Factors that Influence the Satisfaction and Persistence of Undergraduates

in Computer Related Majors

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ABSTRACT

The demand for workers with college level training in computer related skills is growing rapidly. Although the number of computer science jobs is growing, the percentage of these jobs currently held by women is lower than in 1983 (Commission on Professionals in Science and Technology, 2004). The underrepresentation of women and minorities in postsecondary computing education has become a major national concern (Cohoon & Aspray, 2006).

Despite a growing literature on women in STEM fields, there is a lack of theoretical development about women's participation and attrition in computer related majors. The findings are often inconsistent and there are few discipline-specific guidelines for policy. An important next step is to examine these insights with confirmatory quantitative methods. Larsen and Stubbs (2005) argue that efforts to increase diversity in computer fields should be broad-based and move beyond gender. Factors that are successful in attracting and retaining a diverse population of undergraduates in computer related majors will also benefit women and minorities.

The purpose of this quantitative study was to develop and test a model of factors influencing the satisfaction and persistence of undergraduates in computer related majors at two universities in Virginia. There were three major independent constructs: academic, social, and institutional factors. Dependent constructs were persistence and satisfaction.

The sample was a convenience sample of classes at differing academic levels. A total of 388 students in computer-related majors were surveyed during regularly scheduled class sessions.

Data analysis was conducted using structural equation modeling (SEM) techniques. The goal of SEM is to determine the extent to which a theoretical model is supported by data. Both measurement and structural models were tested.

Results indicate that these factors have significant and substantive effects on satisfaction and persistence. They highlight the importance of faculty, peers, and family support for student satisfaction and retention, and the need to examine instruction and content in computer related majors. The findings suggest the need for further work in the measurement of the constructs, and for further refinement of the final model. In addition, comparison of individual item means suggest that models may vary significantly among majors and between white and minority students. Future research should continue to test and refine the model for the influence of academic, social, and institutional factors on student satisfaction and persistence in computer related majors so that educators and policy makers can enhance the academic and social support structures for students in these majors.

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Chapter 1: Introduction

Background

There has been a rapid increase in the demand for workers with college level training in computer related fields in recent years. Many educators and policymakers claim that college preparation in computer related majors is vital to the economic health and national security interests of the United States (National Science Board, 2004). Projections indicate that careers requiring advanced computer skills will be among both the fastest growing and the most economically advantageous occupations through 2014; median annual income for computer and information scientists was $85,190 in May 2004 (Bureau of Labor Statistics, 2007).

Although the number of computer science jobs is increasing rapidly, the supply of graduates in computing fields is not keeping up with the demand. Several recent articles (Courte & Bishop-Clark, 2007; Howles, 2007; Lang, 2007) cite decreasing enrollment in computer related majors. Universities with well-known computer science (CS) programs, such as Carnegie Mellon, Rutgers, Stanford, and the University of California at Berkley, have reported a significant decline in CS applicants and degrees awarded (Carter, 2006). Enrollment in computer and information sciences has dropped from approximately 1,297,000 students in 1999 to 998,000 in 2003; the number of bachelor's degrees awarded dropped from a high of 59,488 in 2004 to 54,111 in 2005 (NCES, 2006). Certain populations, especially women and minorities, are underrepresented in computer-related majors. Incoming students are often not interested in majoring in computers. Only 2.9% of students taking the ACT college entrance exam from 1995-2000 intended to choose a career in a computer field; in 2006 and 2007, only 2% of test-takers indicated an interest in computing careers (ACT, 2005, 2006, 2007).

In the wake of decreasing enrollment and increasing demand, computer-related programs must assess their current state of affairs in order to determine where changes may lead to an increase in the number of computing degrees awarded. One aspect of the problem is increasing enrollment, which can be addressed by evaluating the prevailing image of computer majors. Several studies indicate that students do not understand what is involved in computing majors (Berry, Rettenmayer, & Wood, 2006; Lee & Lee, 2006). Some students associate CS with writing programs, while others believe that it involves finding information on the web or using computers for daily tasks (Courte and Bishop-Clark, 2007).

In addition, the stereotyped image of computer majors can deter some students. Margolis and Fisher (2002) call this phenomenon the "prevailing geek mythology." First-year students' description of the "typical" CS major: anti-social, unathletic, highly intelligent, in love with computers, often to the neglect of all else, and living and breathing the world of computers. Most students, however, said this image of the CS student was "not me:" 68% of the women and 32% of the men perceived themselves as different from the majority of their peers (Bjorkman, Christoff, Palm, & Valin, 1998).

A second factor in increasing the number of graduates in computing fields is retaining those students who originally choose computing majors. Student attrition in these majors is highest in the first two years (Howles, 2007). In fact, women who initially enroll in computer majors are more likely than men to drop out in the freshman or sophomore years (Cohoon, 2001). This early attrition rate is usually attributed to "weed out" courses and courses that focus entirely on programming. Recent research calls for computer educators to evaluate the pedagogy and environment of computing majors (Howles, 2007; Miliszewska, Barker, Henderson, & Sztendur (2006); Turner, Albert, Turner, & Latour, 2007; Varma & Lefever, 2007).

Before seeking ways to address the problem of decreasing enrollment and high attrition rates in computing majors, it is important for educators and researchers to understand the current state of affairs in computer related majors (CRM). This is being done in small steps, often by individual departments of computer science or information technology (Besana and Dettori, 2004; McDowell, Werner, Bullock, & Fernald, 2006; Pioro, 2006; Turner et al., 2007; Varma & Lefever, 2007). Many studies are based on small, non-random samples or single-site case studies; these conditions do not permit in-depth analysis of the complex interaction of components that affect students' decisions to persist or drop out of computer related majors.

Insights derived from the literature should be examined using confirmatory quantitative methods. Reliable and valid measures of constructs in computer fields are needed to examine student perceptions of pedagogy and classroom environments. Explanatory quantitative research that tests *a priori* hypotheses will allow for the development of theory and greater generalizability of results.

Much of the literature concerning attracting and retaining students in CS focuses on women, since this population has traditionally been underrepresented. In a qualitative follow-up to Margolis and Fisher (2002), Larsen and Stubbs' (2005) found that the perceptions of men and women were similar in defining of computer science, explaining the lack of diversity in computer science, characterizing "typical" CS students, and describing impressions of CS culture. They argued that efforts to increase diversity in computer fields should be broad-based and move beyond gender. Factors that are successful in attracting and retaining a diverse population of undergraduates in CRM will benefit women and minorities as well.

Computer related majors all have strong computer science components, but they differ from computer science in particular ways. They include majors such as computer science (CS), computer engineering (CE), information technology (IT), and information science (IS), which all include a strong programming component and the need to understand both hardware and software functions of computers. These majors differ mainly in how they apply this knowledge of computers to other domains (Cukier, Shortt, & Devine, 2002). Although the general term computer related majors (CRM) was used to describe all of these majors, specific majors were referenced as used in the relevant literature. Differentiating among majors is important because some papers focus on the difference in student persistence and satisfaction across an array of computer related majors (Henwood, 2000; Varma, 2002).

Problem Statement

In order to increase enrollment and decrease attrition in CRM, educators and policymakers need to examine factors that influence student persistence and commitment to CRM. The majority of the literature on student persistence focuses on two theories: Tinto's Student Integration Theory (1975, 1982, 1993) and Bean's Student Attrition Model (1985). They are often cited as competing theories, although Cabrera et al. (1992, 1993) have studied the convergence of the two models and suggested a model that integrates both theories.

Both Tinto's and Bean's models view persistence as the result of a complex set of interactions over time, which is affected by a successful match between the student and the institution. Bean's model emphasizes the role factors external to the institution play in affecting attitudes and decisions. While Tinto's model regards academic performance as an indicator of academic integration, Bean's model regards college grades as an outcome variable. (Cabrera, Castaneda, Nora, and Hengstler, 1992; Cabrera, Nora, and Castaneda, 1993)

Three types of people are commonly cited as influential in student's decisions to stay or leave school: peers, faculty, and parents. Most studies that look at peer influence on retention focus on such measures as the number of friends a student has on campus, the time the student spends with other students, and the student's satisfaction with his or social life in college. Similarly, the influence of faculty members on student attrition tends to focus on the amount of contact a student has with faculty, the student's evaluation of faculty, and the level of satisfaction the student has with these interactions. Parental influence on student persistence is usually evaluated by measuring status characteristics of parents, such as parental education levels and family income (Bank, Slavings, & Biddle, 1990).

The result of this study was an analysis of factors impacting the satisfaction and persistence of undergraduates in CRM. In order for the supply of graduates in these majors to meet the growing demand, the climate and pedagogy of CRM need to be considered. Dependent variables included student satisfaction with academics and instruction, commitment to major, and persistence. Increased student satisfaction and commitment are associated with higher persistence rates in general (Tinto, 1982; Bean, 1985; Caberra et al., 1992, 1993; Bank et al., 1990; Suhre, Jansen, Harkskamp, 2007). Little work has been done focusing on the unique factors influencing student satisfaction and persistence in CRM.

Factors potentially impacting the dependent variables of satisfaction, commitment, and persistence were largely derived from the literature pertaining to women and minorities in CRM. These independent variables included academic factors (general academics and instruction); social factors (faculty, peer, and family support); and institutional factors (perception of the field, climate, and program support). Choice of these variables was supported by general literature for persistence models at the postsecondary levels (Tinto, 1982; Bean, 1985; Caberra et al., 1992, 1993; Bank et al., 1990).

Data for the study was collected via a pencil-and-paper survey from undergraduates in CRM at two universities in southwestern Virginia. Two to three majors were represented at each university to allow for comparison across and between majors. Attempts to over-sample women and minority students to allow for separate analysis for these populations were unsuccessful; the percentage of these groups in the population was so small that this analysis was not possible. One limitation of the study was that data was only collected from two institutions.

Purpose

The purpose of this quantitative study was to develop and test a model of factors impacting the satisfaction and persistence of undergraduates in computer related majors at two universities in Virginia. Computer-related majors (CRM) at these schools included Computer Science (CS), Computer Science and Technology (CST), Computer Engineering (CE), Information Science and Systems (ISS), and Business Information Technology (BIT).

Research Questions

1) Do academic factors (courses, instruction, pedagogy, etc.) influence student commitment and satisfaction in CRMs?
2) Do social factors (peer support, faculty support, family support, etc.) influence student commitment and satisfaction in CRMs?
3) Do institutional factors (perception of the field, climate, program support, etc.) influence student commitment and satisfaction in CRMs?
4) Does the model for student commitment and satisfaction differ among computer related majors?
5) Does the model for general student commitment and satisfaction in CRMs differ from the model for women?

6) Does the model for general student commitment and satisfaction in CRMs differ from the model for minorities?

Questions four through six could only be answered if subgroup sample sizes were sufficiently large; this was not the case. Pursuing these questions lead to insights that can assist policy makers in determining potential changes to CRM that will encourage more students, especially women and minorities, to persist and enroll in these fields. Increased enrollment and persistence will lead to higher graduation rates and an increased workforce to meet the growing need for computer workers.

Chapter 2: Review of Selected Literature

There has recently been a rapid increase in the demand for workers with college level training in computer related fields. In 2004, approximately 3,046,000 jobs were in strongly computer related occupations, such as computer science, database administration, computer programming, computer software engineering, computer support specialization, systems administration, and computer systems analysis (Bureau of Labor Statistics, 2007). Careers requiring advanced computer skills are projected to be among both the fastest growing and the most economically advantageous occupations through 2014; median annual income for computer and information scientists was $85,190 in May 2004 (Bureau of Labor Statistics, 2007).

Although the number of computer science jobs has increased rapidly, the supply of graduates in computing fields is not keeping up with the demand. Several recent articles (Courte & Bishop-Clark, 2007; Howles, 2007; Lang, 2007) cite decreasing enrollment in computer related majors. Well-known computer science (CS) programs at Carnegie Mellon, Rutgers, Stanford, and the University of California at Berkley have reported a significant decline in CS applicants and degrees awarded (Carter, 2006). Enrollment in computer and information sciences has dropped from approximately 1,297,000 students in 1999-2000 to 998,000 in 2003. The number of bachelor's degrees awarded in these majors dropped from a high of 59,488 in 2004 to only 54,111 in 2005 (NCES, 2006). Women and minorities are underrepresented populations in computer-related majors.

Many incoming students are simply not interested in computer majors. Only 2.9% of students taking the ACT college entrance exam from 1995-2000 intended to choose a career in a computer field. Only 2% of these test-takers in 2006 and 2007 indicated an interest in computing careers (ACT, 2005, 2006, 2007).

In the wake of decreasing enrollment and increasing demand, computer related programs must assess their current state of affairs in order to determine where changes may lead to an increase in the number of computing degrees awarded. One aspect of the problem is increasing enrollment, which can be addressed by evaluating the image of computer majors. A second factor in increasing the number of graduates in computing fields is in retaining those students who originally choose computing majors. In order to increase enrollment and decrease attrition in computer related majors (CRM), educators and policymakers need to examine factors that influence student persistence and commitment to CRM.

Computer related majors refers to a group of majors with strong computer science components, but with distinct differences. Majors such as computer science (CS), computer engineering (CE), information technology (IT), and information science (IS) all include a strong programming component, as well as the need to understand both hardware and software aspects of computers. These majors differ mainly in how they apply this computer knowledge to other domains (Cukier, Shortt, & Devine, 2002). The general term computer related majors (CRM) was be used to describe all of these majors, but specific majors were mentioned as used in the relevant literature. Differentiating among majors is important because the focus of some papers is the difference in student persistence and satisfaction across an array of computer related majors (Henwood, 2000; Varma, 2002).

The literature review is presented in two parts. The first section focused on general literature on student persistence models at the postsecondary level. Most student persistence literature is general in scope and does not seek to isolate factors unique to specific majors. Since the overall focus of this study is students in computer related majors (CRM), the second section of the review focused on undergraduates in CRM. Much of the literature in this section focuses on women and minorities, an area that has received increasing attention in recent years, and which was the original focus of this study. A large portion of this section was duplicated in Singh, Allen, Scheckler, and Darlington's (2007) synthesis of research and theory on women in computer related majors from 1994 to 2005.

In their qualitative follow-up to Margolis and Fisher (2002), Larsen and Stubbs (2005) found that the perceptions of men and women were similar in regards to definitions of computer science, reasons for the lack of diversity in CS, characterizations of "typical" CS students, and impressions of CS culture. They argue that efforts to increase diversity in computer fields should be broad-based and move beyond gender. Their study implies that those factors that are successful in attracting and retaining a diverse population of undergraduates in CRM will benefit women and minorities as well.

Search Process and Terms

The literature review was conducted in two sections. In section one, the focus was on general student persistence models at the college level. Section two focused on undergraduates in computer related majors (CRM), with particular emphasis on women and minorities. Searches were conducted on the following data bases: Ingenta, Education Full Text, ERIC, Educational Research Complete, and JSTOR.

Search Engines. Ingenta ConnectComplete is a searchable database of more than 20 million citations from over 30,000 journals. A weekly email alert from Ingenta was established for new articles related to the search terms. Education Full Text is a database of citations and abstracts for English-language articles, yearbooks and books; the search was limited to articles for which the full text was available. The ERIC database, via FirstSearch, includes journal articles and reports on all aspects of education, 1966 to present, with the full-text of ERIC

Documents (items with ED numbers) from 1994 to present. Education Research Complete provides indexing and abstracts for more than 1,500 journals; this database also includes full text for selected books and education-related conference papers. JSTOR archives complete digitized runs of core scholarly journals, some dating as far back as the 1600s. The most recent issues are typically not available until a few years following publication.

Student Persistence Models. The databases mentioned above were searched using the terms “student persistence” or “persistence model” and “higher education”, “college”, or “university. The original search focused on articles from 1992 to the present. Very few of these articles included complete models of student persistence; most referred to earlier work. The second phase of the search focused on finding earlier articles commonly referred to in literature reviews of the newer work.

Computer Related Majors. The previously mentioned databases were searched using the terms “women” or “minority” and “computer science”, “computer engineering”, or “information technology.” For the reveiw, the intent was to examine selected studies that focus on undergraduate women and minorities in CRM, that are empirical and data-based, and that were published after 1994. Additional articles were added later, based on references in existing literature reviews.

In addition, a search was conducted of major journals which were likely to publish research on gendered retention in computer science. Seven primary journals were included: *Computers & Education*, *Computer Science Education*, *Journal of Research on Computing in Education*, *Journal of Educational Computing Research*, *The Journal of Computing Sciences in Colleges, Journal of Women and Minorities in Science and Engineering*, and *SIGCSE Bulletin* (Special Interest Group of Computer Science Education), published in the Digital Library of the

ACM (Association of Computing Machinery).

The final step in the selection process was to conduct a follow up search for any relevant articles which may have been missed. The Social Science Citation Index was searched with the same key words, which yielded additional articles. Lastly, the final pool of articles were examined and articles included in this review were selected.

There has been a rapid increase in literature focusing on women in CRM in recent years. This is not the case for minorities in CRM. Most articles focusing on minorities at the college level and in STEM fields were broader in scope and did not focus specifically on CRMs.

