computing programs earlier on in student education. While this study focuses on students in a postsecondary setting, it provides opportunity for future discussion on the importance of Computer Science training earlier in a student's education. As the state of Maine greatly needs more qualified professionals entering the field of computing, research on the satisfaction and retention of students in computing disciplines is important now more than ever.

Requirements for COS 125

Before delving into the methodology of this study, it is important to be aware of the expectations of students to be qualified to take COS 125: Introduction to Problem Solving Using Computer Programs, and what grade they need to successfully pass the course to satisfy the Computer Science major requirements. In order to be eligible to take COS 125, a student needs to have passed part 3 of the general math placement exam administered by the university, or a grade of C or better in the pre-calculus course offered at the University of Maine. This means that a student must be ready to take Calculus I, either alongside COS 125, or having already taken it before enrolling in the introductory Computer Science course. In order to successfully pass COS 125, a student must receive a C or better in the course, regardless if they are a Computer Science major or minor. In order to be included in this present study, students must have been enrolled in COS 125 at the beginning of the Fall of 2019, which means they also qualified for Calculus I through placement exams or successfully completing previous courses.

Target Population

The target population for this study was first-year students (as of Fall 2019) with a declared major in Computer Science enrolled in COS 125: Introduction to Problem Solving Using Computer Programs, at the University of Maine. The collection of student data through surveys, focus groups, and interviews began in the Fall semester of 2019 and continued into the Spring semester of 2020. All students enrolled in COS 125 were expected to participate in the study, which also included non-Computer Science majors and upperclassmen. The responses from students other than first-year Computer Science students provided useful feedback on the introductory course, and also contributed outsider perspectives on this specific Computer Science course. During this study, there was no exclusion of data based on student demographics. For example, while there is a known difference in the persistence between male and female students, it was important to be aware of the gender gap during the present thesis, particularly in the realm of Computer Science. Further, it was critical to be aware of how the specific student population in the present study persisted, rather than expecting their results will be similar to the results of previous similar research. Through the duration of this study, any biases based on gender identity, race, ethnicity, or age were taken into account. It was important to be aware of these biases, particularly those that were specific Computer Science biases identified in research does in the past. In order to mitigate the biases within this study, demographic questions were asked at the end of the surveys rather than at the beginning so any potential anxiety over their characteristics affecting how their responses were received would hopefully be alleviated. While executing this study, it was prudent to gather student information without hindering their emotional safety.

Research Design and Process

Through this mixed-method study, both qualitative (focus groups, interviews, and write-in survey questions) and quantitative (historic data and Likert scale questions from surveys) were utilized to gather enough supplemental data to understand the characteristics, opinions, and abilities of the Fall 2019 cohort in introductory Computer Science courses. It was important to utilize this method in order to reach as many students as possible through both the online surveys and the in-person meetings. The mixed method also helped to gain multiple forms of data, both in-depth anecdotes from the focus groups and interviews as well as a larger volume of answers from multiple choice and Likert scale questions. With this method, it was easier to fully understand the student population, and to gain a holistic view of the factors that affect their success. In order to gain more information on this specific population, this study also followed social constructivism in order to understand the "multidimensional individual, relational, collective, and material identities" (Patton, Renn, Guido, & Quaye, 2016) of these Computer Science students. This research paradigm allowed me to understand the development of the students' knowledge based on interactions with others, and how these students learned through shared social and cognitive processes in their Computer Science courses. Throughout the methodology section of this study, the design process describes the utilization of these methods to ensure a holistic understanding of the student population within the Computer Science major, and to further understand the factors that affect their success.

Recruitment

Throughout the duration of this study, students were asked to participate in surveys, focus groups, or interviews to answer questions about their experiences in COS 125 in Fall 2019. The method for recruiting these students for each portion of the study, as well as when each component was administered, are described below.

Surveys

During the Fall 2019 semester at the University of Maine, students were asked to participate in two surveys; one at the beginning of the semester and one at the end of the semester, in order to compare their opinions of the introductory Computer Science course as well as the Computer Science major in general as they persisted throughout the semester. In September 2019, all students enrolled in COS 125 (n=114) were contacted by their professor, Penny Rheingans, via email to participate in a 24-question preliminary survey through Google Forms. In order to ensure a higher participation rate, Rheingans delivered the survey as a mandatory assignment for all students in her COS 125 course; a 10-point assignment at the beginning of the semester. The preliminary survey was also sent out to two additional introductory courses within the Computer Science program; COS 120: Introduction to Programming I and COS 140: Foundations of Computer Science. The purpose of this method was to receive a general understanding of student perceptions of the major as a whole, whether they were incoming CS students, seasonsed CS students, or students from other majors. From the pre-survey, a totally of 107 students replied, specifically those enrolled in only COS 125 or both COS 125 and COS 140 (n=87), and COS 120 and/or COS 140 (n=20). Specifically speaking towards students enrolled in COS 125 (CS and non-CS majors), this resulted in a 76% response rate. Answers from COS 125 students (n=87) were siphoned out from the overall sample set in order to understand the specific effects that COS 125 had on its students. Results from students enrolled in COS 120 and COS 140 were also siphoned and sent to the respective professors teaching the courses to identify any specific characteristics and needs of their current student population.

The post-semester survey, released in December 2019 during the Fall semester finals week, was administered in the same manner as the preliminary survey; students (n=114) were invited to participate in a 23-question Google Form, via email by Rheingans, and was offered as another 10-point mandatory assignment they had to complete by the end of the semester. The post-survey was only sent out to students in COS 125, as other course-specific surveys were sent to the professors of both COS 120 and COS 140 to send out to their students, if they chose to do so. This strategy was utilized in order to receive student responses that were specific to the material offered in each course. In total, 49 students participated in the post-survey, 29 of these students were also Computer Science majors. In total, the post-survey had a 43% response rate (including non-Computer Science students), and a 25% response rate from Computer Science students only. Additionally, questions pertaining to the lab sections of COS 125 were able to be asked during the post-survey, as COS 120 and 140 did not include lab sections. For the post-survey for COS 125, Rheingans made sure to send invitations to students who had withdrawn from the course during the Fall semester to ensure that their opinions and comments were heard alongside students who stayed in the course. Table 1 (below) summarizes the student response rates from each administered assessment tool.

	Students Invited		**Students Participated**	
Assessment Tool	n	%	n	%
Pre-Survey	114	100%	87	76%
Post-Survey	114	100%	49	43%
Focus Groups	114	100%	4	4%
Interviews	114	100%	8	7%

Table 1: Student response rates from assessments tools.

Focus Groups and Interviews

During the Fall 2019 semester, students were invited to participate in either a focus group or interview regarding their experiences in COS 125 and the Computer Science major as a whole. Invitations via email were sent out to students at the beginning of November by Penny Rheingans to participate in the discussions. A brief Google Form was attached to the email, asking if the student was interested in participating, and if they would prefer participating in a focus group or an interview. At the end of the questionnaire, a hyperlink to appointment slots via Google Calendar was provided. Each appointment window was an hour long and were held in Rheingans' lab in Boardman Hall. In order to increase the number of participants in the focus groups and interviews, Rheingans offered end-of-the-semester extra credit to students who participated.

These focus groups and interviews continued into the Spring 2020 semester with the same populations of students; first-year Computer Science majors (as of Fall 2019) who had taken COS 125 in the Fall of 2019. As these students were no longer in a course with Rheingans, any student who participated in the Spring of 2020 did not receive extra credit. To increase the rate of participation, second-year students (started in Fall 2018) were asked to participate in the focus groups and interviews (whether they continued in the Computer Science major or not), to provide feedback on their experiences in COS 125. These students were also asked to reflect on how their experiences in COS 125 prepared them for their future courses in the Computer Science major. Through conducting the focus groups and interviews, one focus group was conducted with four participants, and eight interviews were conducted with individual students (n=12 in-person connections). Table 1 (above) summarizes the response rate from students in both the focus groups and interviews. I conducted both the focus groups and the interviews and then transcribed the qualitative data from the connections made with the students.

Procedures and Instruments

Surveys

This survey platform through Google Forms was chosen for 1) its accessibility to University of Maine students, 2) its email-collection tool, and 3) the ability to easily convert the data into Excel. Before students began the surveys, an introductory message was provided at the top of the Google Form (see Appendices A and B). Both the preliminary and post-surveys included a mix of open-and-closed-ended questions, addressing both the students' personal and academic experiences in Computer Science. Questions that were asked in the preliminary survey (see Appendix A) addressed student preparation for the introductory Computer Science course as well as their preconceived perceptions of the major in general. Questions from the pre-survey included:

- What have you done in relation to CS prior to this class? List any programming languages and software that you have used in the past.
- Why have you chosen Computer Science to be your major? Or, what other major did you choose and why?
- What is your level of confidence that you will do well in your CS courses this semester?
- How confident are you that your educational background has prepared you for your CS courses this semester?

The preliminary survey recorded student demographics, such as their place of residency (in-state, out-of-state, or international), family educational background (first-generation status), and gender identity. In the effort to make students as comfortable as possible during their participation in the pre-survey, and to avoid any known biases, the question concerning gender identity was the last question asked in the survey. This strategy was utilized so that students would not feel that their gender identity was immediately attached to their responses. With the exception of the demographic identifiers listed above, students were not asked about their age, race, and ethnicity so that they could focus on answering the course- and major- specific questions, rather than their identity and how they could be perceived. In order to collect this additional demographic data, a data request was sent to the Office of Institutional Research and Assessment.

Questions asked on the post-survey (see Appendix B) addressed course-specific experiences, their confidence in their abilities to succeed, and their levels of self-efficacy. These questions included, but were not limited to:

- How confident are you that your educational background prepared you for COS 125?
- Did taking COS 125 increase or decrease your interest in taking additional courses in this department?
- Did you feel a sense of belonging in the CS major?
- Do you have any suggestions for next year's COS 125 class (content, teaching style, homework assignments, etc.)?

Apart from the student names and email addresses, no identifying information was asked through the post-survey, as that information was gathered through the preliminary survey.

The open-ended questions in both the preliminary and post-surveys provided a clearer idea of student experiences within the major, and COS 125 in particular. This also allowed for more qualitative data from students, especially if they did not participate in the focus groups and interviews. The close-ended questions were supplemental in providing additional personal identifiers to paint a more definitive picture of where students come from, who they are, and how these characteristics can affect one's performance in the Computer Science program.