Student Persistence Models

The majority of the literature on student persistence focuses on two theories: Tinto's Student Integration Theory (1975, 1982, 1993) and Bean's Student Attrition Model (1985). They are often cited as competing theories, although Cabrera et al. (1992, 1993) have studied the convergence of the two models and proffered a model that integrates both theories. Very few articles explicitly defined a model for student persistence; most just referred to Tinto's or Bean's earlier work.

Tinto's Student Integration Model

Tinto's Student Integration model (1975, 1982, 1987) is the most commonly cited conceptual model for student persistence at the college level, according to the Social Science Citation Index. There is a large volume of work describing and testing his theory (Thomas, 2000). A student's decision to leave school arises out of a longitudinal process of interactions between the individual and other members of the academic and social systems of the institution (see figure 2.1). The student enters college with certain attributes, skills, and dispositions (intentions and commitments). Experiences within the context of college, indicated by the student's intellectual and social (personal) integration, continually modify those intentions and commitments. Positive experiences reinforce persistence and commitment to the institution, while negative ones weaken this commitment and enhance the likelihood of the student leaving. Other things being equal, the lower the student's degree of social and intellectual integration into the academic and social communities of the college, the greater the likelihood that the student will leave. Conversely, the greater the student's integration, the greater the likelihood that they will persist. (Tinto, 1987, pp 113-116).

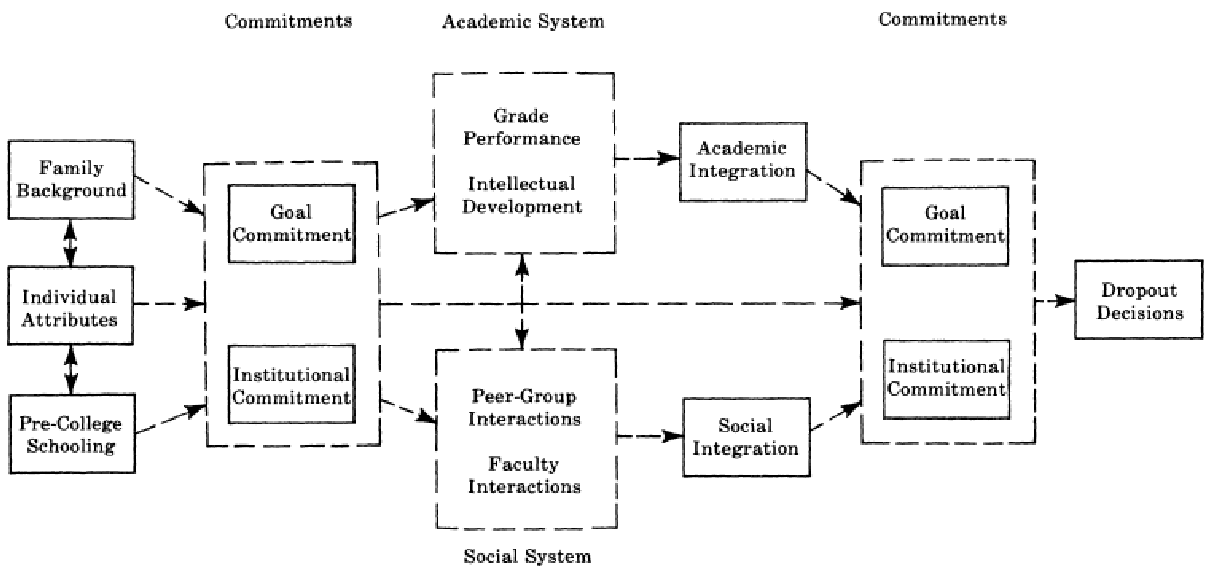

Figure 2.1: Tinto's Student Integration Model (Tinto, 1975, p. 95)

Bean's Student Attrition Model

Bean's Student Attrition Model (1985) builds upon process models of organizational turnover and attitude-behavior interactions (Cabera, Nova, and Castaneda, 1993). Academic, social-psychological, and environmental factors are expected to influence three factors assumed to result from the socialization/selection process; these factors in turn influence "dropout syndrome" (see Figure 2.2). College grades are a positive external assessment of the student's past behavior; institutional fit indicates the extent to which the student perceives a personal match with the norms and values of peers and mentors; and institutional commitment indicates the student's personal attachment to the institution. Academic factors primarily influence college grades; social-psychological factors have primary positive influence on institutional fit and commitment; and environmental factors negatively influence institutional fit and commitment and directly affect dropout syndrome. (Bean, 1985 pp 37-38).

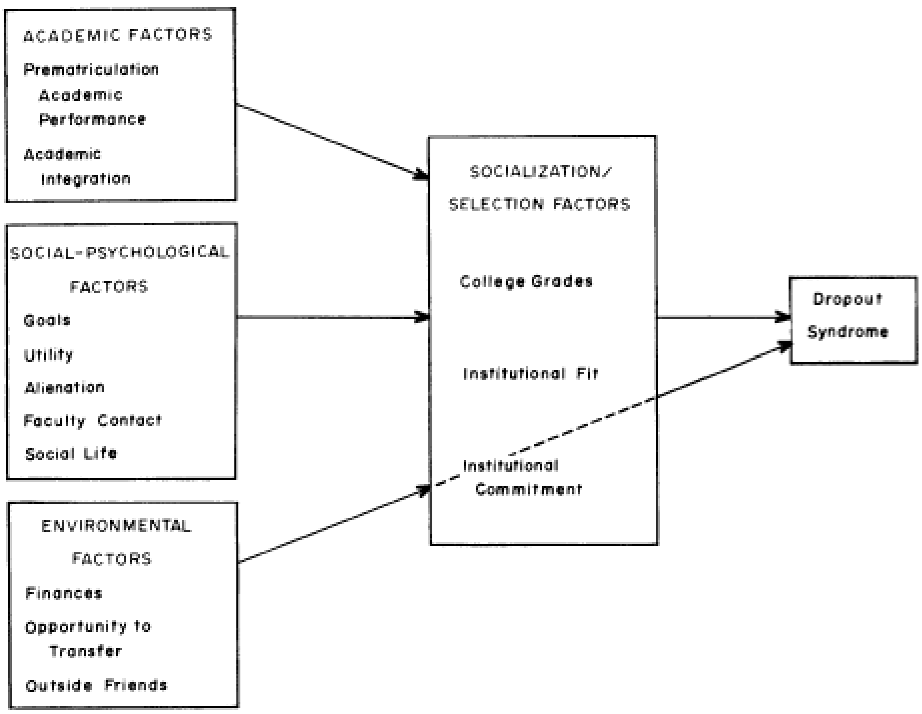

Figure 2.2: Bean's Student Attrition Model (Bean, 1985, p. 37)

Cabrera et al.'s Integrated Model

Cabrera and associates have proffered an integrated model that combines Tinto's and Bean's approaches. Both models have several commonalities: persistence is seen as a result of a complex set of interactions over time; precollege characteristics affect how well students later adjust to their institutions; and persistence is affected by a successful match between the student and the institution. Both models also have unique qualities: Bean's model emphasizes the role factors external to the institution play in affecting attitudes and decisions; and while Tinto's model regards academic performance as an indicator of academic integration, Bean's model regards college grades as an outcome variable. Building upon the results of previous research, the baseline model in figure 2.3 was identified that incorporated both theoretical frameworks. (Cabrera, Castaneda, Nora, and Hengstler, 1992; Cabrera, Nora, and Castaneda, 1993)

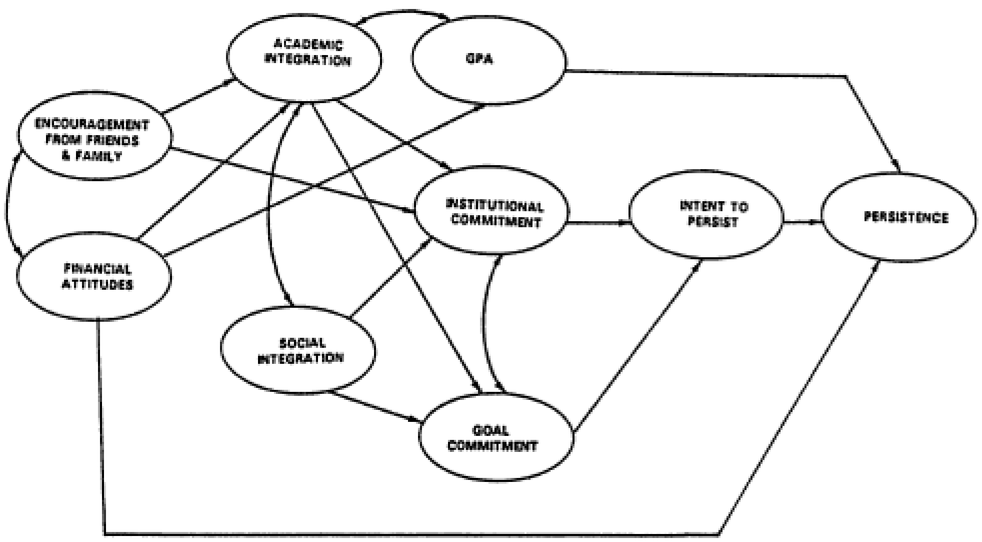

Figure 2.3: Cabrera et al.'s Integrated Model (Cabrera et al., 1993)

Other studies

According to Bank, Slavings, and Biddle (1990), three types of people are commonly cited as influential in student's decisions to stay or leave school: peers, faculty, and parents. The influence of peers is most likely to be examined; decisions to drop out are affected by peers' acceptance or the extent to which students form close friendships with peers. Unfortunately, empirical studies have failed to provide consistent support for this suggestion. Most studies that examine peer influence on retention focus on measures such as the number of friends a student has on campus, the time the student spends with other students, and the student's satisfaction with his or her social life in college. Similarly, the influence of faculty members on student attrition focuses on the amount of contact a student has with faculty, the student's evaluation of faculty, and the level of satisfaction the student has with these interactions. Parental influence on student persistence is usually evaluated by measuring status characteristics of parents, such as parental education levels and family income.

Hu and St. John (2001) examined the effect of policy changes in state financial aid on student persistence in higher education by racial and ethnic differences. They found that the observed disparity in persistence among racial/ethnic groups were not the result of financial aid; instead, good grades seemed to be a better indicator of student persistence.

In a study of Dutch law students, Suhre, Jansen, and Harkskamp (2007) examined the relationship of student satisfaction with their academic accomplishments and persistence. They found that program degree satisfaction has a direct positive effect on the number of credits a student acquired (academic accomplishment) and a negative effect on dropout. Eliott and Healy (2001) found three dimensions predictive of student satisfaction: "student centeredness," which reflects the institution's effort to convey to students that they are welcome and valued; "campus climate," which reflects the student's sense of campus pride and belonging; and "instructional effectiveness," which reflects the student's experience of the curriculum, curriculum quality, and the perceived effectiveness of faculty and staff. Their results indicate that instructional effectiveness is the most important dimension. Athiyaman (1997) also acknowledges the importance of perceived quality of instruction as a main source of student satisfaction.

Summary

It seems evident from the general literature on student persistence that student persistence or drop-out is affected by a complex interplay of academic, social, and institutional factors, and that it evolves over time. General models only capture part of the complexity in CRM, however.

There are additional aspects unique to CRM that effect student commitment and persistence; these are examined in the next section.

Computer Related Majors

There is a high demand for citizens who have college level training in Science, Technology, Engineering, and Mathematics (STEM) fields in general, and in computer related fields in particular. College preparation in CRM is viewed as vital to the economic, health and national security interests of the United States. (Duderstadt, Atkins, & Houweling, 2002). Careers requiring advanced computer skills are projected to be among both the fastest growing and the most economically advantageous occupations through 2014 (Bureau of Labor Statistics, 2007). Despite the efforts of colleges and universities to encourage participation of women and minorities in computer fields (Goodman, Cunningham, & Lachapelle, 2002; Rosser, 1997), the number of women in computer science and computer engineering majors has decreased (National Science Foundation, 2007). For example, 24,769 bachelor's degrees in computer science were awarded in 1995 and 57,405 in 2004. At the same time, the percentage of women earning these degrees dropped from 37% in 1984 to 22% in 2005. The percentage of minorities earning bachelor's degrees in computer science increased from 34% in 1996 to 41% in 2004, but dropped to 39% in 2005 (NCES, 2007).

The last decade has seen the growth of a large body of research on topics related to reasons for women's persistent underrepresentation in information technology areas (Etzkowitz, Kemelgor, & Uzzi, 2000; Gürer & Camp, 2002; National Science Board, 2003; National Science Foundation, 2007). Margolis and Fisher (2002) conducted the first comprehensive study on the persistent problems in recruiting and retaining undergraduate women in computer science at Carnegie Mellon University. They documented the complexity of problems and barriers that women face, and provided profiles of women who persist and succeed in computer science. Most of the literature on minorities is more general in scope, focusing on STEM fields in general, rather than on more specific CRM.

In a qualitative follow-up to Margolis and Fisher (2002), Larsen and Stubbs (2005) found that perceptions of men and women were similar in defining of computer science, explaining the lack of diversity in computer science, characterizing of “typical” computer science students, and describing impressions of CS culture. They argued that efforts to increase diversity in computer fields should be broad-based and move beyond gender. Factors that are successful in attracting and retaining a diverse population of undergraduates in CRMs will benefit women and minorities as well. Although the majority of the literature reviewed focuses on women in CRM, the factors influencing women’s commitment and persistence are crucial to all students.

Although the low participation of women and minorities in CRM is strongly related to educational and cultural factors well before college entry, this review focused on undergraduate experiences. Included studies examined the role academic and social experiences on the decision to major in computer and IT fields. Despite a growing literature on women and minorities in STEM fields, there is a lack of empirical studies about their participation in computer related majors. More research is needed on the unique issues in CRM that influence women’s and minorities’ persistence and commitment decisions. The findings of the few empirical studies on college women and minorities in computer and IT fields indicate that a wide variety of institutional and personal factors influence the decision whether or not to major in CRM. The findings are grouped under two broad sections: Factors that influence initial enrollment in CRM and factors that influence attrition and retention in CRM.

Initial Enrollment: Trends

Although 58% of undergraduates are female, a much smaller percentage of women go into CS, IS, or IT (Gadalla, 2001; Randall, Price, & Reichgelt, 2003). Men outnumber women in all computer related majors and are five times more likely than women to choose majors in CS or CE (Camp, 1997; Cohoon, 2001). Camp (1997) further noted that CS departments in engineering colleges graduate, on average, fewer women than CS departments in non-engineering colleges; this trend is discouraging, since many CS departments have recently moved to colleges of engineering, including Virginia Tech.

Women in CRM are more concentrated in Information Science (IS) and Information Technology (IT) programs than in CS (Randall et al., 2003). This concentration of women seems to be related to the more applied nature of these programs. Participation and enrollment of women seem to vary by the type of program (Randall et al., 2003). Spahn (2001) focused on adult women and minority students in a non-traditional four-year university and analyzed reasons for their enrollment in IT degree programs. He reports that 33% of the women in these programs were from a racial/ethnic minority. Most of these women were not interested in computers in high school; in fact, they learned to use computers more recently. Their primary motivation for pursing an IT degree was economic.

Lopez and Schulte (2002) studied National Science Foundation data on degrees earned in CS. They found almost no gap between African-American males and females in CS degrees earned. Margolis et al. (n.d.) noted that international women tend to choose CS in larger numbers and have higher persistence, despite the fact that they enter the program with the least computer experience of any other population. These international women chose to major in CS for pragmatic and economic reasons, and as they took computer courses, they began to master and enjoy working with computers.

International studies (Adams et al., 2003; Fan & Li, 2005) based on computer science students in Mauritius and Taiwan reported that pipeline issues are unique to the United States; in these countries women enroll and succeed in computer related majors in equal numbers. Adams Bauer & Baichoo, (2003) offered two possible reasons: possibilities of financial rewards and prestige for women, and single sex secondary education which better prepares women for entry into technical fields. Two more recent studies examine perceptions of CS/IT in countries where women are the majority of students in CRM. In Malaysia, 53% of CS/IT majors are female. Although male students have higher confidence in their abilities before starting the program, women had a more positive attitude towards CS/IT and were more confident they would pursue a career in the field after graduation. Othman and Latih (2006) conclude that Malaysian students have different perceptions of CS/IT than students in other countries, but give no explanation for the discrepancy. Gharibyan and Gunsaulus (2006) provide a possible explanation. In Armenia, the percentage of women majoring in CS never fell below 75% in two decades. Students, parents, and professionals felt that CS and math major were suitable for women, but engineering majors were unsuitable. The authors suggest that classifying CS as engineering, which is frequently the case in the United States, may deter women from choosing to major in CS.

It is important to understand the state of CRM in countries where women are not underrepresented. However, simply concluding that students in these countries have different perceptions regarding CRMs than those in the United States does not solve the problem. Further research should compare the image of CRM in the United States and abroad, and seek reasons for the differing perceptions that have been investigated to date. Gharibyan and Gunsaulus

(2006) mention additional research in the pipeline that makes this sort of comparison; their future work merits continued scrutiny.

Academic Factors that Effect Satisfaction and Commitment

Beyer et al. (2005) examined gender differences in computer science students' perceptions of CS stereotypes and their attitudes toward CS classes and the CS program from one semester to the next. They concluded that those perceptions were not stable. Although no differences were reported in intent to major in CS, and in plans to take math and science courses, men had significantly higher educational aspirations than women did and valued extrinsic rewards more (Beyer, Rynes, Perrault, Hay & Haller, 2003). Male and female students alike regarded CS as a worthwhile major. Women had significantly less confidence in their computing ability, controlling for ACT scores. Female CS majors had lower computer confidence than male non-majors (Beyer et al., 2003). Other researchers (Scragg & Smith, 1998; Varma, 2002) found similar gender differences in confidence.

In contrast, Clegg, Trayhurn and Johnson (2000) observed classroom interactions and concluded that women students appeared confident, were more vocal, and were sought by peers for advice. Sturm and Moroh (1995) reported that although the percentage of women passing the introductory CS course was higher than that of men, women dropped out from CS programs in larger numbers. Although women did significantly better in calculus courses than men, they expressed doubt in their ability to handle the mathematics necessary for a CS degree (Sturm & Moroh, 1995). Varma (2002) also found women had lower confidence levels in math and IT in her study of women in a minority serving institution. Staehr, Martin & Byrne (2000) reported that early programming experience was a good predictor of success in first programming course.

Newer studies reveal a "we can, but we don't want to" attitude among young women which indicates a lack of interest in CS and CE. One commonly stated theory is that women do not go into CS because they cannot do the math; while this may have been the case in earlier studies, women's math scores have recently become comparable to men's. Sturn and Moroh (1995) found that women did significantly better in calculus courses than did men. Secondary girls typically dismissed the idea of a computing career with replies such as "boring," "menial," "not sufficiently challenging," and "wouldn't want to be stuck in an office with just a computer." Most indicated that they had learned computing at school, they had found it boring, and they were not interested in computers. Students did not choose CRM majors because they lacked interest, and they felt the courses were difficult and too time consuming (Weinberger, 2004; Wilson, 2003).

Many incoming students simply are not interested in majoring in computers. Only 2.9% of students taking the ACT college entrance exam from 1995-2000 intended to choose a career in a computer field. Only 2% of test-takers in 2006 and 2007 indicated an interest in computing careers (ACT, 2005, 2006, 2007).

Student attrition in computer majors is highest in the first two years (Howles, 2007). In fact, women who initially enroll in computer majors are more likely than men to drop out in the freshman or sophomore years (Cohoon, 2001). For example, attrition among females with declared computer science majors in Virginia was twice as high as the male rate from 1992-1997 (Cohoon, 2002). This early attrition rate is usually attributed to "weed out" courses and early courses that focus entirely on programming, without showcasing the broader impact of the discipline. Second and third year students revealed an almost total preoccupation with programming. Women reject computer related majors rather than fear them (Wilson, 2003).

Bunderson and Christensen (1995) studied reasons that students endorse for changing from CS to other majors. A key factor in the high rate of attrition rate of women is lack of previous experience with computers.

CS students agreed that there was a need for more female role models in CS but most did not agree that a course about the significance of gender in computing is needed (Bjorkman et al., 1998). Clegg et al. (2000) suggest that women tutors demonstrate a more active coaching style, which encourages collaboration and more peer interaction. In Gokhale and Stier's (2004) study of female students in an introductory course, participants were satisfied with instructors, curriculum, and instruction, but made suggestions to modify instruction, such as making examples gender neutral. Women also wanted more classroom interaction (Gokhale & Stier, 2004). Weinberger (2004) found that at least one-third of the women indicated that they would not go into IT because of an unwelcoming classroom (or workplace) atmosphere. West and Ross (2002) found that women still perceived gender bias in computer science and found the environment cold and unresponsive. They reported that female students felt less comfortable asking questions of male CS professors and the male-dominated culture affected their self-esteem and learning.

In contrast, Greening (1999) explored the validity of gender stereotypes and found that statements of self-perceptions and bias elicited gender-neutral responses from both male and female students. Scragg and Smith (1998) reported few gender differences in social pressures that discourage women, in perceptions of classroom environment, or math anxiety.

Variables such as self-confidence, attribution of success, and specific self-concept of ability play a complex role in women's decisions to persist or dropout of CRM. For example, women believe that women in general can succeed in computer majors, but they assessed their own ability less favorably ("they can, but I can't). Most students believe that there is already equal opportunity for males and females to choose CS majors. Women did not want special treatment, but lacked belief in their equal abilities (Wilson, 2003). Women had lower self-confidence in CS, regardless of quantitative ability (Beyer et al., 2003). Female students tended to have a less favorable attribution index, had a lower computer-specific self-concept of ability, expected less success, and used computers less intensively than males (Dickhäuser & Stiensmeier-Pelster, 2002).

Fisher et al. (1997) noted a gap between women's perceived ability and their actual performance. Several studies pointed out the issue of a confidence gap (Irani, 2004; Scragg & Smith, 1998; Wilson, 2002). Irani (2004) reported that establishing an identity of competence is critical for women to continue in computer science. Gendered self-representation, not ability or performance, affected women's confidence and persistence in computer science. Wilson (2002), in a study of factors that are related to success in computer science, found three factors predictive of success: comfort level, math background and attribution of success to luck. The first two had positive effect, the third had a negative effect; she found no gender differences in these factors.

Recent research calls for computer educators to evaluate the pedagogy and environment of computing majors (Howles, 2007; Miliszewska, Barker, Henderson, & Sztendur (2006); Turner, Albert, Turner, & Latour, 2007; Varma & Lefever, 2007). The earliest programming classes may be crucial for women's later success in the field. Earlier studies indicate that women who initially enroll in computer-related majors tend to drop out in their freshman or sophomore years (Cohoon, 2001). Two 2006 studies found that although many women begin computing careers with less exposure to programming than men, there are no differences in women's programming knowledge or course grades after the earliest courses (Vilner & Zur, 2006;

Murphy, McCauley, Westbrook, Richards, Morrison & Fossum, 2006). Two other studies recommended changes in the curriculum which could potentially increase retention of women (Pioro, 2006; McDowell et al., 2006).

Vilner and Zur (2006) found that, although a smaller percentage of women than men passed introductory CS and math courses, once women passed the introductory courses there was no difference in the pass rates for courses later in the sequence. Murphy et al. (2006) found that, while women on average are introduced to and master fewer programming concepts than men before college, by the time they finish introductory CS courses they “catch up” with the men.

Mathematical background may be a factor in success in early programming courses. Pioro (2006) found that students whose background included both Discrete Math and Calculus performed better on programming tasks and received grades in programming classes close to the average grade in the math courses. There was no evidence that academic major (CS, EE, MIS) or gender contributed a significant factor in programming ability.

McDowell et al. (2006) suggest a change in introductory programming classes that benefits all students. Students who participated in paired programming in an introductory CS course had higher course completion rates, better programs, more confidence and enjoyment of programming, and were more likely to declare a CS major. This is true for both women and men, but women reported a much larger increase in confidence levels.

Social Factors that Effect Satisfaction and Commitment

Women choose computer related majors when encouraged by colleagues and family and when they see increased job opportunities and monetary rewards. This choice is especially true of minority and international women (Margolis et al., n.d.; Spahn, 2001). International women entered CS with the least experience of any group of students, and in some cases, no experience at all. Most were successful in the program and developed an intellectual pleasure in CS that was lacking at the beginning of the program. For many, their families depended on them for economic survival (Margolis et al., n.d.). Many women also cite the influence of male friends and colleagues. Some women committed to the field in increments; work experience and exposure over time led to an enjoyment of the field (Spahn, 2001). For many female first-year Information and Computer Technology students, intrinsic pleasure was embedded in the instrumental view that completing a CRM degree would lead to job choices with the power to do the things they enjoy (Clegg & Trayhurn, 2000).

Two Cohoon studies (2001, 2002) found that CS departments retained more women when the faculty included women, mentored female students, and enjoyed teaching, and when there were sufficient number of women students in classes to support each other (Cohoon, 2001). Staehr et al. (2000) reported an improved retention rate for women after an intervention program was implemented. Their study concluded that mentoring programs were critical for women's success. Besana and Dettori (2004) also reported a positive effect of an informal learning community and support program for female programs.

Institutional Factors that Effect Satisfaction and Commitment

Several studies indicate that students do not understand what is involved in computing majors (Berry et al., 2006; Lee & Lee, 2006). Some student associate CS with writing programs, while others believe that it involves finding information on the web or using computers for routine tasks (Courte and Bishop-Clark, 2007). There was no gender difference in knowledge concerning what is involved in CS (Beyer et al., 2003). Both male and female students rated the career opportunities in CS as excellent, although more male students perceived computer scientists as loners and interested in numbers. Fewer women were aware of the high financial compensation in CS fields (Beyer et al., 2003).

Two recent studies found that the information systems (IS) major is not well-understood by business majors (Berry et al., 2006; Lee & Lee, 2006). The general perception is that IS is the most difficult business major and that job opportunities are lacking. Non-majors had incorrect preconceptions of what an IS major entails. Lee and Lee (2006) found that women placed higher priority on family preference when selecting their major than males, and that parents and peers are less likely to recommend IS than other business fields. Very few women ruled out IT because they felt it would be difficult to combine these careers with raising a family, although earlier literature cites this as a factor in women's decision not to pursue computer majors (Beyer et al., 2003; Weinberger, 2004). At least one-third of women, however, said that they would not go into IT because of the unwelcoming classroom (or workplace) atmosphere.

The stereotyped image of computer majors can deter some students. Margolis and Fisher (2002) call this phenomenon the "prevailing geek mythology." First-year students described the typical CS major as anti-social and unathletic, but intelligent and in love with computers—in fact, living and breathing computers—myopically focused on computers to the neglect of all else. Most students, however, said this image of the CS student was "not me:" 68% of the women and 32% of the men perceived themselves as different from the majority of their peers (Bjorkman et al., 1998). Negative stereotypes of computer scientists (Beyer et al., 2003) and masculine views of computing (Clegg & Trayhurn, 2000) have been cited as reasons for women's absence and attrition in CS.

Male CS students attributed the low percentage of women in CS as a general lack of interest in computing on the part of women. Second and third year CS majors believed that women failed to enroll in CS because the stereotyped images of computing is technical, male sex-typed, and mathematical; girls were not encouraged to study computing; and girls were not interested in computing (Clark, & Teague, 1996). Although earlier research found that women thought computer fields lacked social impact, more recent research refuted that view with findings suggesting women do not rule out IT majors for fear that socially useful applications cannot be found (Weinberger, 2004).

Earlier papers theorize that women who choose CRMs are drawn towards application-oriented majors rather than programming-oriented (and theoretical) majors. Frieze et al. (2006) present three case studies which suggest that the divide in how students relate to CS, particularly with respect to programming versus applications, is not a product of gender but rather a product of micro-cultural and environmental conditions. When women are well-represented in the CS program, the gender divide is not evident; rather, there is a spectrum of attitudes and attachments among women and men.

Summary

Women tend to drop out of CRM because they have less prior experience than males, lack confidence, and perceive an unwelcoming environment. Many first-year CS women question whether they belong in CS because they feel they lack the intensity of focus and interest that they see in their male peers. Although they did better in an introductory programming class, more women dropped out of the major than men. Women did significantly better in calculus courses, but often expressed doubt in their ability to handle the math in a CS degree (Sturm & Moroh, 1995). Although women saw the environment as unwelcoming, CS students (male and female) resisted affirmative action as “reverse discrimination” and saw no real need to change the environment (Bjorkman et al., 1998). Some female first-year CS students experienced direct discrimination and problems with boys at school or with men at work (Clegg & Trayhurn, 2000). Lack of same-sex peer support, faculty support, and female role models were also cited in the literature as factors in women's persistence (Cohoon, 2001, 2002). In traditional computer science programs, there is little emphasis on cooperative and collaborative approaches, changing social attitudes, or providing mentors and role models for young women (Besana & Dettori, 2004).

Conversely, women are more likely to persist in a CRM if there are female faculty mentors, departmental support, and access to job opportunities. Cohoon (2001) found that CS departments retained women at comparable rates to men when faculty included at least one woman; were stable; valued, mentored, and supervised female students; shared responsibility for success with their students; the department had (perceived) above average support from its institution; graduating seniors had access to a strong local job market; and perhaps, high starting salaries; and there were sufficient numbers of female students in each class for peer support. A complex picture emerges of the reasons for women's persistence in computer related majors. An interplay of personal, cultural and structural factors are at the heart of women's decisions to continue in CRM. It is also clear that institutional changes enhance women's persistence. The perceptions of supportive and female friendly environments foster retention of women in CRM.

Although the review of the literature yielded some significant insights and highlighted the role of college experiences in the decisions to major in CRM, there is a strong need for more research that is discipline specific. There are some unique issues related to CRM, in addition to the general reasons for women's and minorities' small numbers in STEM. The gap is closing in some fields (e.g. Biological sciences) while the number of women has continued to decline in

CRM; such uneven patterns of women's enrollment in different fields suggest unique issues in CRM.

Despite important findings gleaned from this literature review, many studies on women and minorities in CRM are anecdotal or based on small, non-random samples, single site case studies, or descriptions of intervention programs. Computer majors are often not separated out and most studies focus on the K-12 system and not on college women. Thus, findings are inconsistent and there are only a few robust and discipline specific guidelines for policy. Much of the literature is inconsistent due to samples of convenience and measures that are inconsistent across studies.

There is distinct lack of quantitative studies. Much of the early research has been qualitative or focused on single schools and convenience samples. A large part of the existing literature is from other countries; very little of it focuses on undergraduates in the United States. Most of the groundbreaking literature in the United States comes from very small, elite colleges, and few attempts are made to control for experiences prior to college.

There is also need for closer scrutiny of specific populations of student in CRM. International women have been successful in CRM and have persisted in these fields despite their lack of access and prior experience with computers before attending college. When compared with African-American males, African-American women have also shown more persistence than women in general. These are groups that ought to be studied further. In order to more fully understand the declining enrollment in CRM, it is time to focus on issues that may be unique to CRM.

The literature review on women and minorities in CRM suggested several factors that influence student persistence in these fields. Students with strong social support systems that include family, faculty, and peers have a higher likelihood of completing their degree. Academic factors such as the structure, pace, and content of instruction can make a difference in students' desire to stay or leave a major. Institutional factors, such as perception of the field, climate, and program support structures also play a role. These factors, derived from the literature, were echoed in the literature on student attrition at the college level. These factors are the foundation of the conceptual model that was tested in this study.

Chapter 3: Methodology

The purpose of this quantitative study was to develop and test a model of factors influencing the satisfaction and persistence of undergraduates in computer related majors at two universities in Virginia. Computer-related majors (CRM) at these schools included Computer Science (CS), Computer Science and Technology (CST), Computer Engineering (CE), Information Science and Systems (ISS), and Business Information Technology (BIT).

The model had three major independent constructs: academic, social, and institutional factors. Academic factors included two subscales: general academics and instruction. Social factors included three subscales: faculty support, peer support, and family support. Institutional factors included three subscales: perceptions of the field, climate, and program support. Dependent constructs (outcome variables) were persistence and satisfaction, which represent student commitment to their major and computing occupations.

The sample was largely one of convenience. With cooperation of each department, several classes at differing academic levels were identified to complete the Computer Related Majors Survey (CRMS). Instructors of these classes were contacted via email and asked to provide class time for survey completion. Sample size varied among departments, from a low of 18 ISS majors from Radford to a high of 200 CS majors at Virginia Tech; in all, 494 surveys were collected, with 388 respondents in CRMs.

Primary data analysis was conducted using structural equation modeling (SEM) techniques via Lisrel 8.80. The goal of SEM analysis is to determine the extent to which a theoretical model is supported by data. “Structural equation modeling techniques explicitly take measurement error into account when statistically analyzing data” (Schumacker & Lomax, 2004, p. 7).

Research Questions

1) Do academic factors (courses, instruction, pedagogy, etc.) influence student commitment and satisfaction in CRM?
2) Do social factors (peer support, faculty support, family support, etc.) influence student commitment and satisfaction in CRM?
3) Do institutional factors (climate, program support, etc.) influence student commitment and satisfaction in CRM?
4) Does the model for student commitment and satisfaction in CRM differ among computer related majors?
5) Does the model for general student commitment and satisfaction in CRM differ from the model for women?
6) Does the model for general student commitment and satisfaction in CRM differ from the model for minorities?

Questions 4-6 could only be answered if subgroups sample sizes were sufficiently large. Attempts were made to over-sample women and minority students to allow for separate analysis for these populations; however, the percentage of these groups in the population was sufficiently small enough that this analysis was not possible.

Survey Development

Qualitative Pilot

In Spring 2005, a pilot study was conducted on persistence of women in computer related majors. The purpose of this qualitative study was to explore the factors that junior- and senior-level undergraduate women perceive influence their persistence in computer related majors at Virginia Tech. Research questions focused on student perceptions of how significant relationships (family, peers, teachers, etc.), courses and classroom experiences, and out-of-class experiences influenced their persistence in CRM.