Focus Groups and Interviews

Commencement of focus groups and interviews during this study began in November of 2019 and continued into the Spring of 2020 (Acquired IRB approval in June 2019 to conduct focus groups and interviews; approval number: 20019-03-17). Each interview that was conducted with individual students took approximately 30-minutes to complete, while the focus groups, which were expected to include between 4-6 students, took approximately 60 minutes to complete. Each session was recorded via an Apple MacBook Pro laptop using the Voice Memo Application. Recordings of each session were saved to a file, and kept confidential, as the laptop remains password protected. For efficient transcribing, the text-to-word function on Microsoft Word was utilized during each focus group and interview. While text-to-word does well with recording full words and sentences, a second review of the transcription was needed to include any additional noises from the participants. This helps to further understand the emotions behind the answers that students provide during the focus groups and interviews. Before each interview or focus group, the script was read aloud (see Appendices D and E) to each student involved. In general, students were able to answer any question that they chose, while being able to avoid questions that they were not comfortable with answering.

Conducting focus groups and interviews allowed students to elaborate on questions similar to those asked on the pre- and post-surveys, as well as additional questions that were not asked as part of the surveys. Various questions requested students to delve into their experiences and opinions of the COS 125 course and the Computer Science major in general, while allowing them to reflect on how their personal characteristics might have affected their performance. Sample questions asked during both the focus groups and interviews include:

- Were your expectations at the beginning of the Fall semester accurate to what the semester was actually like?
- What parts of COS 125 stood out to you/piqued your interest? What felt irrelevant?
- What concepts in the courses were particularly challenging for you?
- What did you wish was included in the COS courses? What would have helped you succeed?

During the focus groups and interviews, students from underrepresented populations, specifically in Computer Science courses (female, first-generation, Black, Hispanic) were asked to unpack their experiences in the program with their personal characteristics in mind. This helped to further understand these student populations, who, in previous research, proved to have struggled in Computer Science programs, mainly due to the lack of diversity, resulting in a lack of belonging. Finding thematic evidence from these populations, and from the overall student population enrolled in COS 125 will help to discover practices and policies that can be implemented to adhere to the diverse needs in order to promote student success.

Data Requests

In order to understand student pathways in Computer Science over the years, requested data from the Office of Institutional Research and Assessment (OIRA) provided historic data from past cohorts, ranging from Fall 2009 to Fall 2019. An updated version of the IRB included the data request that was sent to the OIRA (re-approved on November 14^{th}). In this longitudinal data, each row was dedicated to a student who started out with a Computer Science major, and either continued on in the major, switched to another major, or left the university completely. Columns within this dataset depicted either a demographic data point (gender, ethnicity, first-generation flag, and residency status), information on math experience (math placement scores, first and second math courses taken, final grades in said math courses), and each student's outcome in regard to Computer Science. Student outcomes were coded on a scale from 1 to 5; 1 = Graduated in COS, 2 = Graduated in different major, 3 = Still active in COS, 4 = Still active in different major, 5 = Left the institution without graduating. The data also depicted student activity each semester, creating a visual representation of the individual pathways each student pursued, telling the story of their coded outcome.

Historical data from the Office of Institutional Research and Assessment provided necessary supplemental material to enrich the present study with current first-year Computer Science students. Analyzing the pathways that past students took helped to predict the pathways that current and future students could take. Further, this could help to focus on specific points during the Computer Science major that may be particularly challenging for students and figure out why that might be the case. Who is most likely to leave? When are they most likely to leave? And where are they going?

Data Analysis and Coding

Surveys

Once surveys were closed to students, data from the Google Form was exported to an Excel sheet, which organized the data with a row dedicated to each student and their personal responses. While the survey included multiple choice, Likert scale, short answer, and long answer questions, different analyses were utilized to illuminate all potentially significant data points. Firstly, the data was filtered in order to detect any at-a-glance data points and themes that were compelling. From there, the data was cross-tabulated, specifically categorizing student populations that have been researched in the past; female students, first-generation students, and white male students, for comparison. This cross-tabulation analysis was utilized when working with the ordinal data from the survey (Likert scale). Correlations were drawn between the differing student populations, such as their sense of belonging and their confidence in their performance.

With the open-ended questions from the survey, student answers were extracted and mapped out and coded in order to find commonalities and themes in student responses. A framework analysis provided structure to this process of coding themes, as it highlighted stages of "indexing and charting" to manage and organize the qualitative data, by "pasting" like-quotes together (Ritchie & Spencer, 1994). This step was mandatory before deciding which common themes were most prevalent and relevant amongst the student responses. While themes from former research was deductively extracted, special attention was given to the inductive themes that emerged as to not neglect potentially important data points that could enhance the present study.

Through the analysis of the pre- and post-surveys, student answers from the pre-survey were not directly matched to their answers in the post-survey. Rather, students were categorized by their pathway (continuer, persister, or withdrawer), and then the answers from each group were matched between the pre- and post-surveys. This can be described as a limitation to this study, as student pathways would be better interpreted if their answers were directly matched in the two surveys. However, it was difficult to execute this direct matching, as there was an immense decrease in participation in the post-survey, which made it challenging to match student answers. To enhance the data from the surveys, student anecdotes from the focus groups and interviews were supplemental in uncovering in-depth student answers to their experiences in the course.

Focus Groups and Interviews

As focus groups and interviews were conducted, the recorded sessions were transcribed during and after the student interactions. Specifically speaking, verbatim transcription was used to record the sessions, in order to convey the emotions and current state of the interviewees as accurately as possible. Similar to the open-ended answers from the pre- and post-surveys, the transcribed answers from students participating in the focus groups and interviews were then coded using framework analysis; categorizing each student response into potential themes and selecting practically and statistically significant themes from the groupings. While coding the results from the focus groups and surveys, themes were ultimately inductively coded, in order to stay aware of all student opinions and experiences in COS 125 and the major as a whole. Additionally, in order to stay in line with Tinto's model and the conceptual framework, themes were also deductively coded, keeping in mind the factors that affect a student's ability to succeed, such as their pre-entry attributes, goals and commitments, and institutional experiences. In addition to the themes extracted from Tinto's model, student responses began to be categorized for the model that has been created as a part of this current study. The categories of "continuers," "persisters," and "withdrawers" were constantly revisited to discover significant differences between student responses based on these characteristics.

Positionality Statement

While I have not always been interested in researching Computer Science students, I have had a continuous interest in understanding student retention and success, and what factors contribute to their reasons for persisting or leaving. After doing some research and assessments of the Computer Science major, specifically at the University of Maine, I discovered the vast difference in retention and diversity compared to other majors at the university. This sparked motivation to visit this issue, to see if I could incorporate my interests in assessment into helping to increase student satisfaction and retention within the Computer Science major.

With regard to my own identity and gender, it is important to me that women are supported and heard. Through this study, students were given a chance to express their opinions of their introductory courses in the Computer Science courses. Especially for students who can be described as underrepresented minorities in Computer Science programs, female student included, this provided them with an opportunity to express any challenges that arose for them being minoritized populations. Additionally, as a white person, it can be difficult to fully understand the hardships of ethnically and racially minoritized groups, yet it is equally important to be an advocate, by providing a chance for all students to express their experiences in their courses.

Summary

Through the analysis of student responses in the surveys, interviews, and focus groups, conclusions can be drawn to categorize the pathways that students take after their first semester in Computer Science, and what student characteristics coincide with these pathways. From analyzing these student characteristics, the creation of a model depicting students who are either “continuers” “persisters” or “withdrawers” to demonstrate the different motivations for staying or leaving the major. From this, new suggestions for initiatives can arise to assist specific student populations in finding what support they need in order to be successful in the Computer Science major; what are successful students doing differently apart from unsuccessful students, and how can these behaviors be adapted to be achievable for different student populations.

Chapter 4

RESULTS

This study addressed four research questions: (1) What factors affect a students’ ability to succeed in their introductory Computer Science courses? (2) What specific student populations, if any, struggle more than others, and how can these be addressed? (3) What are the characteristics of students who either continue, persist, or withdraw from the Computer Science major? (4) What preventative measures can be taken to increase student retention and completion within the Computer Science major? In this chapter, I strive to answer each of these questions by analyzing sections of Tinto's model of departure (pre-entry attributes, goals and commitments, and institutional experiences) and categorizing student characteristics based on their chosen pathway (continue, persist or withdraw from the major). From there, a major-specific predictive model will be created based on these student characteristics and their differing reasons for staying in or leaving the major. Analysis of the surveys, focus groups, and interviews as well as historic data allowed for a closer look into what factors can contribute to a student's success within the Computer Science major at the University of Maine, and what factors can potentially contribute to student departure.

Student Population Analysis

The demographic statistics of the current population expresses the lack of diversity within the Computer Science major. As Computer Science, in general, is known for having a lack of diversity in regard to gender, this specific cohort at the University of Maine mirrors that statistic. From the data gathered on the current cohort of Fall 2019 enrolled in COS 125 (n = 73), 84% identify as male (n = 61) and 12% identify as female (n = 9). In addition to this binary statistic, this cohort also included 4% (n = 3) students who identified as either non-binary, transgender male, transgender female, or preferred not to have their gender identity recorded (these identifiers were grouped together to ensure privacy, as it was a smaller sample size). This distribution of gender identity data was already expected, as Computer Science programs, as well as various computing and programming companies across the nation face this gender gap. This data was available through the preliminary survey that students took at the beginning of the fall semester. If a Computer Science student did not take the pre-survey, their professor Penny Rheingans possessed the supplemental data in order to fill the gaps if necessary.

Another demographic data point that was extracted from the pre-survey was residency. This was an interesting factor to analyze, specifically when it comes to the Computer Science major as a whole. This particular major stands out as bringing in more in-state students than out of state and international students compared to similar STEM majors and a number of non-similar majors at the University of Maine. That being said, the Fall 2019 cohort mirrored this in the responses from Computer Science students in the pre-survey (n = 60) with 77% in-state students (n = 46), 17% out of state students (n = 10), and 7% international students (n = 4). A reason for this decreased percentage of out of state and international students could have something to do with financial aid packages offered by the University. The New England Board of Higher Education (NEBHE) Regional Student Program provides additional financial aid to students in New England who wish to attend the University of Maine with a certain major that is not offered at their home-state flagship. As many STEM majors are included in this program (depending on the state), Computer Science is not listed as a compatible major. While a large portion of the University of Maine’s out of state student population comes from other New England states, this could be a reason for the lack of out of state students for the Computer Science major as well as other majors not included in the NEBHE program.

Pre-Entry Attributes

As Tinto described in his model of student departure, pre-entry attributes can be described as a student's previous exposure to academic content, their family background, and their personal skills and attributes. Through this section of the analysis, students are categorized according to their pathway, whether they decided to stay or leave, and focuses on their unique characteristics according to their pathway in comparison to the other pathways. This will, in turn, showcase differences in student characteristics, and why they choose to stay in the major or leave.

Previous Experience

Overview of previous experience

The preliminary survey gave students who were enrolled in COS 125 the chance to discuss their previous experience with computing, and what kind of experience they have been exposed to. Initially, CS students who participated in the survey (n = 60) were asked about their type of experience they had prior to enrolling in COS 125; no experience (8%; n = 5), learned a little on their own time (13%; n = 8), learned a lot on their own time (3%; n = 2), had one formal CS course (32%; n = 19), or had more than one formal CS course (43%; n = 26). Students were able to select more than one of these options as well as write in their own responses if they wished. A common combination included students stating that they learned a lot on their own time as well as being in one or more formal CS courses. While only a few students wrote in their responses, some responses included learning basic concepts on YouTube, having a job in the field, or that they had family members who work in the field. While there were only a handful of students that stated that they entered COS 125 with no experience, it is still important to be aware of the limitations they can face compared to those who have either a little or a lot of experience. As I further discuss the pre-entry attributes of Computer Science students analyzed in this study, I begin to discuss the factors that most commonly affected the students who participated in this study. From there, I begin to construct the student pathway model inspired by Tinto's institutional departure model.

First-Generation Status

Out of the students that were both enrolled in the Fall 2019 COS 125 cohort and were declared Computer Science majors (n = 60), 30% of these students (n = 18) were identified as first-generation (their parents have not completed a 4-year Bachelor degree or higher), and 70% identified as non-first-generation students (n = 42). During the focus groups and interviews, students were also asked about their first-generation status and if they would like to share about how that has affected their ability to perform in the Computer Science courses. One student described their experience as “challenging,” as they had no prior experience with computers before entering the major. They discussed how they might have had it easier if one of their family members had experience in the field, or if they had “more access to computers growing up.” If they had access to computers earlier on in their life, they mentioned how they could have had a better understanding of Computer Science in general or could have gained an interest in them sooner. Most of these students who defined themselves as first-generation students also were more likely to declare that they were entering the Computer Science program with little to no experience in computing. This can describe their limitations and struggles as two-fold; their inexperience with the knowledge of computing as well as their lack of knowledge of college in general.

Pre-Entry Attributes and Student Pathways

The creation of this model inspired by Tinto’s model of departure begins with the pre-entry attributes that students bring with them as they enter their institution. Specifically speaking toward Computer Science students, their pre-entry attributes can either assist in their success in introductory courses or hinder their ability to succeed, whether they have previous experience with computing, or they are first-generation students. During this present study students who, at the end of the semester, passed COS 125 and decided to continue on in the major, as well as students who did not pass COS 125 and decided to persist in the major both were more likely to have taken one or more formal Computer Science courses. This shows that, in this present study, previous experience was not a factor in a student’s decision to persist and continue on in the major, regardless of their final grade in COS 125. As there was not enough data about students who withdrew from the course and their previous experience, no conclusions can be made on how their previous experience affected their ability to succeed or stay within the major.

In terms of first-generation students, there were no statistically significant differences in student decisions to stay or leave the major. However, 38% of student who identified as first-generation did not pass the course. While many still decided to persist in the major, this shows that first-generation students are still at a higher risk of not doing well in their introductory Computer Science courses.

Below is the first portion of the Computer Science-specific pathway model (Figure 2.1), as it begins to express each categorized student pathway, as well as the "red flags" that express student characteristics that are potential at-risk factors. Throughout the remainder of the study, each part of the pathway model will be added in the respective section.

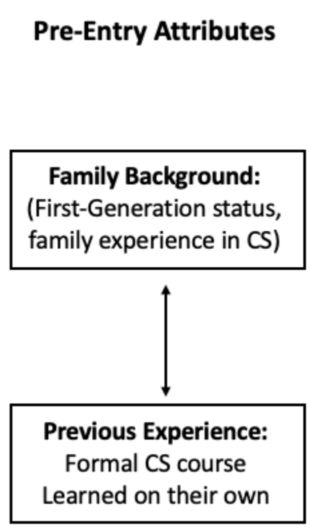

Figure 2.1: Pre-entry attributes addition to pathway model.

Goals and Commitments

During the focus groups, interviews, and surveys, students were asked why they enjoyed Computer Science, and why they decided to choose it as their major at the University of Maine. For this present study, students were divided into the three categories that drive this study, “continuers,” “persisters,” and “withdrawers,” in order to find any prevalent differences in their motivation to choose Computer Science as their major, as well as their motivation to enroll in COS 125. Below is a table that provides a list of coded themes from students describing their reasons for choosing Computer Science (see Table 1) categorized by their pathways. This qualitative data provides another factor into describing the different characteristics for each student population and their pathways.

”Continuers” (n = 36)	“Persisters” (n = 13)	“Withdrawers” (n = 7)
I enjoy Computer Science	Job opportunities and get paid well	Computers interest me
Many job opportunities	Interest in the major	No shortage of job opportunities
CS skills are necessary everywhere/job flexibility	Important skill set for the field/flexibility	Overlap with other major
I’m good at it/I have previous experience	Family member in Computer Science	
I enjoy problem solving		
Working toward my career/degree goals		

Table 2: Student reasons why they chose Computer Science.

These responses from students provide a look into their personal reasons for choosing Computer Science as their major. While students who are categorized as “continuers,” “persisters,” and “withdrawers” answered relatively similarly when asked about their reasons for choosing the Computer Science major, there are subtle differences in their responses that can express differences in motivation for choosing this specific major.

Continuers

A number of the “continuers” were genuinely *interested in Computer Science* in general, but also stated that they were attracted to the *well-paying jobs that the field had to offer*, as well as the *plentiful job opportunities*. Some "continuers" stated that they chose the major because they were either *good at it, or they had previous experience* in the field. This can paint the picture of this student population (1) doing well in the major because they've had previous experience and (2) deciding to stay in the major as they know they are good at the major and will succeed. Additionally, these students found intrinsic motivation in their work, as many of them stated that they *enjoyed the problem-solving aspects* of Computer Science. Through the responses of the "continuer" student population, it is prevalent that students have both intrinsic and extrinsic motivation when discussing their reasons for being in Computer Science and their goals for the future.

Persisters

Students who are categorized as "persisters" expressed similar reasons to the "continuers," as their motivation was represented as both intrinsic and extrinsic. Similar to the "continuers," "persisters" top three reasons for choosing the Computer Science major was based on *job opportunities and getting paid well,* their *interest in Computer Science,* and the *flexibility of the job* as well as the *skillset* that is necessary for many fields. Different from the responses of the "continuers" and "withdrawers," some of the "persisters" also stated that they chose the Computer Science major because they have family members or friends that work in the field. This shows that some of the "persister" population is choosing the major based on (1) what others have said about the field and (2) what kind of job they have. Similar to the "continuers" the reasons expressed for choosing the major describes the types of motivation they had when making their decision.

Withdrawers

Like the "continuers" and "persisters," the students who withdrew from the program chose the Computer Science major because they had an *interest in Computer Science* and because of *the* *job opportunities* that the field has to offer. In addition to the “withdrawers” reasons, a few students found themselves choosing Computer Science because it *overlapped with another STEM major*, allowing them to gain experience in both. This can express the distance that students have from the Computer Science major. While some students still have an interest in Computer Science, some are in the major to fill gaps in other majors, specifically if they are a double major.

Goals and Commitments and Student Pathways

Tinto describe a student’s goals and commitments as what drives them to choose their major or program, and what motivates them to stay within this major. This can also be described as students having a sense of purpose in their work, which requires motivation to do the work. Student motivation can be seen through their reasons for choosing a major, their reasons for staying in a major, or in their reasons to leave the major. Tinto’s model inspires this present study to depict the pathways of “continuers,” “persisters,” and “withdrawers” as they make decisions about their major based on their personal reasonings and motivations. Below is the next step in Tinto’s model (Figure 2.2), goals and commitments, based on Computer Science-specific motivations for each student pathway. This provides an analysis of the different motivations that students possess when entering a major and deciding if they are going to stay in the major or not.

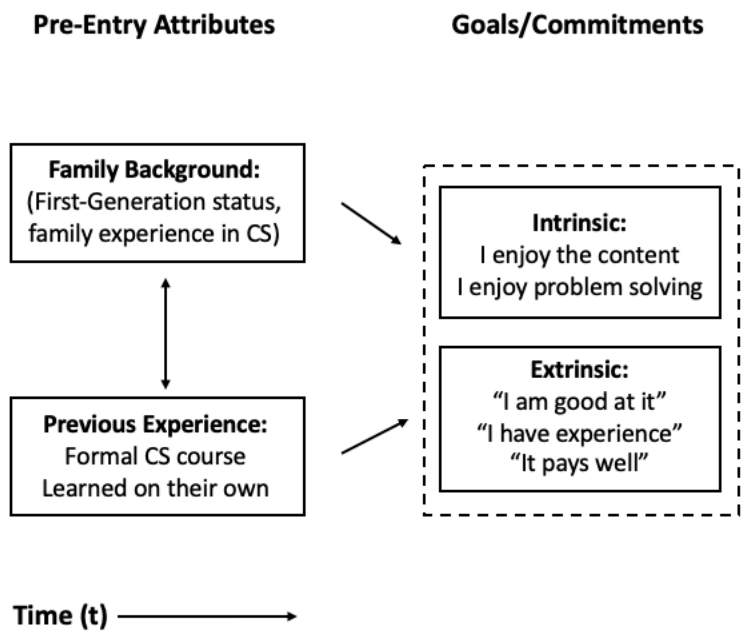

Figure 2.2: Goals/Commitments addition to pathway model.