Six junior- and senior- level undergraduate women in CRMs chose to participate in this study; one junior BIT major, three senior CS majors, and two junior CE majors All were Caucasian, and all but one were 21 years old. An in-depth interview, lasting approximately half an hour, was conducted with each participant. All interviews took place in a two-week period in early April. All interviews were audio-taped and one was later transcribed by the researcher. Shortly following each interview, field notes were recorded that summarized key points discussed in the interview. These field notes were the primary source of data, and were cross-referenced by referring to the tape recordings and/or transcript.

Data were analyzed through a constant-comparative method similar to the one used in grounded theory research. Field notes were subjected to three rounds of coding; initial codes were compared and refined. Audio-taped interviews were then used to verify and extend codes noted in field interviews.

The overriding theme noted from the interviews was that a combination of internal and external factors has enabled these students to persist in CRM. Internal factors included stubbornness, competitiveness, and an outlook focused positive experiences and goals. External factors included academic and social support networks with faculty, peers, and family. Students had or actively developed academic and social support networks among faculty, peers, and family. A supportive faculty member was often key in preventing students from switching majors. Students focus on positive experiences instead of negative ones; they view classroom complaints as "like other majors." Students enjoyed the challenge in CRMs; they felt early weed-out classes were important and were proud to have been successful in them. Students focus on goals, future plans, and why they chose the major in the first place. All students had some form of prior experience with computers and programming. They attributed their success to stubbornness, competitiveness, and the ability to accept failure.

Pilot Survey

The Computer Related Majors Survey (CRMS) was developed and piloted in late fall 2006 and early spring 2007. The pilot version of CRMS was based upon the qualitative pilot interviews and a synthesis and critique of the literature on women in CRM from 1994 to 2005 (Singh, Allen, Scheckler, and Darlington, 2007). Items focused on academic, social, and institutional experiences of CRM majors. Some items were adapted from pre-existing surveys; several new items in each category were created based upon the literature review. Additional items collected information on demographics, computer experience prior to college, satisfaction and commitment to the field, and perceptions of computing careers.

Since this was to be a pilot survey, the pool of items was very large. The survey was split into two forms, each with 100 items. Similar items were split between the two forms, and a large pool of fifty-three items was common to both forms for comparison purposes. With the exception of demographic and previous experience items, most items used a four-point Likert scale, with responses of Strongly Disagree, Disagree, Agree, and Strongly Agree.

The survey was piloted online at Virginia Tech using the campus web survey application. Since the target population was computer-related majors, a reasonable response rate was expected for the online survey. The target population was undergraduate students at the University with declared majors in CS, CE, and BIT. In fall 2006, when the pilot was conducted, there were 341 BIT majors, 331 CE majors, and 339 CS majors. Women were a small proportion of these enrollment figures: 16.2% of BIT, 6.3% of CS, and 5.5% of CE majors were female. Each department was asked to provide email addresses for 100-150 students (2 classes at different academic levels); this was intended to provide a cross-sectional sample. Addresses were randomly assigned to one of the two forms. Students were contacted via email and invited to participate; a second follow-up email was sent one week later. The initial contact was close to Thanksgiving break. Due to a low rate of response, the invitation was repeated early in the Spring 2007 semester. A total of 150 BIT majors, 114 CS majors, and 219 CE majors were invited.

Pilot Sample. A total of 69 responses were received for the pilot survey (see Table 3.1). Most respondents (85%) were Caucasian; 43% were CS majors, 47% were CE majors, and only 10% were BIT majors. Participants were mostly sophomores and juniors; 19% of the respondents were female, and one participant did not indicate gender.

Table 3.1: Pilot Survey Respondents by Academic Level, Major, and Gender

	Fresh.		**Soph.**		**Junior**		**Senior**		**Totals**		
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**All**
CS	1	0	5	0	7	2	8	6	21	8	**29** (.43)
CE	0	0	16	1	10	1	3	1	29	3	**32** (.47)
BIT	0	0	0	0	2	2	3	0	5	2	**7** (.10)
Total	1	0	21	1	19	5	8	4	**55**	**13**	
	1 (.01)		**22** (.32)		**24** (.35)		**12** (.28)		(.81)	(.19)	**68**

Overall, the pilot response rate was 14.1%. This was much lower than anticipated. Online surveys presented to similar populations have reported response rates varying from 43-60% (Dillman, 2000). There were several possible explanations for the low response rate. Some studies indicated online surveys have much lower response rates than traditional paper-and-pencil surveys (Coupler, Bair, & Tripplet, 1999; Couper, 2001; as cited in p. 154 of Groves, Fowler, Couper, Lepkowski, Singer, & Tourangeau, 2004). In addition, the pilot was conducted in the weeks surrounding Thanksgiving break. The holiday and the end of the semester rush may explain why some students did not respond. The survey itself was long; we indicated to students that it would take about 20 minutes to complete, which may have deterred some students. In addition, there were some problems with non-majors in the class lists provided by the department. After the last round of invitational emails, we received several replies that indicated that the student was not a BIT, CS, or CE major. Regardless of the explanation, the low response rate made statistical analysis problematic.

The Computer Related Majors Survey

Based upon analysis of pilot results, the final version of the CRMS was developed. See the Appendix for the full instrument. Items common to both forms were analyzed for correlations among items and scale reliability. Some items from the pilot were dropped due to low correlations with other items within the scale. Items from the separate forms were grouped for similarity and items with the highest variance were retained. Scales were adjusted so that each target factor, except for demographics, was represented by six items. The final version of the CRMS had seventy-two items. Dependent constructs (outcome variables) were persistence and satisfaction. Demographic variables included major, race/ethnicity, gender, year in college, and items assessing background in computers prior to entering college. There were three major independent constructs: academic, social, and institutional factors.

Outcome variables were satisfaction and persistence, which represent student commitment to their major and computing occupations. Satisfaction items focused on student satisfaction with their choice of major and occupational opportunities in the computing field (e.g, I am satisfied with my choice of major). Persistence items assessed the student's intent to complete a degree in their current major and to seek employment in the computing field (e.g, After graduation, I will seek employment opportunities in my major).

Academic factors included two subscales: general academics and instruction. General academics included items assessing the student's perceptions of the academic background, difficulty levels, and time demands of coursework (e.g., I had the background to be successful in classes early in my major). Instruction included items focusing on student views of instruction, group work, and teaching (e.g., I feel comfortable asking questions in class).

Social factors included three subscales: faculty support, peer support, and family support. Faculty support included items focusing on the student's relationship with faculty and instructors (e.g., Faculty in my major have given me an opportunity to apply classroom learning to "real-life" issues). Peer support included items assessing the student's relationship with classmates and peers, both within and outside of their major (e.g, I frequently study and/or work with other students in my department). Family support included student perceptions of the supportiveness and understanding of their family with regards to their choice of major (e.g., My family is supportive of my choice of major).

Institutional factors included three subscales: perceptions of the field, climate, and program support. Perceptions of the field included items dealing with student views of computer majors and computing careers (e.g, Computer majors are nerdy). Climate included items focusing on perceptions of how students are treated in the classroom and in the department (e.g, My department favors students with previous programming experience). Program support included items that assessed student views of support mechanisms within the department, such as tutoring and financial support (e.g, It is easy to switch between concentrations and/or special programs within my department).

Population and Sample

Virginia Tech. Virginia Polytechnic Institute and State University (Virginia Tech), located in Blacksburg, Virginia, was founded in 1872 as a land-grant college. It offers sixty bachelor's degree programs and 140 master's and doctoral degree programs. Over 25,000 full-time students are enrolled in its eight colleges and graduate school (Virginia Tech, 2007). Virginia Tech offers three computer-related majors: computer science (CS), computer engineering (CE), and business information and technology (BIT).

The Department of Computer Science is located in the Department of Engineering. According to the departmental website, the major is software oriented, in contrast to the hardware-oriented computer engineering major. "Computer science majors design and develop software, from the software systems that control the functioning of the computer such as operating systems and compilers to applications software for areas such as numerical analysis, graphics, and data bases" (Computer Science @ VT, 2007). In fall 2007, 292 students were enrolled as undergraduates with declared CS majors, either full or part time. Of these, only 4.5% were female; 68.2% were Caucasian (VT Institutional Research, 2007).

The Department of Electrical and Computer Engineering is also located in the Department of Engineering at Virginia Tech. According to the departmental website, "as one of the country's larger ECE departments, The Bradley Department offers strong education and research opportunities in diverse areas, including computers, control systems, communications, electronics, electromagnetics, and power" (The Bradley Department …, 2006). For fall 2007, 296 students were enrolled as undergraduates with declared CE majors, either full or part time. Of these, only 4.7% were women; 59.1% were Caucasian (VT Institutional Research, 2007).

The Department of Business Information Technology is located in the Pamplin College of Business at Virginia Tech. According to the departmental website, the BIT major is "designed to provide our students with expertise in the development and use of computer systems and quantitative modeling techniques for solving business problems and making managerial decisions. […] The degree program especially focuses on the practical application of computing to business problem-solving" (Pamplin College of Business, 2007). In fall 2007, 287 students were enrolled as undergraduates with declared BIT majors. Of these, only 16.7% were female; 66.9% were Caucasian (VT Institutional Research, 2007).

Radford University. Radford University (Radford), located in Radford, Virginia, was founded in 1910 as a women's university. Now coeducational with over 9,000 students, Radford offers 153 graduate and undergraduate degree options in seven colleges. (Radford University, 2007). Radford offers two computer-related majors: Computer Science and Technology (CST) and Information Science and Systems (ISS).

Both CST and ISS majors are located in the Department of Information Technology in the College of Science and Technology. Within the CST program, students choose from four concentrations: Computer Science, Database, Software Engineering, or Networks. Within the ISS program, students choose from three concentrations which include additional courses in business: Information Systems, Enterprise Systems Development, or Web Development.

(College of Science and Technology, 2007). For fall 2007, 121 students were enrolled as undergraduates with declared ISS majors. Of these, only 14.0% were female; 80.1% were Caucasian. In fall 2007, 196 students were enrolled as undergraduates with declared CST majors. Of these, only 7.1% were female; 87.2% were Caucasian. (RU Institutional Reseach, 2007).

Sample and Data Collection. The sample was largely a convenience sample. With cooperation of each department, several classes at differing academic levels were identified to complete the CRMS. All students attending class on the selected day were asked to complete the survey. Sample size varied, with larger samples from VT than from RU.

Surveys were administered during regular class sessions during the Spring 2007 semester. Classes at Radford and VT Computer Science classes were surveyed in the first three weeks of the semester. VT BIT and CE classes were surveyed later in the year, most in the week following spring break. Department heads identified key classes and sent out requests for cooperation to instructors via email. Professors were contacted via email to obtain their permission to survey during class time. In some classes, the survey was conducted at the beginning of class; in others, it was conducted at the end or during a lab session. In most cases, the survey was administered by the researcher, although one CS class' surveys were administered by their professor and a CE class was administered by a friend of the researcher.

Although permission to collect data was obtained at Radford, due to difficulty in communications and scheduling, only three classes were surveyed. All were first-semester courses, and many students surveyed were not enrolled in Computer Related Majors. In addition, the faculty advisor and president of the Association of Women in Computing, National Society of Black Engineers, and Society of Women Engineers at Virginia Tech were contacted in an attempt to over-sample women and minorities. Although two organizations responded, only the Association of Women in Computing followed through on the request to ask their members to complete the CRMS. Only two additional surveys were collected—either very few women attended the meeting in question, or everyone else had already taken the survey.

In all, 494 surveys were collected. Answers were marked on Scantron sheets and scanned by campus test scoring services, which provided a data file. Scantrons were used to increase efficiency and minimize data entry errors (Dillman, 2000). The data file was imported into SPSS 15.0. Surveys were then assessed by hand to determine which blank items were truly left blank and which were scanning errors. In most cases, isolated items (often only one per survey) were left blank by participants. In one case, responses were recorded in pen instead of #2 pencil—these responses were unscannable and were entered by hand. In a few cases, smudges and impartial erasures were corrected by hand.

One item (#7) had multiple possible answers. This was not corrected prior to distributing the survey; respondents were asked to mark all applicable answers. Before forms were scanned, the researcher re-coded items 73-80 to reflect yes/no responses to the eight options in this question—the data file reflects multiple responses for these items as well. In addition, since the major option "other" did not differentiate between "other" majors at Radford and VT, item 81 was hand-coded prior to scanning to reflect school affiliation.

Data Analysis

Initial data analysis was conducted using SPSS 15.0. Frequencies, descriptive statistics, and distributions were examined for all variables, at both the aggregate level and by major, gender, and race/ethnicity. The primary goal was to test a model for all students; if sufficient numbers of women and minorities were included in the sample, additional analyses would have been conducted to test model similarities for these groups and for males and Caucasians. Item level data analysis was conducted prior to creating scales; reliability estimates for each scale were calculated. T-tests for comparisons based on major, gender, and race/ethnicity were conducted for all variables of the model. Based upon prior theory and research, an *a priori* model was hypothesized.

Primary data analysis was be conducted using structural equation modeling (SEM) techniques via Lisrel 8.80. The goal of SEM analysis is to determine the extent to which a previously specified theoretical model is supported by sample data. This theoretical model is generally derived from the relevant literature (Schumacker & Lomax, 2004). In this study, the theoretical model was derived from the literature on women and minorities in CRM and from qualitative pilot interviews. Outcome variables were student persistence and satisfaction in CRM. There were three major independent constructs: academic, social, and institutional factors. See the section on the Computer Related Majors Survey (CRMS) for more detail. The theoretical model is presented in figure 3.1.

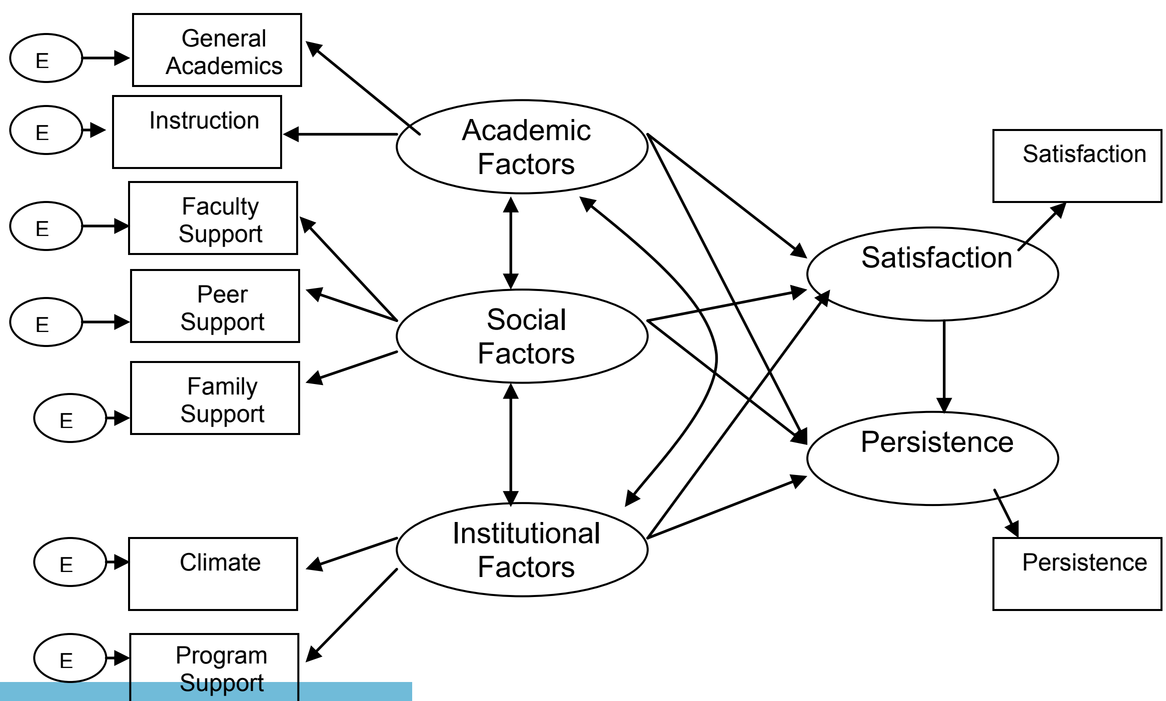

Figure 3.1: Hypothesized Model of Student Satisfaction and Persistence in CRM

SEM techniques allow increasingly more complex phenomena to be statistically modeled and tested than possible using basic statistical methods. In addition, "structural equation modeling techniques explicitly take measurement error into account when statistically analyzing data" (Schumacker & Lomax, 2004, p. 7). SEM models include both latent (constructs) and observed variables as well as measurement error terms (Schumacker & Lomax, 2004). Correlation, multiple regression, ANOVA, and factor analysis are, in fact, structural equation models. SEM is a general linear model that can be used to statistically evaluate most research hypotheses of interest to social science researchers (Hoyle, 1995).