Institutional Experience

This section of the analysis mirrors Tinto's model of departure and its section on institutional experience. Within this section, there are a number of factors that can affect a student's ability to succeed (e.g. interactions with their professor or teaching assistants, how often they utilize resources available to them, and feeling a sense of belonging and support in their courses and the major as a whole). More often than not, these factors rest on the shoulders of the students, as it is their responsibility to take advantage of the resources available to them. Adversely, institutions may lack the necessary resources for students to be successful and be supported. It is important to be aware of any gaps in programs, and how they can be filled to adapt to specific student needs.

Sense of Belonging

As a part of the post-survey, students were asked two questions that were relatively similar in content but received different answers from the participants, (1) did you feel a sense of belonging in the CS major? (2) did you feel that you had the support you needed to succeed? These were asked in the form of Likert scale questions on a five-point scale (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree). In the effort to express any differences between students who took different pathways, the responses between students who “continued” and those who “persisted” in the major were compared. Students who withdrew from the major did not answer these questions as they did not participate in the post-survey. Students who were defined as “continuers” expressed an average Likert score of 3.9, or that they “agree” when asked if they felt a sense of belonging in the Computer Science major. For students who were defined as “persisters,” their average Likert score for feeling a sense of belonging was 3.8, or that they “agreed” to the question. While their answers are not statistically significantly different. With regard to students feeling that they had the support they needed to succeed, both “continuers” and “persisters” had an average Likert score of 4.2, or “agree” when asked about the support that they felt. While there was little to no difference between the responses of “continuers” and “persisters” when asked about feeling like they belonged or felt supported, this can show similarities in the motivation that students have when deciding to stay in a major, regardless of their grades in introductory courses.

Utilizing Resources

With regard to the types of resources that were available to all students enrolled in COS 125, students were asked about how often they found themselves utilizing these resources. This question was asked on a 5-point Likert scale (1=Never, 2=Rarely, 3=Sometimes, 4=Often, 5=Always). Students were also able to state, “not applicable” (N/A), if they felt the resource was not available to them. Below (see Figure 3) depicts the difference between students who were “continuers” and those who were “persisters,” and how often they utilized the resources available to them. Interestingly, differences between the student populations stood out in their use of in-person and online resources. Students who were defined as “continuers” were less likely to utilize the internet to help them with assignments, while students who were defined as “persisters” were more likely to utilize online resources over in-person resources. As “continuers” were more likely to utilize in-person resources, they were specifically more likely to converse with the professor and the teaching assistants of COS 125. Both “continuers” and “persisters” took similar advantage of the Computer Science lab which is located in Boardman Hall. This was a TA-run lab that students could go to during regular office hours if they needed assistance on an assignment or were looking to prepare for an exam. Students who also participated in the focus groups and interviews mentioned that they found themselves utilizing the Boardman Lab, as it provided the most amount of support during difficult assignments.

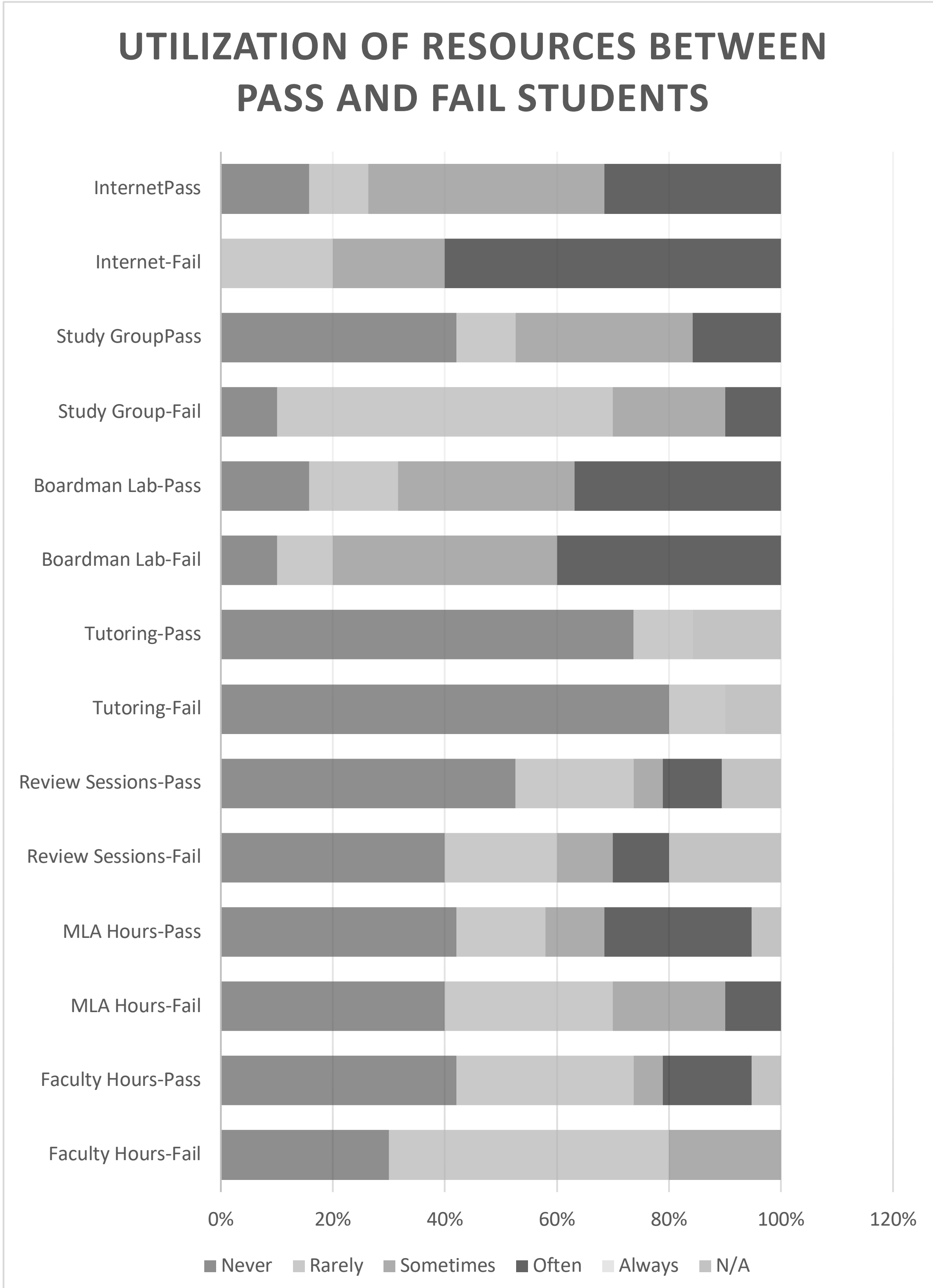

Figure 3: Comparison of “continuers” and “persisters” utilizing available resources.

Adjective Responses

On the post-survey that students received, they were asked to relate a variety of adjectives (see Table: 2) to their experience during the course. This set of eleven adjectives allowed students who were either "continuers" or "persisters" to reflect on their experience in the course, whether it was positive or negative. "Withdrawers" were not included in this table as there were no students who withdrew from the course who took the post-survey at the end of the semester. For this question, students were asked to rate these unique adjectives based on a five-point Liker scale; 1=Never, 2=Rarely, 3=Sometimes, 4=Often, 5=Always. As depicted in the table below, students who were more successful, or those labeled as "continuers" were more likely to state that they felt "comfortable" and "confident" more "often" than students who did not do well in the course, or those labeled as "persisters." Adversely, these students categorized as "persisters" were more likely to state that they were "challenged," "stressed," and "worried" during their Fall 2019 semester. These adjectives can express differences in how students learn and engage in their course, and how that can, in turn, affect their performance in the course.

	"Continuers"		"Persisters"	
	Average	Mode	Average	Mode
Challenged	Sometimes	Sometimes	Sometimes/Often	Often
Comfortable	Sometimes/Often	Sometimes	Rarely/Sometimes	Sometimes
Confident	Sometimes/Often	Sometimes	Rarely/Sometimes	Sometimes
Discouraged	Rarely	Sometimes	Rarely/Sometimes	Rarely/Sometimes
Excited	Sometimes/Often	Sometimes	Sometimes	Sometimes
Engaged/Involved	Sometimes/Often	Often	Rarely/Sometimes	Sometimes
Isolated	Rarely	Never	Rarely/Sometimes	Sometimes
Prepared	Sometimes	Sometimes	Rarely/Sometimes	Sometimes
Stressed	Rarely/Sometimes	Sometimes	Sometimes/Often	Often
Supported	Sometimes/Often	Sometimes	Rarely/Sometimes	Sometimes
Worried	Rarely/Sometimes	Sometimes	Sometimes/Often	Often

Table 3: Student responses to adjectives that may/may not describe their experiences.

Student Pathways and Institutional Experiences

As the third step in Tinto's departure model comes into play (see Figure 2.3), it expresses how institutional experiences can greatly affect a student's ability to succeed. While it is important for students to interact with their professors and TAs as well as feel a sense of belonging and support, it is also important for students to be involved in other activities, on or off campus. This can include having a job or participating in various clubs.

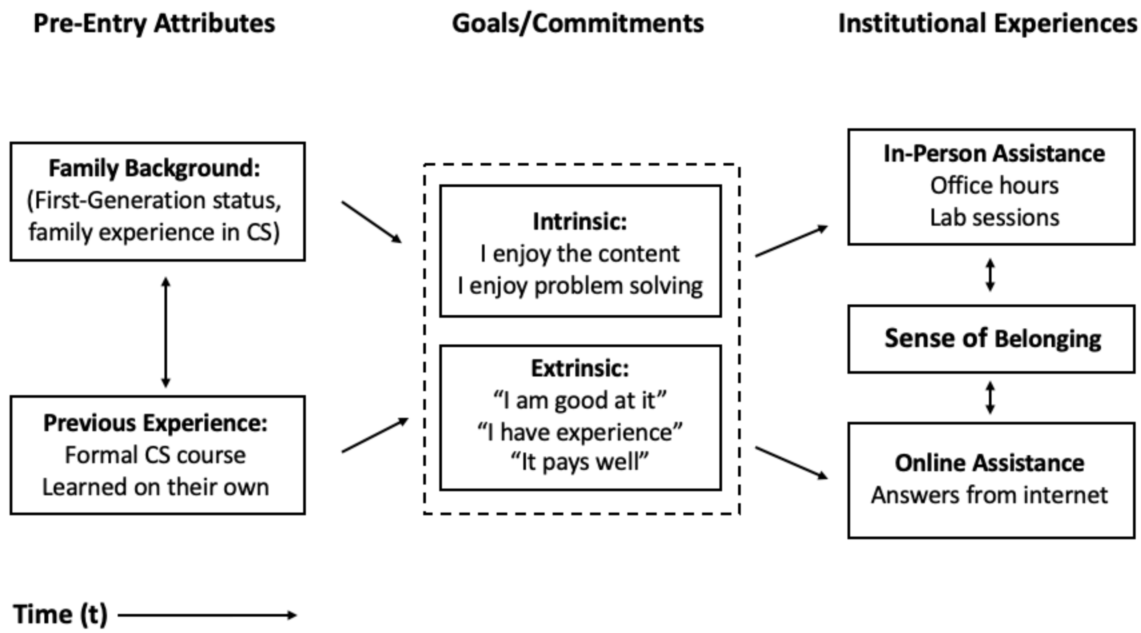

Figure 2.3: Institutional experience addition to pathway model.