Measurement Model

The preliminary step of the analysis was to examine the relationship between each observed variable and the factor on which it loads. Each factor had six items which were expected to load onto the factor. The measurement model was a confirmatory factor analysis (CFA) to determine which items load on which latent variable. At this stage, the researcher sought to determine to what extent the observed variables (survey items) measure the hypothesized latent variable (factor) (Schumacker & Lomax, 2004). Items with insignificant loadings were dropped from the scale. Measurement models for each construct and sets of related constructs were developed prior to estimating the structural model. Several indices of model fit were assessed for measurement models, including Chi-Square (χ^2), Root Mean Square Error of Approximation (RMSEA), Parsimony Normed Fit Index (PNFI), and the Goodness-of-Fit Index (GFI).

There are two types of factor analyses: exploratory (EFA) and confirmatory (CFA). The goal for EFA is to find a model that fits the data. Exploratory factor analyses are data-driven. The researcher does not have a model, but explores how many factors there are, how the factors are correlated, and which observed variables seem to best measure each factor. CFA, on the other hand, is model-driven. Confirmatory factor analyses seek to determine if the observed data fit a previously defined theoretical model. The number of factors, correlations between factors, and which observed variables load on each factor are specified before analysis begins (Schumacker & Lomax, 2004). Confirmatory approaches are less likely than exploratory to capitalize on chance relationships within the observed data, and hence are preferred.

Structural Model

The hypothesized conceptual model is included in Figure 3.1 above. The structural model goes beyond the measurement model by specifying the relationship between latent variables (Schumacker & Lomax, 2004). In this case, the hypothesis was that academic, social, and institutional factors predict, to some extent, student satisfaction and persistence in CRM.

"Finding a statistically significant theoretical model that also has a practical and substantive meaning is the primary goal of using structural equation modeling to test theories" (Schumacker & Lomax, 2004, p. 81). The first criterion for judging the significance and meaning of model is based upon global fit measures: the chi-square test and the root-mean-square error of approximation (RMSEA). A non-significant ($p>.05$) chi-square value indicates that the sample covariance matrix and the model-implied covariance matrix are similar. RMSEA values are considered acceptable if they are less than or equal to .05. The second criterion for significance is the statistical significance of individual parameter estimates for the paths in the model. This is usually expressed as a t-value (parameter estimate divided by standard error) and compared to a tabled t-value of 1.96 at the .05 level of significance. The third criterion is based upon the magnitude and direction of the parameter estimates. Magnitude and direction should be consistent with expected values (Schumacker & Lomax, 2004).

Model fit indices indicate to what extent the observed data fit the hypothesized model. Indices such as chi-square, goodness-of-fit (GFI), adjusted GFI, and root-mean-square residual (RMR) are indicators of model fit. The Tucker-Lewis index and the normed fit index (NFI) are model comparison indices, in which the specified model is compared to the null (independence) model. Model parsimony is evaluated through normed chi-square, parsimonious fit index (PFI), and the Akaike information criterion (AIC); these indices adjust for the number of parameters specified in the model (Schumacker & Lomax, 2004).

The final step in structural equation modeling is to consider model modification in order to achieve a better fit of the observed data to a model. Modifications may include removing nonsignificant parameters or adding additional paths. These models are technically data-driven, but must be grounded in theory as well. Model modifications should be made sparingly and one at a time. Too many model modifications can capitalize on chance aspects of the data (Schumacker & Lomax, 2004).

The model for student satisfaction and persistence in CRM was evaluated in terms of model fit indices previously mentioned. Direct and indirect effects of each factor on persistence and satisfaction were examined. A general model of student satisfaction was tested, with minor model modifications made as indicated by fit indices. Since sample sizes within majors varied greatly, it was not feasible to compare this general model to models for individual majors to determine unique effects of each major. However, analysis of individual items was conducted to pinpoint differences among majors, as well as by gender and race. Insufficient numbers of women and minorities were included in the sample to compare separate structural models for men and women, or for Caucasian and minority students.

Chapter 4: Results

This chapter is divided into four sections. The first section is a detailed examination of who responded to the survey, based upon demographic information collected. The second section describes the process of scale development, based upon individual items responses. In the third section, comparisons are made on individual responses among various groups—by major/non-major, by school, by race, by gender, and among majors within each school. Finally, the hypothesized structural equation model (SEM) and the results of the SEM analysis will be examined.

Sample and Demographic Characteristics of the Sample

A total of 494 Computer Related Majors Surveys (CRMS) were collected. (See Table 4.1) Of these, 388 were students in CRMs; 347 from VT and 41 from RU. Of the 65 RU students who responded, 24 indicate a non-CRM major. Of the 421 VT students, 77 indicated a non-CRM major. Most of these (50) were electrical engineering majors—both computer engineering and electrical engineering are in the same college, and many required classes overlap. Fifty-seven BIT majors, 200 CS majors, and 81 CE majors responded from VT. Twenty-three CST and 18 ISS majors responded from RU.

All respondents indicated an academic level. Most were sophomores (33.4%) or juniors (31.5%). The majority of the students were Caucasian (71.1%); the next highest group (15.8%) was Asian or Pacific Islanders. African Americans represented approximately 6% of the sample; Hispanics were less than half of that. Three percent indicated "other" and .4% left this item blank. As expected, a large proportion of respondents (86.6%) were male; only 12.6% were female, while some (0.8%) did not indicate a gender.

Table 4.1: Survey Respondents by Major, Gender, and Academic Level

	Freshman	**Sophomore**	**Junior**	**Senior**	**Other**	**Total**
BIT (VT)	**2**	**3**	**36**	**16**	**0**	**57**
Male	2	1	30	15	0	48
Female	0	2	6	1	0	9
CS (VT)	**54**	**74**	**50**	**22**	**1**	**201**
Male	46	66	47	18	1	178
Female	8	8	3	4	0	23
CE (VT)	**2**	**34**	**29**	**15**	**1**	**81**
Male	2	32	27	15	1	77
Female	0	2	2	0	0	4
CS/CE (VT)	**0**	**1**	**3**	**3**	**0**	**7**
Male	0	1	2	3	0	6
Female	0	0	1	0	0	1
CST (RU)	**11**	**7**	**4**	**1**	**0**	**23**
Male	10	7	3	1	0	21
Female	1	0	1	0	0	2
ISS (RU)	**10**	**6**	**2**	**0**	**0**	**18**
Male	8	5	2	0	0	15
Female	2	1	0	0	0	3
EE (VT)	**0**	**24**	**17**	**9**	**0**	**50**
Male	0	21	16	6	0	43
Female	0	3	1	3	0	7
Other (VT)	**10**	**9**	**5**	**2**	**1**	**27**
Male	8	6	5	1	0	20
Female	2	3	0	1	1	7
Other (RU)	**6**	**5**	**8**	**4**	**1**	**24**
Male	5	4	7	2	1	19
Female	1	1	1	2	0	10
Total	**95**	**163**	**154**	**72**	**4**	**488***
Male	73	136	139	61	3	412
Female	22	27	15	11	1	76

* Note: 6 respondents omitted some of this information

Almost half of the respondents indicated intentions to complete a Master's degree; 40% plan to complete a Bachelor's, and 11.1% plan to go on to a doctorate or professional degree. Two percent either left this item blank or gave a non-valid response, which implies that they were unsure of (or unwilling to share) the highest degree they intend to complete. Many students indicated that they intend to pursue graduate studies in their current major. About 1/5 do not, and a higher percentage (35.0%) were unsure.

Most participants first encountered computers at an early age; 90.9% encountered computers before the end of elementary school. A few did not encounter computers until middle school or high school; 2 students indicated that they first encountered computers in college. Almost all participants (96.7%) had access to a personal or family computer before college.

When asked who most influenced their choice of major, over half of respondents (50.8%) indicated no one. Twenty-three percent credited a family member, while 8% (each) credited a friend or a high school teacher for their decision. About 10% credited "other" for influencing their choice of major, which may indicate a guidance counselor, college admissions officer, or even a college professor. Over half of participants (52.8%) indicated that their interest in the area was the most important reason for their choice of major. Other reasons for major choice included: 9.9% the amount of money they could make after graduation; 9.3% emphasis on programming; 9.1% had a specific job in mind; 5.5% emphasis on application; 4.3% emphasis on hardware; 2.4% prestige of field; 6.5% other; and .2% omitted.

Most respondents (50.6%) indicated they make mostly B's in their major. Ten percent claimed all A's; 29.7% claimed mostly A's; 10% claimed mostly C's; and only one student each claimed mostly D's, F's, or gave an invalid response.

Participants were asked what type of computer classes they had taken prior to entering college--to mark as many of the choices as applied. Only a small percentage (6.7%) took no computer classes before college. Most students took programming (58.5%) or keyboarding (53.8%). Twenty-nine percent took spreadsheet or database courses; 25.9% took web design. Sixteen percent took hardware courses; 15% took networking; and 9.9% took "other" computer-related courses.

Item Means and Scale Development

The model has three major independent constructs: academic, social, and institutional factors. Academic factors include two subscales: general academics and instruction. Social factors include three subscales: faculty support, peer support, and family support. Institutional factors include three subscales: perceptions of the field, climate, and program support. Dependent constructs (outcome variables) are persistence and satisfaction, which represent student commitment to their major and to computing occupations. Each subscale was represented by six items on the survey. Items were reported in a four-item Likert scale, ranging from 1 = "Strongly Disagree" to 4 = "Strongly Agree." Some items were reverse coded, so that a higher score represented a positive response; i.e., a high level of satisfaction, a positive climate, etc. In developing scales, only responses from students enrolled in computer related majors (N=388) were utilized. Scales were formed by calculating the average of item responses.

Outcome Variables

Persistence items were fairly similar in mean and standard deviation (See Table 4.2). Item 5 ("I Plan to pursue graduate studies in my current major") had the lowest mean, of 2.57. Since a mean of 2.50 is halfway between "Agree" and "Disagree", this indicates that students were as likely to agree as to disagree that they planned to attend graduate school in a CRM.

Table 4.2: Outcome Means and Subscale Item-Total Statistics

Code	Item	Mean (SD)	Corrected Item-Total Corr.	Sq. Multiple Corr.	α if item deleted
	Persistence Scale (N=373)	**3.23 (.516)**			**.764**
PERST1	I will complete my degree, but I don't plan to work in the field after graduation.*	3.37 (.760)	.655	.554	.690
PERST2	I feel confident I will complete my degree in my major.	3.50 (.594)	.288	.107	.776
PERST3	I do not plan to work in my field after graduation.*	3.39 (.767)	.675	.567	.690
PERST4	After graduation, I will seek employment opportunities in my major.	3.36 (.729)	.662	.506	.684
PERST5	I plan to pursue graduate studies in my current major.	2.57 (.903)	.317	.104	.790
PERST6	I plan to continue my education but not in my current major. *	3.17 (.779)	.502	.259	.731
	Satisfaction Scale (N=374)	**3.12 (.424)**			**.709**
SAT1	I am satisfied with my choice of major.	3.22 (.621)	.554	.330	.624
SAT2	I enjoy courses in my major.	3.04 (.660)	.558	.343	.620
SAT3	I would like to work in a computer field because of the financial rewards. **	2.93 (.767)	----	----	----
SAT4	I don't expect the workplace atmosphere to be welcoming to me in a computer related field.*	3.20 (.668)	.379	.179	.699
SAT5	I am satisfied with the coursework in my major.	2.85 (.580)	.379	.195	.694
SAT6	I am satisfied with the occupational opportunities in my field.	3.28 (.583)	.472	.252	.659

*Item was reverse coded.
**Item was removed from the scale.

Students were confident that they would complete their degree in their major (item 2); the mean was 3.50, halfway between "Agree" and "Strongly Agree."

Items 1, 2, and 4 all sought to discover whether or not students intended to seek employment in computer related fields after graduation. All were coded so that a high score implied intention to seek employment in the field, and all had essentially the same mean, ranging from 3.36 to 3.39. All six items were retained for the scale, which had a reliability estimate of .764. The Persistence scale mean was 3.23, indicating that, overall, students were fairly likely to persist in CRMs.

Satisfaction items were also fairly similar in mean and standard deviation (see Table 4.2). Students were satisfied with the educational opportunities in their field (M=3.28) and with their choice of major (M=3.22). Overall, they expected a welcoming workplace atmosphere (M=3.20). Although they enjoy their in-major coursework (M=3.04), they are less satisfied with it (M=2.85).

Item 3 ("I would like to work in a computer field because of the financial rewards.") had low correlations with other items in the scale (r=-.037 to r=.147); it was removed from the scale. Scale reliability was .709. The Satisfaction scale mean was 3.12, indicating that students were, overall, satisfied with their major, but not strongly.

Academic Factors

General academic items tended to have lower means than outcome items; they ranged from 2.11 (item 3) to 2.94 (item 1) (See Table 4.3). All of these items fell between "Disagree" and "Agree" on the scale. Most students felt they had the background they needed to be successful in early class in their major (M=2.94), and they did not find the coursework boring (M=2.90). The remaining four items were closer to "Disagree". Coursework was somewhat

Table 4.3: Academic Means and Subscale Item-Total Statistics

Code	Item	Mean (SD)	Corrected Item-Total Corr.	Sq. Multiple Corr.	α if item deleted
	General Academics (N=378)	**2.51 (.512)**			**.735**
GAC1	I had the background to be successful in classes early in my major.	2.94 (.822)	.307	.127	.746
GAC2	I am stressed because of the difficulty of my classes.*	2.29 (.823)	.633	.554	.647
GAC3	I am stressed because of the time demands of my course work.*	2.11 (.807)	.572	.529	.667
GAC4	The courses in my major are difficult for me.*	2.45 (.746)	.587	.382	.666
GAC5	The courses in my major are boring to me.*	2.90 (.738)	.162	.066	.776
GAC6	The coursework in my major is too time-consuming.*	2.36 (.742)	.611	.409	.659
	Instruction (N=376)	**2.50 (.351)**			**.468**
INST1	There are weed-out courses in my department. *	1.85 (.798)	.165	.076	.472
INST2	I feel comfortable asking questions in class.	2.87 (.685)	.129	.030	.481
INST3	The primary mode of instruction is lecture. *	2.10 (.708)	.152	.025	.470
INST4	Classes need more concrete examples. *	2.32 (.695)	.338	.151	.361
INST5	Grading in my courses is fair.	2.95 (.524)	.392	.209	.358
INST6	Teaching in my courses is good.	2.91 (.584)	.303	.169	.391

*Item was reverse coded.

difficult (M=2.45) and time-consuming (M=2.36); students felt stress due to the difficulty (M=2.29) and time demands (M=2.11) of their coursework.

All six items were retained for the scale, which has a reliability estimate of .735. The scale mean is 2.51, which is fairly neutral in interpretation, halfway between “Disagree” and “Agree”. Student responses fell fairly evenly between these two responses.

Instructional items also had lower means, ranging from 1.85 (item 1) to 2.91 (item 6) (See Table 4.3). Most items fell between “Disagree” and “Agree.” Students felt that grading was fair (M=2.95) and that teaching was good (M=2.91); they also felt comfortable asking questions in class (M=2.87). At the same time, they felt that courses needed more concrete examples (M=2.32) and that the primary mode of instruction was lecture (M=2.10). Students agreed that there are weed-out courses in the computer-related majors (M=1.85).

All six items were included in the scale, which had an estimated reliability of .468. Again, the scale mean was 2.50, which is fairly neutral in interpretation, halfway between “Disagree” and “Agree”. Student responses fell fairly evenly between these two responses.

Social Factors

Social factors tended to have lower reliabilities than the academic factors. Estimated reliabilities ranged from .500 for faculty support to .670 for family support.

Faculty support item means ranged from 1.50 (item 6) to 3.03 (item 3). Students liked most of the teachers in their major (M=2.99), and indicated that they have not received negative feedback about their academic work (M=3.03). Some faculty members have provided opportunities to apply classroom learning to real life issues (M=2.68). A mean of 2.38 on item 1 indicated that many students did not feel that their instructors know them, and faculty members have not provided emotional support and encouragement (M=2.36). Neither mean indicated a

Table 4.4: Social Means and Subscale Item-Total Statistics

Code	Item	Mean (SD)	Corrected Item-Total Corr.	Sq. Multiple Corr.	α if item deleted
	Faculty Support (N=373)	**2.49 (.376)**			**.500**
FAC1	My instructors know me.	2.38 (.715)	.342	.130	.408
FAC2	Faculty in my major have given me emotional support and encouragement.	2.36 (.752)	.376	.159	.385
FAC3	Faculty in my major have given me negative feedback about my academic work. *	3.03 (.667)	.128	.039	.515
FAC4	Faculty in my major have given me an opportunity to apply classroom learning to "real-life" issues.	2.68 (.716)	.288	.138	.438
FAC5	I like most of the teachers in my major.	2.99 (.568)	.322	.159	.430
FAC6	I have been a guest in a professor's home.	1.50 (.785)	.117	.060	.533
	Peer Support (N=373)	**2.92 (.412)**			**.540**
PEER1	In general, my peers are friendly.	3.21 (.537)	.284	.105	.500
PEER2	I have many friends who are always there for me.	3.04 (.706)	.378	.177	.438
PEER3	Social connections with peers are important to me.	3.09 (.701)	.353	.155	.454
PEER4	My classmates are sympathetic when I do poorly on an assignment or test.	2.64 (.661)	.254	.077	.513
PEER5	I am mainly friends with people outside my major. * **	2.02 (.820)	---	---	---
PEER6	I frequently study and/or work with other students in my department.	2.61 (.833)	.273	.077	.513
	Family Support (N=372)	**3.27 (.441)**			**.670**
FAM1	I can count on my family for financial support.	3.27 (.802)	.409	.217	.626
FAM2	My family does not understand my choice of a computer related major. *	3.45 (.632)	.364	.372	.641
FAM3	It was hard to convince my family of the value of my major. *	3.54 (.602)	.391	.398	.633
FAM4	I could not have persisted so far in my program without the support of my family.	2.62 (.898)	.317	.224	.671
FAM5	My family is supportive of my choice of major.	3.44 (.563)	.456	.320	.617
FAM6	My family is a big source of support for my education.	3.29 (.747)	.525	.399	.581

*Item was reverse coded.
**Item was removed from the scale.

strong level of disagreement, but both were areas of concern. Students overwhelming agreed that they have not been guests in a professor's home (M =1.50). All six items were retained for the faculty support scale, which had a reliability estimate of .500. The mean was 2.49, which was again, a fairly neutral response.