Outcomes

At the end of the Fall semester, the responses that students provided during the surveys, focus groups, and interviews were factors that went into the decision that students made, whether to stay in or leave the major. As Tinto's model helps to shape this present study of student pathways, it is important to understand certain factors that can either hinder or help student success, as well as any risk factors that stakeholders should be aware of when working with this student population. Specifically speaking for the Computer Science students at the University of Maine, this model strives to describe what difficulties students faced, as well as risk factors that also can be factors when students are deciding whether to stay in or leave the major at the end of the semester. The completed model, shown below (Figure 2.4) depicts the pathway based on the factors that Tinto states in his model of departure as well as the factors that positively or negatively contribute to student success, and flags the risk factors that can potentially affect a student's decision.

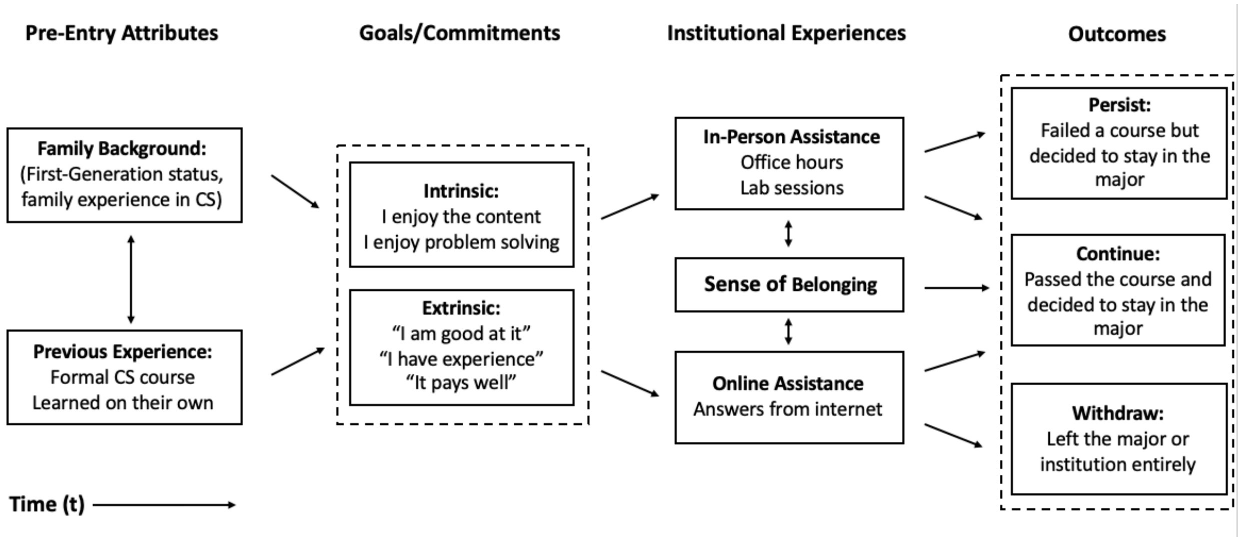

Figure 2.4: Completed student pathway model.

Summary

This chapter discussed the results from the data analysis of Computer Science students enrolled in COS 125 in the fall of 2019. I particularly wanted to focus on these particular data points as they were most in line with the factors that were included in Tinto's model of departure. Additionally, I wanted to showcase a combination of different types of questions that students answered in order to express both quantitative and qualitative results that arose from the study. Including evidence from the pre-survey, post-survey, focus groups, and interviews, provided a more holistic presentation of student experiences within COS 125.

Specifically, I presented the student pathway model based on the responses from Computer Science students who participated in surveys, focus groups, and interviews, and reveals potential pathways that students pursue based on their background, abilities, and major-specific goals, and how I came to discover these findings. Preceding the results is the discussion that describes the results more in depth, and also provides suggestions for future research and recommendations based on the methodology conducted and the results extracted from this present study. Further, in the discussion section, I provide explanations of how the student pathway model can be utilized in other program assessments and how the results from the model can assist in predicting future student outcomes based on the results discovered in this present study.

Chapter 5

DISCUSSION

I designed this study to examine the differences in student decisions to either stay in or leave the Computer Science major at the University of Maine, and what factors contribute to their decision-making process. I also strived to create a student pathway model inspired by Tinto's (1993) model of departure to assist future students in their decision-making process and assist stakeholders in helping their students succeed. In this section, I offer suggestions for future research, recommendations to consider, and the limitations of the present study that could have affected the results.

Through each step of the pathway model, student characteristics, aspirations, and abilities all played an important role in determining their potential pathway through the Computer Science program. As seen in the literature, this present study presented cases of struggling students who did not have previous experience in Computer Science (i.e., Barker et al., 2009; Biggers et al., 2008; Ott et al., 2018) as well as the struggles of first-generation students (i.e., Blaney & Stout, 2017), provided a deeper understand of student goals and aspirations within the major (i.e., Carter, 2006; Guzdial et al., 2018), and reiterated the need for a sense of belonging and communication with faculty (i.e., Blaney & Stout, 2017; Funke et al., 2016; Höhne & Zander, 2019; Leaper, 2015; Mendoza-Denton et al., 2002) to ensure a holistic student experience within the major. This present study depicts the potential pathways that Biggers et al. (2008) depicted in their research on "stayers" and "leavers," while adding a third layer to the analysis of student pathways within the Computer Science discipline. As previous research strives to understand students based on their ability to stay or leave, this present student enhances the analysis, creating a model of student pathways based not only on pre-entry attributes, goals and commitments, and institutional experience, but the motivation behind their decisions, and what determines their decisions to “continue,” “persist,” or “withdraw.” This applied pathway model also contributes to the efforts of enhancing policy and practice by creating a predictive model for future cohorts, whether in a Computer Science discipline, or another field altogether. The University of Maine is a residential institution with low numbers of diverse and nontraditional students. Accordingly, even given the limitations of Tinto’s model, in this context, the student pathway model can provide an opportunity to understand linear student pathways at this institution. With that in mind, this model could also be utilized in other programs at the University of Maine similar to the CS major, . It may also be transferable to institutions with similar student populations.

“Successful” Students

Those students who were deemed “continuers” were also labeled as successful; passing the COS 125 course and continuing on in the Computer Science major. These were the students that were closely observed based on the factors that helped them be successful; their pre-entry attributes, their goals and commitments, and their institutional experiences. Students that were successful (1) were more likely to have previous experience with content similar to that in the introductory Computer Science course, (2) were more likely to state that they had personal interests in both problem solving and Computer Science in general, and (3) were more likely to seek in-person help, such as professor and teaching assistant office hours and extra help in the Computer Science lab located in Boardman. While some of these attributes are not always achievable to all students (e.g., previous experience in the major), it is important to be aware of the actions that successful students took during their time in the Computer Science major (e.g., taking advantage of in-person connections) so that other students, who are potentially struggling, can regard possible actions they can take to improve their chances of success in the major. It is also important for students to find meaning in their work (e.g., flexibility of having CS skills, interest in computers, benefit of problem solving) in order to be motivated to do the work as part of the major.

While students who were successful were more likely to have previous academic attributes and were more likely to take advantage of in-person assistance for Computer Science, a number of these students also participated in activities outside of their major, whether it was a job or an extra-curricular activity such as clubs and intermural sports. This shows that many successful students not only have the motivation to do well in their major-specific courses, but also participate in other activities to increase their involvement on campus.

The creation of this model inspired by Tinto's model of departure was designed to understand what successful students have done while taking their introductory courses and how these actions could help future students and increase their chances of being successful by (1) potentially finding resources for students to utilize prior to their entrance into the major to increase the number of students with previous experience with introductory content, (2) allowing students to find meaning in their work, and help them to find their own motivation for doing the work, and (3) placing more emphasis on in-person connections, especially for students who are struggling so they are less likely to turn to the internet when they are in need of help. With the research done for this present study at the University of Maine, I am hopeful that this new model can act as a predictive framework to assist future cohorts at the University of Maine looking to become a Computer Science major. The actions taken by successful students (e.g., in-person communication with professor and TA, taking advantage of lab sessions) can be suggested to future students to ensure that they are aware of the resources that are available to them that have been proven to assist previous students.

This model was designed to predict student outcomes based on motivation, sense of belonging and self-efficacy, as well as their utilization of resources. Understanding these student characteristics can further supplement the predictive ability of the student pathway model. Knowing a student's motivation behind why they chose to enter a major, whether intrinsic or extrinsic, can help to predict a student's pathway. For instance, if a student has more extrinsic reasons behind choosing their major, they may be more likely to depart from their introductory courses, as they do not have intrinsic interest in pursuing the material. Likewise, if they are more intrinsically motivated, they are less likely to leave the major. Thus, while it is challenging to predict the outcomes of future students in the Computer Science major given the limitations of the study, this model can help to understand the types of motivations students had entering the major, what actions they took during their time in the program, and how these affected their outcome decisions.

Limitations of the Study

Lack of Participation

Participation in the various components of this study were skewed according to the necessity of its completion. For instance, students were required to complete the pre- and post-survey at the beginning and end of the Fall semester, as each stood as an assignment that counted towards their final grade in COS 125. Statistically significantly more Computer Science students participated at the beginning of the semester, while a number of the students did not take the post-survey. This is due to a number of potential reasons, such as their perception of their accumulation of points at the end of the semester, student withdrawal from the class, or survey fatigue (discussed further below). Specifically speaking, it was challenging to fully analyze the entire Computer Science student population, as none of the students who withdrew from the course participated in the post-survey at the end of the semester. This was an unfortunate loss of data, as it would have been interesting to hear why these students decided to leave the major. In turn, many of the reasons for student departure was implicated based on other factors, such as reasons for choosing the major, their previous experience, and how often they utilized resources.

Moreover, there was a great lack of participation from students during the focus group and interview sessions. This was expected, as their participation was optional, and was advertised as extra credit at the end of the Fall semester. Additionally, as there is a combination of Computer Science and non-Computer Science students enrolled in COS 125, there was an even smaller percentage of Computer Science students participating in the focus groups and interviews, as many of the participants came from an array of majors. The students who decided to participate were either looking forward to providing their feedback about the course or looking for as many extra credit opportunities as possible.

Survey Fatigue

Not only were students tasked with completing the two surveys from this study during the semester, they were also asked to complete a few other surveys from other sources asking them about various components of their experience in the course, or the major in general. This, in turn, potentially affected the number of students participating in the post-survey at the end of the semester, as they had been taking various surveys throughout the semester.

Lack of Diversity

While computing programs nationally are known for their large gender gap, this was also the case for the Fall 2019 cohort in the Computer Science program at the University of Maine. In addition to this large gender gap, there is also a lack of diversity in terms of residency and ethnicity, which resulted in a lack of feedback from diverse populations. As the University of Maine already lacks diversity in terms of ethnicity and race, it would be interesting to do similar research at institutions in different national locations to understand the differences of responses from students.

Model Inspiration

As the present study was inspired by Tinto's departure model (1993), it mimics the limitations found in his model years ago. Importantly, the student pathway model from the present study lacks the ability to be transferrable to non-traditional and diverse populations, making it a model for traditionally aged students. If the pathway model was inspired by a more recent model dedicated to understanding factors that affect student success in broader student populations, it would have the ability to speak to the populations that were left out of Tinto's work, and perhaps become a more flexible model, rather than strictly linear.

Unmatched Populations

During the survey component of the study, student answers from the pre-survey were not directly matched with their answers in the post-survey. While this was difficult to execute because there was a lack of participation in the post-survey, it would have been helpful to have a direct match in answers to increase the validity of pathways from the beginning of the semester to the end of the semester. Instead, student answers were grouped into one of the three categories, continuers, persisters, or withdrawers, and then matched between the pre- and post-surveys. Similar future research experiments such as this one would benefit from directly matching student answers if possible.

Suggestions for the Computer Science Program

Closing the Experience Gap

To close the experience gap, perhaps COS 125 needs to be split into two sections; one for students with no experience in Computer Science, and the other for students who have adequate experience, potentially determined by a placement exam, or based on their performance in previous courses they have taken, whether at their previous secondary or postsecondary institutions. This was also a suggestion from a number of students who participated in the focus groups and interviews, as they were either a student who came in with no experience and felt that the course was rushed, or students who had a lot of experience and felt that they did not learn anything. This can create equal playing ground for each population, allowing students with no experience to learn in an environment with their peers who are at a similar level, and giving students with experience the chance to increase their knowledge and challenge themselves without feeling held back. During the focus groups and post-survey, students who had more knowledge of computing before COS 125 also suggested more projects in addition to their coursework to challenge them when the class is reviewing basic material.

Organized Lab Sessions

The Boardman Lab for Computer Science provides students a chance to ask for help on assignments and study preparation for an exam from Teaching Assistants. Ultimately, this space is open every day during regular office hours and can be used as a resource for students at any point during those hours. However, many students stated that they would go there for help right before substantial projects were due, or before an exam, and stressed how difficult it was to get their questions answered, as many other students were there for the same reasons. Students who participated in the focus groups and interviews suggested that the Lab set aside certain time blocks to assist students as a group to help with these larger assignments and projects. This would ensure that time is used efficiently, and perhaps would encourage more students to go to the lab for help during these specific sessions.

More Networking Experiences

Students in the interviews and focus groups discussed how they could benefit from connecting with University of Maine alumni, allowing them to see what types of careers they qualify for with a Computer Science degree, and what types of steps they should take to be successful in the major. In addition, students also suggested more real-world applications to the work done in current courses, and how it would help them shape their understanding of Computer Science in general, as well as balance theory and practice during the introductory courses.

Recommendations for Future Research and Practice

According to Alexander Astin "administrators and faculty members must recognize that virtually every institutional policy and practice…can affect the way students spend their time and the amount of effort they devote to academic pursuits" (1984, p. 523). For Computer Science, faculty members and stakeholders who are included in decision-making processes must be aware of the differences in student backgrounds, abilities, and major-specific goals that each student possesses, and provide appropriate guidance for future students. Stakeholders from other programs and institutions can adapt to the model from the present study based on their own findings and utilize a similar methodology to understand their specific student populations. Through this practice, there will be a better understanding of student needs based on their personal backgrounds, abilities, and major-specific goals.

While this was an analysis of the University of Maine Fall 2019 Computer Science student population, special continued attention shall and will be made toward female students, students who are first-generation, and students from underrepresented populations at the University of Maine. While these populations represent only a small portion of the Computer Science community, especially at the University of Maine, more attention needs to be made towards how to increase their enrollment, retention, and sense of belonging within the Computer Science courses and the major itself. Further, more attention must be made on the pathways of students as a whole. While Tinto's model provides a linear description of the factors that affect student success, there are other external and macro-level factors that are not mentioned in his research that are large contributors to student outcomes.

Theoretical Factors

As Tinto's model represents linear student pathways that depict their college experience, it does not fully discuss the various levels of factors that contribute to a student's success or failure. This calls for further attention to external and macro-level factors that affect student decision-making, that are described by various student development theorists. As mentioned briefly in the conceptual framework, Tinto fails to include anticipated and unanticipated student transitions in his model, a concept discussed thoroughly in Schlossberg's Transition Theory (1995). Utilizing this theory in concert with the student pathway model unmasks another level of development and process within the student experience. Specifically speaking, students are vulnerable to the unexpected and expected movements of life, and their pathway can be abruptly paused because of external and macro-level factors. As Tinto's model is linear, there leaves no room for student individuality. Having an understanding of the additional factors that can impact student decision-making enhances our ability to perceive student pathway models holistically; through cultural, social, and historic levels.

In addition to Schlossberg's Transition Theory (1995), other theories such as Bronfenbrenner's Ecology model (1993) provides and understanding of how student experiences are shaped by the social and cultural impacts around them. This macro-level theory is helpful in analyzing Computer Science student specifically, as many of their decisions are based on the social norms within the discipline (e.g. gender gap, lack of diversity, etc.). Without acknowledging the macro-level barriers that students face within the field of Computer Science, it is more challenging for students, specifically underrepresented populations, to fulfil their goals. It is also important to be aware of how cultural and social norms change throughout history, and how students are affected by these changes.

In addition to doing more research within the Computer Science program on more specific student populations, as well as more research on other student development theories that can enhance the student pathway model, the model from this present study can be utilized in other programs at the University of Maine and potentially at other institutions, depending on their student populations. While this model was created specifically for Computer Science students at this rural-public institution, elements of this model could be utilized with additional research on more diverse student populations and different institutional contexts. This can be done by altering the student characteristics and risk factors to fit certain student populations, again, based on further research on specific student populations. Finally, as Tinto's model was created with more traditional students in mind, a more comprehensive analysis of specific student populations is needed to holistically understand their persistence and pathways.

Conclusion

Successful students in Computer Science students at the University of Maine found themselves having more previous experience than their peers, a better idea of their intrinsic and extrinsic motivation to continue on in the major and were more likely to have in-person connections with faculty and peers. While these findings were almost assumed, it is important to map out the differences between students who were successful (continuers) those who were unsuccessful and decided to stay (persisters) and those who decided to leave within the semester of their introductory Computer Science course (withdrawers), and how their varying characteristics and actions can affect their decisions to stay, and their ability to be successful.

Student success and retention heavily relies on how they perceive the Computer Science major and how much effort they put into their work. While these seem like simple factors on paper, many components can either positively or negatively affect their perceptions, such as their first-generation status, their sense of belonging in the major, and the support they do or do not receive from their professors. In order to find more specific reasons for student pathways within the Computer Science major, more complex research must be done to unveil more factors that can affect student retention and success.

While this present study provides a closer look into the reasons different student populations stay in the Computer Science major or leave, more research must be done on more specific populations (e.g. female students, first-generation status, underrepresented minorities) to understand the gaps in diversity in Computer Science programs across the nation. With supplemental theories guiding the student pathway model inspired by Tinto's work, more comprehensive initiatives can be designed to target the success of the specific students. A better understand of these populations can assist researchers and stakeholders within the discipline to assist the various student populations, and hopefully begin to increase the diversity in Computer Science as they gain the tools they need to supplement *all* student learning, regardless of their backgrounds and risk factors.

References

Al-Harthy, I. S., Was, C. A., & Isaacson, R. M. (2010). Goals, efficacy and metacognitive self-regulation a path analysis. *International Journal of Education*, *2*(1), 1.

Astin, A. W. (1984). Student involvement: A developmental theory for higher education. *Journal of college student personnel*, *40*, 518-529.

ASTRA and R. S. Boege. (2018). "Maine's 2018 STEM & Innovation Report Card," *The Alliance for Science & Technology Research in America (ASTRA).* Retrieved from https://www.usinnovation.org/state/pdf_cvd/ASTRA-STEM-on-the-Hill-Maine2018.pdf

Barker, L. J., McDowell, C., & Kalahar, K. (2009). Exploring factors that influence computer science introductory course students to persist in the major. *ACM SIGCSE Bulletin*, *41*(1), 153-157.

Barker, L. J., O'Neill, M., & Kazim, N. (2014, March). Framing classroom climate for student learning and retention in computer science. In *Proceedings of the 45th ACM technical symposium on Computer science education* (pp. 319-324). ACM.

Biggers, M., Brauer, A., & Yilmaz, T. (2008). Student perceptions of computer science: a retention study comparing graduating seniors with cs leavers. In *ACM SIGCSE Bulletin* (Vol. 40, No. 1, pp. 402-406). ACM.