Peer support items tended towards agreement. Students agree that their peers were friendly in general (M=3.21); social connections with peers were important (M=3.09); and that they had many friends who are always there for them (M=3.04). In a slightly less positive response, students felt their classmates were sympathetic when they did poorly on an assignment or test (M=2.64), and they frequently study with students in their department (M=2.61).

Item 5 ("I am mainly friends with people outside my major") had poor correlations with other items in the scale (r=.137 to r=.213), and a lower mean of 2.02. It was omitted from the scale. Peer support reliability was estimated at .540. The mean was 2.92, which was close to "Agree."—students felt supported by their peers.

Family support items had fairly high means; they ranged from 3.54 (item 3) to 2.62 (item 4). Students had little difficulty convincing their family of the importance of their major (M=3.54), and their family was supportive of their choice of major (items 2 and 4, Ms=3.45 and 3.44). Family was a strong source of support, in general (M=3.29) and financially (M=3.27). Only one item (item 4) had a mean less than 3.00, "Agree," although it is close: "I could not have persisted so far in my program without the support of my family (M=2.62)." All six items were retained for the family support scale, which had an estimated reliability of .670. The mean was 3.27, which indicated a strong perception of familial support.

Institutional Factors

At a glance, perception of field items looked fairly cohesive. Means ranged from 2.14 (item 6) to 3.15 (item 3), and standard deviations were very similar. Most students could see themselves working in a technical position in a computer related field (M=3.15). Students agreed that females have as much innate ability as males when learning to use and program computers, and that it will not be difficult to combine a computing career with raising a family (both Ms=3.11). There was little concern that they will spend most of their time working on projects alone (M=2.87). Many students felt that computer majors are nerdy (M=2.34) and that they will be required to work long hours (M=2.14).

When the items were combined into a scale, however, problems arose. The scale's estimated reliability was only .118, and removal of individual items did little to improve alpha. Individual items had low correlations (r=-.151 to r=.127), even after several items were reverse-coded. This indicated that there was no consistent perception of the field of computing. Scale mean was 2.79, indicating mostly positive perceptions, but the low reliability indicated a great deal of inconsistency. This scale was not included in the structural equation model.

Climate item means ranged from 2.12 (item 1) to 3.51 (item 5). Students felt strongly that they were not treated differently because of their gender (M=3.50) or race (M=3.51) in classes in their department. They disagreed that the classroom atmosphere was unwelcoming to minorities (M=3.45) and women (M=3.12). There was little concern that the work they were prepared to do was not socially relevant (M=2.82), but they felt that departments favored students with previous programming experience.

Item 1 ("my department favors students with previous programming experience") had low correlations with other items in the climate scale (r=-.106 to r=.091); it was excluded from

Table 4.5: Institutional Means and Subscale Item-Total Statistics

Code	Item	Mean (SD)	Corrected Item-Total Corr.	Sq. Multiple Corr.	α if item deleted
	Perception of Field (N=370)	**2.79 (.320)**			**.118**
POF1	Females have as much innate ability as males when learning to use and program computers. **	3.11 (.834)	.062	.006	.085
POF2	Computer majors are nerdy. * **	2.34 (.835)	.005	.016	.147
POF 3	I can see myself working in a technical position in a computer related field. **	3.15 (.703)	-.037	.050	.174
POF4	It will be difficult to combine my computing career with raising a family. * **	3.11 (.668)	.127	.046	.030
POF 5	I will spend most of my time working on projects alone in a computer related career. * **	2.87 (.758)	.069	.022	.079
POF 6	I will be required to work long hours in a computer related career. * **	2.14 (.645)	.072	.055	.080
	Climate (N=379)	**3.39 (.476)**			**.678**
CLIM1	My department favors students with previous programming experience. * **	2.12 (.778)	---	---	---
CLIM2	The classroom atmosphere is not welcoming to women in particular. *	3.12 (.699)	.336	.148	.694
CLIM3	The classroom atmosphere is not welcoming to minorities in particular. *	3.45 (.581)	.500	.271	.593
CLIM4	I am treated differently because of my gender in classes in my department. *	3.50 (.703)	.481	.302	.597
CLIM5	I am treated differently because of my race/ethnicity in classes in my department. *	3.51 (.680)	.542	.368	.555
CLIM6	The work that my major has prepared me to do is not socially relevant. * **	2.82 (.771)	---	---	---
	Program Support (N=347)	**2.49 (.402)**			**.484**
PROG1	The office personnel in my department know who I am.	1.99 (.792)	.169	.033	.479
PROG2	It is easy to switch between concentrations and/or special programs within my department.	2.62 (.672)	.234	.061	.444
PROG3	Tutoring is readily available in my program.	2.58 (.672)	.279	.132	.423
PROG4	There is a women’s computer club at my school.	2.80 (.897)	.161	.035	.493
PROG5	Financial support is readily available from my department.	2.47 (.746)	.322	.151	.396
PROG6	I have professional role models in my department.	2.50 (.769)	.330	.113	.390

*Item was reverse coded.
**Item was removed from the scale.

the scale. For similar reasons, item 6, "the work that my major has prepared me to do is not socially relevant," was also excluded. The scale had a reliability estimate of .678, and a fairly high mean of 3.39, which indicated a positive perception of climate.

Program support item means ranged from 2.80 (item 4) to 1.99 (item 6), all solidly in the neutral area between "Disagree" and "Agree". Most students agreed that there is a women's computer club at their school (M=2.80, true for both schools). It was relatively easy to switch between concentrations within departments (M=2.62), and tutoring was available in-program (M=2.58). A mean of 2.50 indicated that students were unsure of that they had professional role models in their department. Students felt that office personnel in their department do not know who they are (M=1.99). All six items were retained in the program support scale, which had an estimated reliability of .484. Scale mean was 2.49, which indicated a fairly neutral perception of program support.

Correlations between Scales

The highest correlation between scales was between the two outcome variables, satisfaction and persistence. All scales correlated strongly ($p<.01$) with the two outcome variables. Peer and family support did not correlate significantly with academic factors or with climate. Institutional factors (climate and program support) did not correlate significantly with each other.

Comparisons by Group and Major

Although sample sizes of women and minorities were too small to examine differences in structural models of student satisfaction and commitment, some information was gained by examining differences in responses to individual items by group. Independent sample t-tests were used to compare the pattern of responses between CRM majors and non-majors, males and

Table 4.6: Correlations Between Factors

	SAT	PERST	GAC	INST	FAC	PEER	FAM	CLIM	PROG
Outcome Factors									
SAT	---	.598**	.449**	.395**	.412**	.307**	.330**	.369**	.365**
PERST		---	.223**	.152**	.225**	.197**	.290**	.222**	.184**
Academic Factors									
GAC			---	.507**	.287**	.020	-.023	.171**	.251**
INST				---	.412**	.114*	-.003	.200**	.257**
Social Factors									
FAC					---	.297**	.188**	.042	.392**
PEER						---	.245**	.079	.189**
FAM							---	.288**	.123*
Institutional Factors									
CLIM								---	.066
PROG									---

*p<.05
**p<.01
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females, Caucasians and minorities, VT and RU students, and among the various majors at each school.

Differences Between Groups

Four groupings of responses were considered: CRM majors vs. non-majors, males vs. females, Caucasians and minorities, and VT vs. RU students. Table 4.7 summarizes t-test results for differences in means between these groups. Results are categorized by factor. Respondents included 388 CRM majors and 102 non-majors; 345 men and 43 women; 279 Caucasians and 110 other ethnicities; and 345 VT students and 43 RU students. Groups included only CRM majors, with the exception of majors vs. non-majors category.

There were some differences in the demographics of various groups. CRM majors and non-majors had significant differences in the highest degree they intended to complete and in who influenced them to choose their major. For non-CRM majors, the highest degree mean was

Table 4.7: T-Test for Equality of Mean Among Groups

Item	Major t (df)	Gender T (df)	Race t (df)	School t (df)
Demographic				
Year in college	.662 (491)	1.028 (386)	-1.748 (387)	6.158** (58.417)
Highest degree you intend to complete	2.112* (485)	-.478 (382)	-1.779 (384)	1.624 (385)
When did you first encounter computers?	1.345 (491)	.742 (60.771)	-3.486** (174.656)	-.941 (389)
What is the most important reason for your choice of major?	3.419** (490)	.456 (385)	.201 (386)	-1.502 (388)
What best describes your grades in your major	1.214 (490)	-.280 (385)	-1.453 (386)	-1.964* (388)
Outcome				
PERST1† I will complete my degree, but I don't plan to work in the field after graduation.	1.998* (487)	.292 (383)	-.959 (384)	.329 (386)
PERST2 I feel confident I will complete my degree in my major.	-3.215** (489)	-1.600 (384)	1.220 (385)	2.296* (55.280)
PERST4 After graduation, I will seek employment opportunities in my major.	-2.349* (164.318)	.112 (378)	.861 (379)	.176 (381)
PERST6† I plan to continue my education but not in my current major.	2.353* (471)	1.152 (372)	-2.337* (373)	.690 (375)
Persistence Scale	-2.861** (466)	-1.085 (368)	1.553 (369)	-.105 (371)
SAT1 I am satisfied with my choice of major.	-.993 (488)	.653 (383)	2.525* (195.395)	1.348 (386)
SAT2 I enjoy courses in my major.	-.586 (488)	-.856 (383)	3.503** (384)	1.079 (386)
SAT3 I would like to work in a computer field because of the financial rewards.	-4.118** (137.818)	.368 (381)	.315 (382)	-1.318 (384)
SAT4† I don't expect the workplace atmosphere to be welcoming to me in a computer related field.	2.830** (481)	-1.333 (379)	-3.525** (380)	-1.006 (382)
SAT5 I am satisfied with the coursework in my major.	-1.701 (143.950)	.970 (375)	2.084* (169.058)	-1.207 (378)
SAT6 I am satisfied with the occupational opportunities in my field.	-1.918 (474)	-1.354 (374)	3.114** (375)	.054 (377)

Table 4.7: T-Test for Equality of Mean Among Groups

Item	Major t (df)	Gender T (df)	Race t (df)	School t (df)
Satisfaction Scale	-4.084** (464)	.370 (368)	4.048** (369)	.240 (371)
Academic				
GAC4† The courses in my major are difficult for me.	.856 (486)	-1.637 (381)	-2.328* (382)	-1.106 (384)
GAC6† The coursework in my major is too time-consuming.	.391 (133.534)	.259 (376)	-2.361* (377)	-.250 (55.699)
INST1† There are weed-out courses in my department.	.479 (486)	.138 (384)	-1.183 (385)	3.247** (387)
INST2 I feel comfortable asking questions in class.	-.399 (488)	2.127* (383)	.358 (384)	.063 (386)
INST4† Classes need more concrete examples.	1.016 (134.883)	-.742 (378)	-3.096** (192.860)	-.425 (381)
INST5 Grading in my courses is fair.	-2.995** (133.545)	-.391 (376)	.971 (377)	-.081 (379)
INST6 Teaching in my courses is good.	-.721 (479)	.824 (377)	2.473* (169.854)	.521 (46.225)
Instruction Scale	-2.015* (127.477)	1.315 (371)	1.956 (167.974)	-1.582 (374)
Social				
FAC1 My instructors know me.	.657 (484)	-1.574 (380)	.505 (382)	-2.483* (383)
FAC4 Faculty in my major have given me an opportunity to apply classroom learning to "real-life" issues.	.095 (486)	.495 (381)	2.241* (174.085)	1.032 (384)
FAC5 I like most of the teachers in my major.	.922 (480)	1.471 (47.808)	2.733** (156.272)	-.779 (45.831)
FAC6 I have been a guest in a professor's home.	2.007* (477)	-1.920 (46.566)	-.996 (377)	-.003 (379)
FAM2† My family does not understand my choice of a computer related major.	1.022 (485)	1.888 (381)	-1.200 (382)	-2.608** (384)
FAM3† It was hard to convince my family of the value of my major.	2.134* (132.590)	.786 (382)	-1.249 (383)	-2.113* (47.137)
FAM4 I could not have persisted so far in my program without the support of my family.	1.469 (482)	-3.908** (378)	-1.685 (379)	-.522 (381)

Table 4.7: T-Test for Equality of Mean Among Groups

Item	Major t (df)	Gender T (df)	Race t (df)	School t (df)
FAM5 My family is supportive of my choice of major.	-.497 (478)	-2.598** (375)	2.131* (376)	.920 (378)
FAM6 My family is a big source of support for my education.	2.007* (477)	-2.827** (373)	-1.047 (374)	-.080 (376)
Family Support Scale	-.736 (465)	-3.541** (367)	.215 (368)	1.123 (370)
Institutional				
POF1 Females have as much innate ability as males when learning to use and program computers.	-.285 (483)	-7.463** (70.680)	-1.096 (383)	-.002 (385)
POF2† Computer majors are nerdy.	-.417 (487)	.028 (383)	1.388 (172.672)	2.615** (386)
POF3 I can see myself working in a technical position in a computer related field.	-5.007** (133.083)	2.260* (384)	-.266 (385)	2.027* (387)
POF5† I will spend most of my time working on projects alone in a computer related career.	-2.047* (474)	-.516 (374)	-1.195 (375)	-3.176** (377)
POF6† I will be required to work long hours in a computer related career.	-2.329* (129.552)	.978 (372)	-.767 (373)	-1.259 (375)
CLIM1† My department favors students with previous programming experience.	-.914 (134.073)	.273 (385)	-1.094 (386)	3.046** (388)
CLIM3† The classroom atmosphere is not welcoming to minorities in particular.	1.609 (129.165)	-1.301 (384)	-2.375* (168.416)	-.913 (387)
CLIM4† I am treated differently because of my gender in classes in my department.	1.064 (484)	-5.939** (46.622)	-.881 (383)	-.837 (385)
CLIM5† I am treated differently because of my race/ethnicity in classes in my department.	.755 (476)	-.499 (376)	-3.754** (161.964)	.320 (379)
CLIM6† The work that my major has prepared me to do is not socially relevant.	.003 (468)	.730 (370)	-3.167** (179.524)	-.401 (373)
Climate Scale	-.976 (461)	2.123* (45.513)	2.784** (368)	-.971 (370)
PROG2 It is easy to switch between concentrations and/or special programs within my department.	2.026* (161.513)	.972 (371)	1.235 (373)	-2.340* (54.003)

Table 4.7: T-Test for Equality of Mean Among Groups

Item	Major t (df)	Gender T (df)	Race t (df)	School t (df)
PROG3 Tutoring is readily available in my program.	1.877 (482)	.612 (381)	1.368 (382)	-4.877** (384)
PROG4 There is a women's computer club at my school.	-.701 (453)	-1.508 (47.945)	1.478 (361)	3.875** (362)
PROG6 I have professional role models in my department.	2.391* (469)	-1.312 (370)	1.273 (371)	-.830 (373)

* p<.05
** p<.01
† Item was reverse coded.

1.83; for CRM majors, it was 1.67. This indicated that non-majors were more likely to plan to complete a higher degree than CRM majors, and that most planned to complete a Master's degree. When asked the most important reason for their choice of major, non-CRM majors had a mean of 3.06, while CRM majors' mean was 3.18. This result was difficult to interpret, since all of the reasons were more applicable to CRM majors. Non-majors were more likely to choose emphasis on applications, hardware, or programming than majors.

There were no significant differences in demographics between males and females. Caucasian students indicated encountering computers an earlier age than minority students; the mean for Caucasians was 2.04, while minorities had a mean of 2.44. Although both responses indicated that students encountered computers in elementary school, Caucasians were more likely to first use computers in kindergarten through second grade, while minorities were more likely to use them in third through fifth. RU students in the sample were younger, on average, than VT students, due to the nature of the courses surveyed. RU classes were introductory classes, while VT classes included multiple academic levels. VT students report higher grades in-major, with a mean of 2.57 (mostly A's/mostly B's) compared to RU's 2.83 (mostly B's).

Majors and non-majors had different means on several persistence items. For item 1, CRM majors had a mean of 1.79, while non-majors had a mean of 1.9. This indicates that CRM majors were more likely to plan to complete their degree but not work in the field after graduation. CRM majors were more confident they will complete their degree in their major (M=3.49) than non-majors (M=3.26); they were also more likely to seek employment opportunities in their major (M=3.36 for majors, 3.18 for non-majors). Non-majors were more likely to continue their education in a different major (M=3.17) than CRM majors (M=2.96). CRM majors had higher overall levels of persistence (M= 3.23) than non-majors (M=3.05), as indicated by the persistence scale.

Other groups showed fewer differences in persistence. Caucasians were more likely to plan to continue their education in a different major (M=3.23) than other ethnicities (M=3.02). Although both groups reported high levels of confidence that they would complete their degree in their current major, VT students had higher levels (M=3.51) than RU students (M=3.31).

There were many significant differences in satisfaction items between Caucasians and minorities. Caucasians reported higher levels of satisfaction in their choice of major (M=3.27) and enjoyment of courses in their major (M=3.27) than minorities (M=3.09 for both). Although neither group expressed a large degree of concern over lack of welcome in the workplace, the lower mean of 3.01 for minorities (versus 3.28 for Caucasians) indicates that they are more worried than Caucasians. Caucasians are more satisfied with both their coursework (M=2.89) and their occupational opportunities (M=3.34) than other ethnic groups (M=2.74 and M=3.13, respectively). Overall, Caucasians reported higher levels of satisfaction (M=3.13), as indicated by the satisfaction scale, than other students (M=2.96).

CRM majors were more likely to express interest in computing due to financial rewards (M=2.92) than non-majors. They also reported higher levels of satisfaction overall (M=3.08 for majors and M=2.91 for non-majors), as indicated by the satisfaction scale.

There were significant differences between groups on several academic items as well. Caucasians and other ethnic groups had the most differences on academic items. Minorities were more likely to find courses in their major difficult (M=2.31) and too time-consuming (M=2.22) than Caucasians (M=2.51 and M=2.42, respectively). Caucasians were less likely to feel that their courses needed more concrete examples (M=2.38) and more likely to feel grading in their courses is fair (M=2.96) than other students (M=2.13 and M=2.78, respectively).

Students in CRMS were more likely to feel that grading in their courses is fair (M=2.94) than non-majors (M=2.73); they also had higher academic support levels (M=2.50) than non-majors (M=2.40), as indicated by the academic support scale. Men were more likely to feel comfortable asking questions in class (M=2.89) than women (M=2.65). VT students felt more strongly that there are weed-out courses in their department (M=3.20) than did RU students.

Family support was significantly more important for women than for men. Women were more likely than men to agree that "I could not have persisted so far in my program without the support of my family" (M=3.12 vs. M=2.55), that their family supported their choice of major (M=3.65 vs. M=3.42), and that their family was a big source of support for their education (M=3.60 vs. M=3.25). Overall, women reported higher levels of family support (M=3.50) than men (M=3.24), as indicated by the family support scale.

CRM majors were less likely (M=1.51) than non-majors (M=1.69) to have been a guest in a professor's home. Non-majors had less difficulty convincing their family of the value of their major (M=3.36) than CRM majors (M=3.53); they also were more likely to indicate that their family was a big source of support for their education (M=3.35) than CRM majors (M=3.29). Caucasian students were more likely to like their teachers (M=3.05) and feel they have had the opportunity to apply classroom learning to "real-life" issues (M=2.73) than other ethnic groups (M=2.85 and M=2.54, respectively). Caucasians also felt more strongly that their family was supportive of their choice of major (M=3.48) than minorities (M=3.34). Students from VT felt that their family understood their choice of major (M=3.46) more than RU students did (M=3.19); however, RU students were more likely to feel their instructors know them (M=2.63) than VT students (M=2.34).

There were many differences between groups regarding perceptions of the computing field. This was not surprising since individual perception of field items did not form a cohesive scale. CRM majors were more likely to see themselves working in a technical position in a computer related field (M=3.15) than non-majors (M=2.67); they were also more likely than non-majors to agree that they will spend most of their time working alone (M=2.87 vs. M=3.04) and work long hours (M=2.14 vs. M=2.34). Women (M=3.19) were more likely than men (M=2.93) to see themselves working in a technical position in a computer related field; they were also more likely to agree that women have as much innate ability as men when learning to use and program computers (M=3.74 vs. 3.04). VT students were more likely to see themselves working in a technical position in a computer related field (M=3.18) than RU students (M=2.95), and more likely to feel they will spend most of their time working on projects alone (M=2.91 to M=2.51, respectively).

Most of the differences in perception of climate were between Caucasians and other students. Although means did not indicate a major concern, minority students were more likely than Caucasians to feel that the classroom atmosphere is not welcoming to minorities (M=3.41

vs. M=3.48) and that they were treated differently in class because of their race/ethnicity (M=3.28 vs. M=3.49). Minority students were more likely to agree that the work their major has prepared them to do is not socially relevant (M=2.62) than Caucasian students (M=2.90). Overall, Caucasian students had more positive perceptions of climate (M=3.12) than minority students (M=3.00), as indicated by the climate scale.

Students at Virginia Tech were more likely to feel that their department favors students with previous programming experience (M=2.07) than students at Radford (M=2.45). Women were more likely to feel that they are treated differently due to their gender (M= 2.72) than men (M=3.59). Women also reported lower overall perceptions of climate (M=2.94) than men (M=3.11), as indicated by the climate scale.

Differences in perceived levels of program support were largely between schools. Students at Radford found it easier to switch between concentrations in their department (M=2.83) and find readily available tutoring (M=3.07) than Virginia Tech students (M=2.59 and M=2.54, respectively). Although there is a women's computer club at both schools, VT students were more to know about it (M=2.87) than RU students (M=2.30). Students in computer related majors were less likely to agree that is easy to switch between programs (M=2.62) or find professional role models (M=2.50) in their department than non-majors (M=2.77 and M=2.72, respectively).

Differences Among Majors

Four comparisons were considered: three to determine differences among the three majors at Virginia Tech and one to compare the two majors at Radford. Table 4.8 summarizes t-test results for differences in means among majors. Results are again categorized by factor.

Table 4.8: T-Test for Equality of Mean Among Majors

Item	CS/CE t (df)	CS/BIT T (df)	CE/BIT t (df)	CST/ISS t (df)
Demographic				
Year in college	4.311** (284)	6.850** (257)	-3.281** (134.784)	.878 (39)
Gender	2.086* (217.005)	.779 (257)	-1.994* (83.529)	-.761 (39)
Highest degree you intend to complete	-1.632 (282)	-1.684 (255)	2.822** (137)	.766 (38)
What is the most important reason for your choice of major?	1.392 (283)	1.927 (94.544)	-2.672** (130.954)	-.425 (39)
Which best describes your grades in your major?	-3.028** (284)	.210 (257)	2.225* (139)	1.024 (38)
Outcomes				
PERST1† I will complete my degree, but I don't plan to work in the field after graduation.	.071 (282)	3.111** (255)	-2.563* (139)	1.024 (38)
PERST2 I feel confident I will complete my degree in my major.	.843 (134.119)	3.041** (111.879)	-3.046** (138.944)	-2.316* (34.854)
PERST3† I do not plan to work in my field after graduation.	-.238 (282)	3.183** (256)	-2.539* (138)	1.816 (37)
PERST4 After graduation, I will seek employment opportunities in my major.	.900 (278)	-2.927** (254)	1.840 (136)	-1.968 (37)
PERST5 I plan to pursue graduate studies in my current major.	-.581 (271)	-1.894 (248)	2.011* (135)	1.235 (37)
Persistence Scale	1.276 (269)	-2.697** (247)	1.285 (134)	-1.421 (36)
SAT1 I am satisfied with my choice of major.	2.387* (282)	-2.661** (255)	.418 (139)	-2.041* (38)
SAT2 I enjoy courses in my major.	1.862 (282)	-3.236** (255)	1.515 (139)	-1.143 (38)
SAT5 I am satisfied with the coursework in my major.	2.086* (120.899)	-2.130* (74.281)	.341 (136)	.558 (37)
SAT6 I am satisfied with the occupational opportunities in my field.	2.148* (275)	.398 (251)	-1.990* (136)	-.337 (36)
Satisfaction Scale	2.696** (269)	-2.275* (246)	-.067 (135)	-.956 (36)

Table 4.8: T-Test for Equality of Mean Among Majors

Item	CS/CE t (df)	CS/BIT T (df)	CE/BIT t (df)	CST/ISS t (df)
Academic				
GAC2† I am stressed because of the difficulty of my classes.	-5.272** (171.569)	-1.615 (255)	5.395** (139)	.395 (38)
GAC3† I am stressed because of the time demands of my course work.	-5.795** (283)	-.307 (256)	5.043** (139)	1.023 (37)
GAC4† The courses in my major are difficult for me.	-3.047** (280)	-.802 (255)	2.939** (137)	.097 (38)
GAC5† The courses in my major are boring to me.	-2.392* (276)	4.714** (80.848)	-2.404* (136)	.606 (34.195)
GAC6† The coursework in my major is too time-consuming.	-7.383** (276)	-1.721 (105.597)	7.618** (136)	1.781 (37)
General Academic Scale	6.101** (273)	.054 (250)	-4.851** (135)	-1.213 (37)
INST1† There are weed-out courses in my department.	-4.138** (284)	-3.991** (257)	6.557** (92.828)	.736 (37)
INST3† The primary mode of instruction is lecture.	-4.143** (281)	1.921 (95.239)	1.641 (133.732)	-.056 (37)
INST4† Classes need more concrete examples.	-4.221** (150.277)	1.528 (252)	2.010* (137)	.908 (38)
INST5 Grading in my courses is fair.	-4.221** (150.277)	1.544 (252)	-4.092** (135.966)	.000 (37)
INST6 Teaching in my courses is good.	3.723** (151.468)	-.172 (253)	-2.954** (130.896)	-.148 (37)
Instruction Scale	6.586** (271)	1.068 (248)	-5.586** (135)	-.425 (37)
Social				
FAC1 My instructors know me.	.643 (281)	2.584** (253)	-5.586** (135)	.144 (37)
FAC2 Faculty in my major have given me emotional support and encouragement.	.422 (279)	2.347* (254)	-2.231* (137)	.583 (38)
FAC3† Faculty in my major have given me negative feedback about my academic work.	-2.406* (135.470)	-.283 (254)	2.056* (139)	-.559 (37)
FAC5 I like most of the teachers in my major.	2.221* (134.105)	.978 (253)	-2.539* (136)	-1.015 (37)

Table 4.8: T-Test for Equality of Mean Among Majors

Item	CS/CE t (df)	CS/BIT T (df)	CE/BIT t (df)	CST/ISS t (df)
Faculty Support Scale	1.812 (269)	2.329* (73.846)	-3.424** (133)	.266 (37)
Institutional				
POF2† Computer majors are nerdy.	-1.914 (282)	-2.023* (255)	3.233** (139)	.340 (38)
POF3 I can see myself working in a technical position in a computer related field.	-.355 (283)	-4.437** (78.852)	4.169** (139)	-.667 (30.445)
POF5† I will spend most of my time working on projects alone in a computer related career.	-1.305 (122.120)	-1.652 (251)	2.236* (135)	.638 (37)
POF6† I will be required to work long hours in a computer related career.	-2.358* (272)	.180 (250)	1.552 (134)	-.242 (30.688)
Perception of Field Scale	3.058** (265)	-.597 (245)	-1.765 (132)	-.641 (37)
CLIM1† My department favors students with previous programming experience.	-2.431 (284)	-2.053* (257)	3.803** (139)	-.439 (38)
CLIM2† The classroom atmosphere is not welcoming to women in particular.	-1.787 (282)	-1.447 (255)	2.865** (138.470)	-1.182 (38)
Climate Scale	2.331* (268)	.208 (248)	-2.167* (132)	.482 (36)
PROG1 The office personnel in my department know who I am.	-1.291 (283)	-2.565* (256)	3.302** (139)	-.354 (38)
PROG3 Tutoring is readily available in my program.	-.825 (281)	-2.079* (256)	2.453* (137)	-.354 (37)
PROG4 There is a women's computer club at my school.	1.611 (261)	-6.343** (241)	4.586** (130)	.566 (36)
PROG6 I have professional role models in my department.	1.620 (271)	-2.371* (248)	.830 (135)	-1.501 (36)
Program Support Scale	.846 (245)	-5.182** (228)	3.767** (127)	-.122 (35)

* p<.05
** p<.01
† Item was reverse coded.

Respondents included 202 Computer Science, 84 Computer Engineering, and 57 Business Information Technology majors from VT, and 23 Computer Science and Technology and 18 Information Science and Systems majors from Radford.

There were several significant differences in demographics among majors, particularly between CE and BIT. All of the VT majors had differences in year in school: CS majors were younger (mostly sophomores), and BIT majors were younger (juniors), due to the classes that were surveyed. CE had the fewest women (4.9%); BIT the most (15.8%). CS had 11.4% women, which was significantly different from CE but not BIT. CE majors were more likely to pursue a Master's degree (M=1.82) than CS majors (M=1.52). When asked the most important reason for their choice of major, CE majors had a mean of 4.28 while BIT majors had a mean of 4.96. This difference implied that CE majors were more likely to choose their major for an emphasis on applications, hardware, or programming, or because they had a specific job in mind; BIT majors were more likely to choose their major for their interest in the area, the amount of money they could make, or the prestige of the field. Computer Science students reported the highest grades, with a mean of 2.50 (Mostly A's/B's); Computer Engineering Majors reported the lowest, with a mean of 2.83 (Mostly B's). BIT students had a mean of 2.53, which was significantly different from CE but not CS.

BIT students had significant differences from CS and CE in persistence items. CS and CE students were more likely to intend to complete their degree, but not work in the field after graduation (M=3.05 for both) than BIT students (M=3.41). BIT students were the most confident they will complete their degree in their major (M=3.70 for CE; M=3.48 for CS; and M=3.40 for CE); they were also least likely to work in their field after graduation (M=3.11 for BIT, M=3.47 for CS, and M=3.45 for CE). CS students (M=3.42) were more likely than BIT students (M=3.11) to pursue a graduate degree in their current major. BIT students had a higher overall rate of persistence (M=2.81) than CS students (M=2.74), as indicated by the persistence scale. At Radford, CST students were more confident they will complete their degree (M=3.50) than ISS students (M=3.14).

Radford's ISS students reported higher levels of satisfaction with their choice of major (M=3.33) than CST students (M=2.95). At Virginia Tech, CS students (M=3.30) had higher levels of satisfaction with their choice of major that CE (M=3.12) or BIT (M=3.07) students. Computer Science students were more likely to enjoy courses in their major (M=3.14) that BIT students (M=2.81). CS students were more satisfied with their coursework (M=2.91) than either CE (M=2.74) or BIT (M=2.70). BIT (M=3.35) and CS (M=3.32) students were more satisfied with their occupational opportunities than CE majors (M=3.15). Overall, CS majors reported higher levels of satisfaction (M=3.13) than either BIT or CE majors (M=3.00 for both).

For academic items, there were no significant differences in Radford majors, but many significant differences among these items for Virginia Tech majors. CE majors were more stressed because of the difficulty (M=1.83) and time demands (M=1.63) of their courses than either CS (M=2.34 and M=2.21) or BIT (M=2.53 and M=2.25) students; they also found the courses more difficult (M=2.22) than CS (M=2.51) or BIT (M=2.60) majors. BIT students were the most likely to find their courses boring (M=2.51; CS=3.05 and CE=2.83). Overall, BIT (M=2.59) and CS (M=2.58) majors had a more positive perception of general academics than CE majors (M=2.19), as indicated by the general academic scale.

Computer Engineering majors were more likely to feel their department has weed-out courses (M=1.42) than CS (M=1.81); both were more likely than BIT (M=2.28). CE also had more classes in which the primary mode of instruction is lecture (M=1.42) than either CS (M=

2.20) or BIT (M=2.02); they were more likely to feel that classes need more concrete example (M=2.05; CS=2.44 and BIT=2.28). BIT students were most likely to feel the grading in their courses was fair (M=3.09; CS=2.98 and BIT=2.69); both BIT (M=2.96) and CS (M=2.98) majors were more likely to feel the teaching in their courses was good than CE (M=2.26). Overall, BIT had the most positive perception of instruction (M=2.60), followed by CS (M=2.54) and CE (M=2.26), as implied by the instruction scale.