Blaney, J. M., & Stout, J. G. (2017, March). Examining the relationship between introductory computing course experiences, self-efficacy, and belonging among first-generation college women. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education* (pp. 69-74). ACM.

Braxton, J. M. (2019). Leaving college: Rethinking the causes and cures of student attrition by Vincent Tinto. *Journal of College Student Development*, *60*(1), 129-134.

Braxton, J. M., Hirschy, A. S., & McClendon, S. A. (2004). Understanding and reducing college student departure. *ASHEERIC Higher Education Report, 30*(3).

Bronfenbrenner, U. (1993). The ecology of cognitive development: Research models and fugitive findings. In R.H. Wozniak & K.W. Fischer (Eds.), *Development in context: Acting and thinking in specific environments* (pp. 3-44). Hillsdale, NJ: Erlbaum

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook*, Information Security Analysts, on the Internet at https://www.bls.gov/ooh/computer-and-information-technology/information-security-analysts.htm

Carver, J. C., Henderson, L., He, L., Hodges, J., & Reese, D. (2007, July). Increased retention of early computer science and software engineering students using pair programming. In *20th Conference on Software Engineering Education & Training (CSEET'07)* (pp. 115-122). IEEE.

Carter, L. (2006). Why students with an apparent aptitude for computer science don't choose to major in computer science. *ACM SIGCSE Bulletin*, *38*(1), 27-31.

Corbett, C., and Hill, C. (2015). *Solving the Equation: The Variables for Women's Success in Engineering and Computing*. Washington, DC: American Association of University Women (AAUW). http://www.aauw.org/files/2015/03/Solving-the-Equation-report-nsa.pdf

Elkins, S. A., Braxton, J. M., & James, G. W. (2000). Tinto's separation stage and its influence on first-semester college student persistence. *Research in Higher Education*, *41*(2), 251-268.

Funke, A., Berges, M., & Hubwieser, P. (2016, March). Different perceptions of computer science. In *2016 International Conference on Learning and Teaching in Computing and Engineering (LaTICE)* (pp. 14-18). IEEE.

Giannakos, M.N., Pappas, I.O., Jaccheri, L., Sampson, D. (2017). Understanding student retention in computer science education: The role of environment, gains, barriers and usefulness. *Education and Information Technologies, 22*(5), 2365-2382.

Höhne, E., and Zander, L. (2019). Sources of male and female students' belonging uncertainty in the computer sciences. *Frontiers in psychology*, *10*, 1740.

Kapoor, A., and Gardner-McCune, C. (2018, July). Considerations for switching: exploring factors behind CS students' desire to leave a CS major. In *Proceedings of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education* (pp. 290-295). ACM.

Leaper, C. (2015). Do I belong?: Gender, peer groups, and STEM achievement. *International Journal of Gender, Science and Technology*, *7*(2), 166-179.

Levin, M.E. and Levin, J.R. (1991) 'A critical examination of academic retention programs for at-Risk minority college students.' *Journal of College Student Development*, 32, 323-334.

Lewis, C. M., Yasuhara, K., & Anderson, R. E. (2011, August). Deciding to major in computer science: a grounded theory of students' self-assessment of ability. In *Proceedings of the seventh international workshop on Computing education research* (pp. 3-10).

Martinez, P. (1997) "*Improving Student Retention: A Guide to Successful Strategies*" FEDA.

Mendoza-Denton, R., Downey, G., Purdie, V. J., Davis, A., & Pietrzak, J. (2002). Sensitivity to status-based rejection: implications for african american students' college experience. *J. Pers. Soc. Psychol.* 83, 896–918. doi: 10.1037/0022-3514.83.4.896

Milesi, C., Perez-Felkner, L., Brown, K., & Schneider, B. (2017). Engagement, persistence, and gender in computer science: Results of a smartphone ESM study. *Frontiers in psychology*, *8*, 602.

Miyake, A., Kost-Smith, L. E., Finkelstein, N. D., Pollock, S. J., Cohen, G. L., & Ito, T. A. (2010). Reducing the gender achievement gap in college science: A classroom study of values affirmation. *Science*, *330*(6008), 1234-1237.

National Center for Education Statistics (NCES) IPEDS Completions Survey. (2017). Retrieved from https://nces.ed.gov/ipeds

National Science Foundation (2018). Science and engineering indicators 2018. Retrieved from https://nsf.gov/statistics/2018/nsb20181/report

Ott, L., Bettin, B., & Ureel, L. (2018, July). The impact of placement in introductory computer science courses on student persistence in a computing major. In *Proceedings of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education* (pp. 296-301). ACM.

Pascarella, E. T., Pierson, C. T., Wolniak, G. C., & Terenzini, P. T. (2004). First-generation college students: Additional evidence on college experiences and outcomes. *The Journal of Higher Education*, *75*(3), 249-284.

Patton, L.D., Renn, K.A., Guido, F.M., & Quaye, S.J. (2016). Student development in college: Theory, research, and practice (3rd ed.). San Francisco, CA: Jossey-Bass.

Sass, D.A., Castro-Villareal, F., Wilkerson, S., Guerra, N., & Sullivan, J. (2018). A structural model for predicting student retention. *The Review of Higher Education 42*(1), 103-135. doi:10.1353/rhe.2018.0035.

Sax, L. J., Lehman, K. J., Jacobs, J. A., Kanny, M. A., Lim, G., Monje-Paulson, L., & Zimmerman, H. B. (2017). Anatomy of an enduring gender gap: The evolution of women's participation in computer science. *The Journal of Higher Education*, *88*(2), 258-293.

Schlossberg, N. K., Waters, E. B., & Goodman, J. (1995). *Counseling adults in transition* (2nd ed.). New York: Springer.

Spencer, J., & L. Ritchie. "Qualitative data analysis for applied policy research." *Analysing qualitative data* (1994): 172-194.

State of Computer Science Education. (2018). Retrieved from https://advocacy.code.org/

Tinto, V. (1993). Leaving College: Rethinking the Causes and Cures of Student Attrition (2nd ed.). Chicago: University of Chicago Press.

Tinto, V. (2006). Research and practice of student retention: What next? *Journal of College Student Retention: Research, Theory & Practice*, *8*(1), 1-19.

Trauth, E. M. (2002). Odd girl out: an individual differences perspective on women in the IT profession. *Information Technology & People*.

Yang, Y., Chawla, N. V., & Uzzi, B. (2019). A network's gender composition and communication pattern predict women's leadership success. *Proceedings of the National Academy of Sciences*, *116*(6), 2033-2038.

Appendix A

Fall 2019 Computer Science Pre-Survey

Hello, and welcome to your Fall 2019 Computer Science course! We appreciate you taking the time to complete this brief survey so that we may learn a little more about you before the semester kicks off.

This survey will help us better understand Computer Science students, and to further any research we do to better the CS program. This will take approximately 10-15 minutes to complete. You are not required to answer all of the questions in this survey, but be sure to answer each question carefully, truthfully, and to the best of your abilities. As this survey is completely confidential, any information linking to your identity will not be shared with anyone. Thank you again, and good luck with your Fall semester!

* Required

Name *

____

What is your current major/minor status? (Select all that apply) *

☐ I am a computer science major

☐ I am not a computer science major

☐ I have a declared computer science minor

☐ Considering being a computer science major

☐ Considering being a computer science minor

☐ Other: ____________________________________

Which Computer Science courses are you taking this semester? (Select all that apply) *

☐ COS 120

☐ COS 125

☐ COS 140

What year are you in school? *

◯ First year

◯ Second year

◯ Third year

◯ Fourth year

◯ 5+ year

Where are you from? *

◯ In state

◯ Out of state

◯ International

Where will you be living this semester? *

◯ On campus

◯ At home with family

◯ In an apartment

◯ Other: ____________________________________

Approximately how many hours do you expect to work at a job per week this semester? *

◯ 5-10 hours

◯ 10-15 hours

◯ 15-20 hours

◯ 20+

◯ I do not plan to work this semester

Are you a transfer student? *

◯ Yes

◯ No

◯ What is the highest level of education that either of your parents/guardians has completed? *

◯ High School

◯ Vocational/Technical

◯ Some college

◯ 2-Year/Associates

◯ 4-Year/Bachelors

◯ Masters

◯ PhD

◯ Other terminal graduate degrees (MD, DDS, JD, etc.)

◯ Not sure

◯ Other: ___________________________________

What kind of experience do you have with computer science (CS)? (Select all that apply) *

- Learned a little on my own time
- Learned a lot on my own time
- One formal CS related class
- More than one CS related formal class
- No experience
- Other: ___________________________________

What have you done in relation to CS prior to this class? List any programming languages and software that you have used in the past. (n/a if this does not apply to you). *

List any previous CS courses you have taken in the past. (n/a if you have not taken a course) *

What is the highest-level math course you have taken so far? *

- ○ Pre-Calculus
- ○ Differential Calculus
- ○ Multivariable Calculus
- ○ Other: ___________________________________

Why were you inspired to take this class?

Why have you chosen Computer Science to be your major? Or, what other major did you choose and why?

What are your specific interests in Computer Science?

What are your current career goals after you graduate from college?

What is your level of confidence that you will do well in your CS courses this semester? 1=Not confident at all; 2=A little confident; 3=Somewhat confident; 4=More confident; 5=Extremely confident. *

	1	2	3	4	5	
Not confident at all	○	○	○	○	○	Extremely confident

How confident are you that your educational background has prepared you for your CS courses this semester? 1=Not confident at all; 2=A little confident; 3=Somewhat confident; 4=More confident; 5=Extremely confident. *

	1	2	3	4	5	
Not confident at all	○	○	○	○	○	Extremely confident

What are you expecting from your CS courses this semester?

What are you expecting from your CS professors this semester? Anything you would like them to know about you?

Do you have any additional comments at this time?

To what gender identity do you most identify? *

◯ Female

◯ Male

◯ Transgender female

◯ Transgender male

◯ Gender variant/Non-conforming

◯ Prefer not to say

◯ Other: ___________________________________

Thank you again for your participation!

Appendix B

Fall 2019 COS 125 Survey Pt. 2

Hello! The following survey is asking for your opinion of your Computer Science course, as you are at the end of your Fall 2019 semester! Please answer these questions carefully, truthfully, and to the best of your abilities.

This survey will take approximately 10-15 minutes to complete. You are not required to answer all of the questions in this survey, but any honest feedback we receive is greatly appreciated. Any information linking your identity with your answers will not be shared with others.

Thank you again for you participation and your time!

* Required

Name *

____

Have you switched your major/minor during your Fall 2019 semester? *

◯ Yes

◯ No

If you said "Yes" to the first question, what major/minor did you switch? (Select all that apply)

☐ From the Computer Science major to another major

☐ From another major to the Computer Science major

☐ From the Computer Science minor to another minor

☐ From another minor to the Computer Science minor

Other: ____________________________________

If you answered the question above, briefly explain your reasoning for switching majors/minors.

How challenging was COS 125? (1=Very easy; 2=Relatively easy; 3=Neither challenging nor easy (neutral); 4=Moderately challenging; 5=Very challenging). *

	1	2	3	4	5	
Very easy	○	○	○	○	○	Very challenging

How substantial was the workload in COS 125? (1=Not enough at all; 2=Not too much; 3=Not too much and not too little (neutral); 4=A little too much work; 5=Too much work). *

	1	2	3	4	5	
Not enough at all	○	○	○	○	○	Too much work

How confident are you that your educational background prepared you for COS 125? (1=Not confident at all; 2=A little confident; 3=Somewhat confident; 4=More confident; 5=Extremely confident). *

	1	2	3	4	5	
Not confident at all	○	○	○	○	○	Extremely confident

How often did you take advantage of the following in your courses this semester? *

	Never	Rarely	Sometimes	Often	N/A
Faculty office hours	○	○	○	○	○
MLA/TA office hours	○	○	○	○	○
Review sessions	○	○	○	○	○
Tutoring	○	○	○	○	○
Boardman 138 Lab	○	○	○	○	○
Study groups with other students	○	○	○	○	○
Internet	○	○	○	○	○

In which of the following ways were MLAs helpful? (Please select all that apply) *

☐ Helped with problem solving

☐ Answered questions

☐ Used questioning to help me understand the material

☐ Facilitated group work

☐ Helped with homework

☐ Provided extra materials

☐ Conducted help/review sessions

☐ Gave useful feedback

☐ Helped me understand the field of Computer Science

☐ Other: ____________________________________

How much of an impact did the MLAs have on your overall experience in COS 125? (1=A large negative impact; 2=A small negative impact; 3=Neutral impact; 4=A small positive impact; 5=A large positive impact) *

	1	2	3	4	5	
A large negative impact	○	○	○	○	○	A large positive impact

What was your overall experience in COS 125? *

○ Overall positive

○ Overall neutral

○ Overall negative

Did taking COS 125 increase or decrease your interest in taking additional courses in the department? *

○ Taking this course increased my interest in taking additional courses in the CS department

○ Taking this course did not change my interest in taking additional courses in the CS department

○ Taking this course decreased my interest in taking additional courses in the CS department

Did you feel a sense of belonging in the CS major? (1=Strongly disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=Strongly agree). *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Did you feel that you had the support you needed to succeed? (1=Strongly disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=Strongly agree). *

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Below is a list of adjectives that might describe your experience in COS 125. During your time in this course, how often did you feel: *

	Never	Rarely	Sometimes	Often	Always
Challenged	◯	◯	◯	◯	◯
Comfortable	◯	◯	◯	◯	◯
Confident	◯	◯	◯	◯	◯
Discouraged	◯	◯	◯	◯	◯
Excited	◯	◯	◯	◯	◯
Involved/engaged	◯	◯	◯	◯	◯
Isolated	◯	◯	◯	◯	◯
Prepared	◯	◯	◯	◯	◯
Stressed	◯	◯	◯	◯	◯
Supported	◯	◯	◯	◯	◯
Worried	◯	◯	◯	◯	◯

How often do you hang out with people in the CS major? *

◯ Never

◯ Here and there

◯ Often

◯ All the time

How often do you hang out with people outside the CS major? *

◯ Never

◯ Here and there

◯ Often

◯ All the time

How much time do you spend on academics outside of class per week? *

◯ 0-9 hours

◯ 10-19 hours

◯ 20-29 hours

◯ 30-39 hours

◯ 40-49 hours

◯ 50+ hours

How much time do you spend on non-academic activities outside of class per week? *

◯ 0-9 hours

◯ 10-19 hours

◯ 20-29 hours

◯ 30-39 hours

◯ 40-49 hours

◯ 50+ hours

List any extra-curricular groups/activities that you have been a part of this semester (athletics, clubs, intramurals, etc.)

Do you intend to take other CS courses in the future? *

○ Yes

○ No

○ Maybe

Do you have any suggestions for next year's COS 125 class (content, teaching style, homework assignments, etc.)? *

Do you have any additional comments at this time? (Any comments will be helpful in any decision-making process for future COS 125 courses)

Thank you again for your participation! Have a good break!

Appendix C

Focus Group/Interview Invitation

Hello Student,

We are looking for your input on the computer science major so that we can work to improve the program. You are invited to participate in a conversation about your experiences with the courses, material, and your overall opinions of the major. These will be conducted by Christina LeBlanc, a graduate student in the Higher Education program, who is interested in knowing your opinion of the CS program.

DATES/TIMES: Tuesdays @ 2pm and Thursdays @ 3pm
COMMITMENT 30-60 minutes
LOCATION TBA

Purpose:

The goal of the focus groups and interviews is to understand student perspectives and opinions of the introductory courses in the computer science major. Gathering this information from students can assist in the attempt to make these introductory courses better for students on certain levels. *What were/are your successes, struggles, and obstacles? What should we keep, stop doing, or start doing? How can the program be improved for CS students?*

Confidentiality:

Please note that your name and any identifying information you share will remain confidential. Your responses will be summarized along with other responses and used collectively.

Consent:

There is no obligation to participate in the focus group or interview, however, your participation will help identify key concerns within that program that will be addressed. You may refuse to participate or withdraw at any time and it will not affect your standing as a student. Alternatively, there will be a Google Form

I hope that you will be able to participate in improving the computer science program. Please respond to the email if you are interested.

Appendix D

Focus Group Script

Hello everyone, thank you very much for volunteering to participate in this focus group. My name is Christina LeBlanc and I am a graduate student in the Higher Education program. For my thesis, I am focusing on student success and retention in the computer science major at the University of Maine. I am interested in asking students about their experiences in introductory computer science courses, specifically COS 125. I hope that you will find this to be an interesting experience as we continue the discussion.

As this is a focus group where you will all have a chance to share your personal experiences in the major, I ask that you do not share any information about your colleagues outside of this room. With that in mind, I cannot control what you do or do not say outside of this focus group, but I am asking you to respect each other's privacy.

During our time, I will be recording our conversations, so I am able to go back in and review the conversations. I will be keeping them on my laptop which is protected by a password and I will not be sharing these recordings with anyone. Additionally, I will not be sharing any names or identities.

If at any point in the session you feel uncomfortable and do not wish to continue, you are able to leave the focus group.

Does anyone have questions before we begin?

Appendix E

Interview Script

Hello and thank you very much for volunteering to come to this interview. My name is Christina LeBlanc and I am a graduate student in the Higher Education program. For my thesis, I am focusing on student success and retention in the computer science major at the University of Maine. I am interested in asking students about their experiences in introductory computer science courses, specifically COS 125. I hope that you will find this to be an interesting experience as we continue the discussion.

During our time, I will be recording our conversations, so I am able to go back in and review the conversations. I will be keeping them on my laptop which is protected by a password and I will not be sharing these recordings with anyone. Additionally, I will not be sharing any names or identities.

If at any point in the session you feel uncomfortable and do not wish to continue, you are able to leave the focus group.

Do you have any questions before we begin?

Appendix F

Focus Group/Interview Questions

The following question will be asked during the focus group/interviews including students that withdrew from the computer science course after their first semester or first academic year:

1. At what point in the major were you discouraged to continue with computer science?

The following question will be asked during the focus group/interviews including students that failed one or more introductory computer science courses and persisted in the major:

1. What drives you to continue in the computer science program?

The following question will be asked during the focus group/interviews including students that passed the introductory computer science courses and continued in the major:

1. What do particularly enjoy in the computer science major (what keeps you in the program?)

The following questions will be included in all focus group/interview scripts. Some questions might not be addressed depending on student engagement:

1. What inspired you to take COS 125?
2. Tell me about your experiences in the course?
3. How prepared did you feel for COS 125 and your first semester in general?
4. What previous experience did you have with computer science and has it helped you in your courses?
5. Were your expectations at the beginning of the Fall semester accurate to what the semester was actually like?

6. What parts of COS 125 stood out to you/piqued your interest? What felt irrelevant?
7. What concepts in the course were particularly challenging for you?
8. What did you wish was included in the COS courses? What would have helped you succeed?
9. How did feedback help you understand what was expected of you and what could be improved? How are assignments submitted?
10. How much time do you put into your computer science homework per week? What do you do with your free time? What is your total workload like (gen eds too)?
11. What did you do when you struggled to complete an assignment for COS 125? Where did you get help? (friends, TA, internet, professor, Boardman 138 student lab)
12. How do you feel about the workload in CS? (Too much? Too little? Too challenging? Too easy?)
13. How aware are you of what is expected of you in the major?
14. If you have a job, how many hours per week do you work, what do you do for work, and how far do you have to travel to get to your job?
15. What are your long-term goals and how did you see the computer science major fitting into those goals?
16. Did you take the one credit first year student success course? If so, was it valuable?

Or, if not, why didn't you?

BIOGRAPHY OF THE AUTHOR

Christina LeBlanc was born in York, ME in the October of 1995, and has called Wells, ME her home ever since. She attended Wells High School where she was an honor roll student and was inducted into the National Honors Society. Upon graduation in 2014, Christina went on to study Secondary Education and English at the University of Maine. Throughout her time at the University of Maine, Christina became involved in the Virtual Environment and Multimodal Interaction Lab where she gained skills in research across various disciplines. After graduating in 2018, Christina continued to work with the VEMI lab at the start of her graduate work. From there, she decided to pursue a path working with Penny Rheingans, where Christina was able to work closely with assessing student retention data. Christina continued to work alongside Rheingans until graduation from her program. She is a candidate for the Master of Education degree in Student Development in Higher Education from the University of Maine in May 2020.