All differences in social factors were among the majors at VT, and all were associated with faculty support. BIT students were most likely to feel that their instructors know them (M=2.57; CS=2.30 and BIT=2.24); they were also more likely to have received emotional support and encouragement from faculty (M=2.58; CS=2.32 and CE=2.28). CE students were most likely to have received negative feedback about their academic work (M=2.83; CS=3.06 and BIT=3.09). BIT majors were most likely to like the teachers in their major (M=3.09), followed by CS (M=3.01) and CE (M=2.84) majors; they also reported the highest level of faculty support (M=2.62; CS=2.47 and CE=2.39), as indicated by the faculty support scale.

Radford majors had similar perceptions of the field of computing; Virginia Tech majors differed in their perceptions. CE majors were most likely to agree that computer majors are nerdy (M=2.08), followed by CS (M=2.28) and BIT (M=2.53) majors. CS (M=3.24) and CE (M=3.27) majors were more likely to see themselves working in a technical position in a computer related field than BIT majors (M=2.75); they were also more likely to feel they will spend most of their time working alone (CE=2.76; CS=2.91; BIT=3.09). All three majors felt they will be required to work long hours; CE was most likely to agree (M= 2.01), followed by BIT (M=2.19) and CS (M=2.21). Computer science and BIT majors had more positive perceptions of the field (M=2.82 and M=2.80) than Computer Engineering majors (M=2.69).

(Perception of field items had low correlations, so this scale was not included in the structural model. However, for comparison among groups and majors, a scale value was calculated.)

BIT majors had the most positive view of their departmental climate; CE majors had the least. CE students were the most likely to agree that their department favors students with previous programming experience (M=1.83), followed by CS (M=2.07) and BIT (M=2.32). BIT students felt the classroom atmosphere is welcoming to women (M=3.25), followed by CS (M=3.10) and CE (M=2.93) majors. Overall, the climate scale indicates BIT majors perceived the most positive climate (M=3.12); CS majors had a mean of 3.10 and CE majors' mean was 2.98.

Departmental personnel were most likely to know CE students (M=2.14), followed by CS (M=2.00) and BIT (M=1.70) majors; CE (M=2.62) and CS (M=2.55) students were more likely to find readily available tutoring than BIT students (M=2.35). VT has a women's computer club; CS (M=3.04) and CE (M=2.86) majors were more likely to know about it than BIT majors (M=2.23). CS students felt they had professional role models in their department (M=2.59); CE (M=2.42) and BIT (M=2.32) were less likely to agree. Overall, CS students (M=2.55) had the highest level of program support, followed by CE (M=2.50) and BIT (2.24), as indicated by the program support scale.

Structural Equation Model

Data were analyzed using Lisrel 8.8 (Joreskog & Soborn, 2006). The analysis followed the two-step procedure suggested by Anderson and Gerbing (1988). A measurement model was tested first, using confirmatory factor analysis to test model fit for the data. The second phase was based on the theoretical model derived from the literature and previous pilot work, as described in chapter three. This theoretical model was tested and revised until a theoretically meaningful and statistically acceptable model was found. All models were estimated using correlation and standard deviation matrices (generated in SPSS) rather than raw data.

The Measurement Model

The measurement model was used for a confirmatory factor analysis, to verify that individual items load on the subfactors expected from the theoretical model. It was also used to confirm the development of scales used in the structural model. Nine scales were included in the model: satisfaction, persistence, general academics, instruction, faculty support, peer support, family support, climate, and program support. Perception of field was omitted from the analysis, since correlations between items indicated problems with the scale. Each scale was represented by up to six observed variables; climate had four, while peer and program support had five. These were the same items retained in the scales, based upon correlations and scale reliability, discussed earlier in this chapter. All models were estimated using the maximum likelihood method.

The first criterion for judging the significance and meaning of model is based upon global fit measures: the chi-square test and the root-mean-square error of approximation (RMSEA). A non-significant ($p>.05$) chi-square value indicates that the sample covariance matrix and the model-implied covariance matrix are similar. RMSEA values are considered acceptable if they are less than or equal to .05. The second criterion for significance is the statistical significance of individual parameter estimates for the paths in the model. This is usually expressed as a t-value (parameter estimate divided by standard error) and compared to a tabled t-value of 1.96 at the .05 level of significance. The third criterion is based upon the magnitude and direction of the parameter estimates. Magnitude and direction should be consistent with expected values (Schumacker & Lomax, 2004).

Model fit indices indicate to what extent the observed data fit the hypothesized model. Indices such as chi-square, goodness-of-fit (GFI), adjusted GFI, and root-mean-square residual (RMR) are indicators of model fit. The Tucker-Lewis index and the normed fit index (NFI) are model comparison indices, in which the specified model is compared to the null (independence) model. Model parsimony is evaluated through normed chi-square, parsimonious fit index (PFI), and the Akaike information criterion (AIC); these indices adjust for the number of parameters specified in the model (Schumacker & Lomax, 2004).

In the preliminary measurement model, scales were not allowed to correlate freely. Modification indices in Lisrel suggested allowing the two outcome variables, satisfaction and persistence, to correlate, which significantly improved the model fit. In the third model, errors for three pairs of items were allowed to correlate. Items were similar in topic, so allowing their errors to correlate made sense: GAC 5 and 6 both are related to coursework within the major; FAM 2 and 3 both relate to familial understanding of students' choice of major; and FAM 4 and 6 both relate to family supportiveness. In the fourth model, a correlation between general academics and instruction (which form the academic factor in the theorized model), and correlations between faculty, peer, and family support (which form the social factor in the theorized model) were added. Climate and program support form the institutional factor in the final model, but this correlation was not statistically significant, so it was not included. In the fifth measurement model, correlations between satisfaction and persistence and the other factors, where significant, were added. Table 4.9 shows model fit information for the five measurement models considered. In each case, chi-square change was significant, and model fit indices were improved. Figure 4.1 shows the final measurement model.

Table 4.9: Comparison of Measurement Models

Model	Df	X^2	X^2 Change	RMSEA	NFI	NNFI	PNFI	GFI
1. No correlation	1175	3658.99*	---	.085	.63	.69	.61	.68
2. SAT and PERST correlate	1174	3502.62*	156.37*	.081	.66	.71	.63	.70
3. Correlate errors: GAC 5,6; FAM 2,3; FAM 4,6	1171	3363.15*	139.47*	.078	.68	.73	.65	.71
4. Correlate Social and Academic	1167	3227.68*	135.47*	.074	.70	.76	.67	.73
5. Correlate others with SAT and PERST	1157	2991.49*	236.49*	.068	.74	.80	.70	.75

*p<.01

For all models, chi-squared values were significant. Since non-significant chi-square statistics are associated with good model fit, this implied the model needs more work. Additional modifications suggested by Lisrel, however, were not theoretically meaningful; the final model represents an adequate fit. Since chi-square is sensitive to sample size, chi-square to degrees of freedom ratio was also considered. A lower ratio implies better fit for the model. Ratios ranged from 3.11 for model 1 to 2.59 for model 5. Although RMSEA values were slightly higher than the desired value of .05, they were reasonably close. Other indicators were lower than the reference value of .95, although improvement was evident as the model was modified. It was evident that there is a need for more work in future research to measure these complex constructs.

Individual parameter estimates indicate that all items loaded significantly on their intended scales, with the exception of FAC6, "I have been a guest in a professor's home." This item had a significant loading until the final model. See Table 4.10 for standardized factor loadings from the measurement model. Satisfaction and persistence are correlated in the

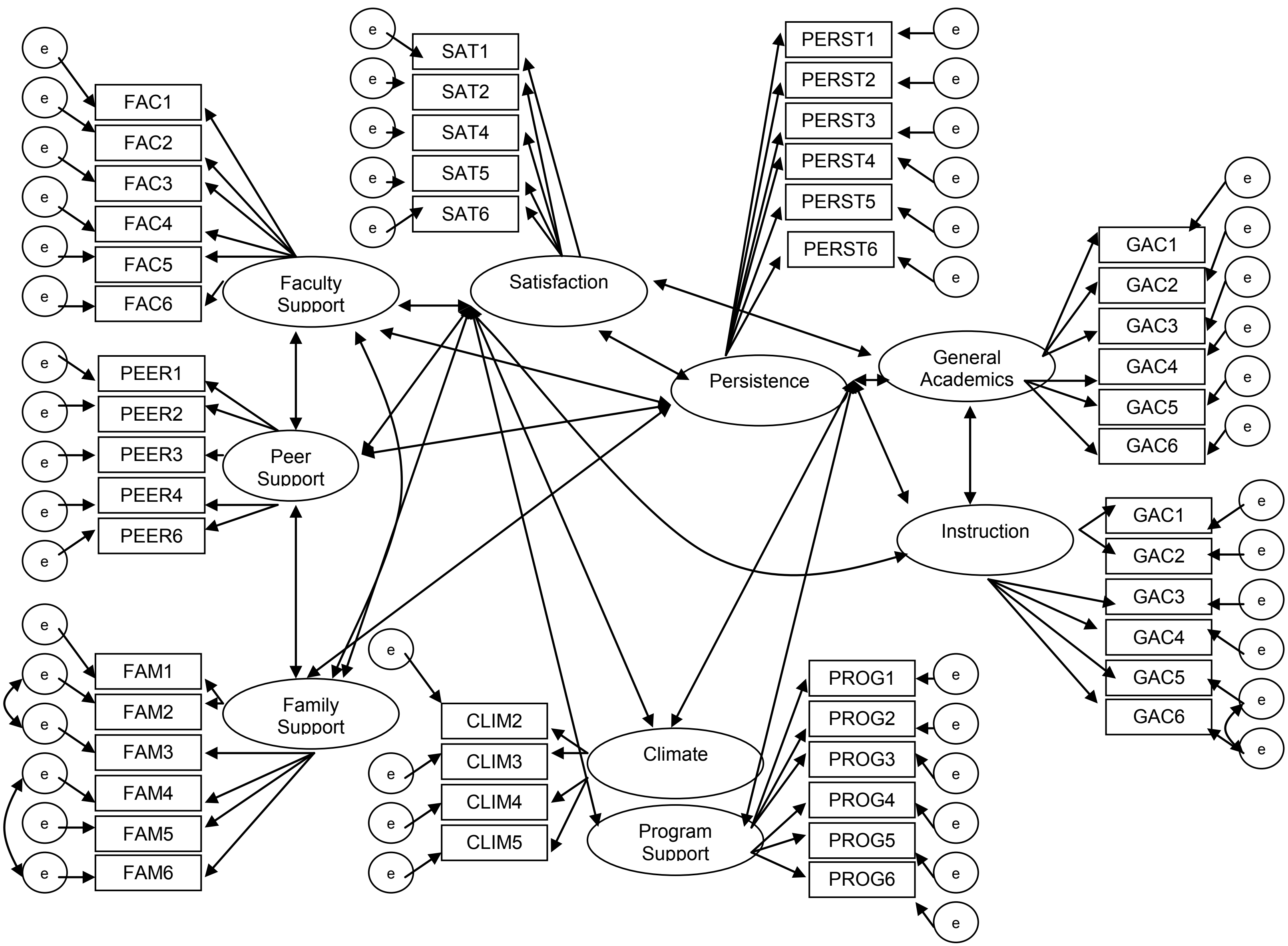


Figure 4.1: Final Measurement Model

Table 4.10: Measurement Model

Scale and Items	Standardized loading	t	Reliability	Variance Extracted
Satisfaction			**.56**	**.25**
SAT1 I am satisfied with my choice of major.	0.59	---	0.34	
SAT2 I enjoy courses in my major.	0.62	9.33**	0.38	
SAT4† I don't expect the workplace atmosphere to be welcoming to me in a computer related field.	0.46	7.43**	0.21	
SAT5 I am satisfied with the coursework in my major.	0.48	7.72**	0.23	
SAT6 I am satisfied with the occupational opportunities in my field.	0.53	8.33**	0.28	
Persistence			**.73**	**.38**
PERST1† I will complete my degree, but I don't plan to work in the field after graduation.	0.79	---	0.62	
PERST2 I feel confident I will complete my degree in my major.	0.34	6.32**	0.11	
PERST3† I do not plan to work in my field after graduation.	0.82	16.37**	0.67	
PERST4 After graduation, I will seek employment opportunities in my major.	0.80	15.89**	0.63	
PERST5 I plan to pursue graduate studies in my current major.	0.34	6.42**	0.12	
PERST6† I plan to continue my education but not in my current major.	0.54	10.36**	0.29	
General Academics			**.96**	**.85**
GAC1 I had the background to be successful in classes early in my major.	0.34	---	0.11	
GAC2† I am stressed because of the difficulty of my classes.	0.82	6.26**	0.67	
GAC3† I am stressed because of the time demands of my course work.	0.77	6.20**	0.60	
GAC4† The courses in my major are difficult for me.	0.65	5.99**	0.43	

Table 4.10: Measurement Model

Scale and Items	Standardized loading	t	Reliability	Variance Extracted
GAC5† The courses in my major are boring to me.	0.15	2.47 **	0.02	
GAC6 The coursework in my major is too time-consuming.	0.69	6.06**	0.47	
Instruction			**.43**	**.15**
INST1† There are weed-out courses in my department.	0.34	---	0.11	
INST2 I feel comfortable asking questions in class.	0.24	3.27**	0.06	
INST3 The primary mode of instruction is lecture.	0.18	2.58**	0.03	
INST4† Classes need more concrete examples.	0.53	4.83**	0.28	
INST5† Grading in my courses is fair.	0.62	5.00**	0.38	
INST6 Teaching in my courses is good.	0.45	4.59**	0.21	
Faculty Support			**.49**	**.17**
FAC1 My instructors know me.	0.42	---	0.18	
FAC2 Faculty in my major have given me emotional support and encouragement.	0.42	4.85**	0.17	
FAC3† Faculty in my major have given me negative feedback about my academic work.	0.24	3.35**	0.06	
FAC4 Faculty in my major have given me an opportunity to apply classroom learning to "real-life" issues.	0.51	5.32**	0.26	
FAC5 I like most of the teachers in my major.	0.58	5.54**	0.34	
FAC6 I have been a guest in a professor's home.	0.09	1.45	0.01	
Peer Support			**.45**	**.17**
PEER1 In general, my peers are friendly.	0.47	---	0.22	

Table 4.10: Measurement Model

Scale and Items	Standardized loading	t	Reliability	Variance Extracted
PEER2 I have many friends who are always there for me.	0.57	5.68**	0.32	
PEER3 Social connections with peers are important to me.	0.44	5.13**	0.19	
PEER4 My classmates are sympathetic when I do poorly on an assignment or test.	0.33	4.33**	0.11	
PEER6 I frequently study and/or work with other students in my department.	0.39	4.80**	0.15	
Family Support			**.54**	**.21**
FAM1 I can count on my family for financial support.	0.38	---	0.15	
FAM2† My family does not understand my choice of a computer related major.	0.48	5.31**	0.23	
FAM3† It was hard to convince my family of the value of my major.	0.50	5.43**	0.25	
FAM4 I could not have persisted so far in my program without the support of my family.	0.21	3.13**	0.05	
FAM5 My family is supportive of my choice of major.	0.74	5.93**	0.55	
FAM6 My family is a big source of support for my education.	0.50	5.45**	0.25	
Climate			**.50**	**.27**
CLIM2† The classroom atmosphere is not welcoming to women in particular.	0.45	---	0.20	
CLIM3† The classroom atmosphere is not welcoming to minorities in particular.	0.85	4.81**	0.72	
CLIM4† I am treated differently because of my gender in classes in my department.	0.40	5.57**	0.16	
CLIM5† I am treated differently because of my race/ethnicity in classes in my department.	-0.13	-2.11*	0.02	
Program Support			**.38**	**.12**

Table 4.10: Measurement Model

Scale and Items	Standardized loading	t	Reliability	Variance Extracted
PROG1 The office personnel in my department know who I am.	0.22	---	0.05	
PROG2 It is easy to switch between concentrations and/or special programs within my department.	0.35	2.79**	0.12	
PROG3 Tutoring is readily available in my program.	0.44	2.93**	0.19	
PROG4 There is a women's computer club at my school.	0.24	2.41**	0.06	
PROG5 Financial support is readily available from my department.	0.52	3.00**	0.28	
PROG6 I have professional role models in my department.	0.49	2.98**	0.24	

*p<.05
**p<.01
† Item was reverse coded

hypothetical model; r=.73 for the measurement model. One unexpected result: CLIM5, "I am treated differently because of my race/ethnicity in classes in my department," had a negative loading. This item was reverse coded, so the loading should be positive.

Convergent validity of the indicators is indicated by the statistically significant t-values obtained for the coefficients, which range from 2.11 through 15.89. For scales with multiple indicators, as all were in this case, the first variable was set to a value of one; hence t-values were not computed for these items. The reliabilities of the indicators (square multiple correlations) were also provided, as was the composite reliability for each construct. Composite reliability is comparable to coefficient alpha as an indicator of internal consistency. The constructs showed moderate levels of reliability, ranging from .38 for program support to .96 for general academics. Reliabilities were highest for outcome factors (in general) and lower for institutional factors. The variance extracted estimate, a measure of the variance captured by the construct relative to variance due to random measurement error, is presented in the final column of the table. Fornell and Larcker (1981) recommend that these estimates be .50 or higher. General academics was the only scale that achieves this level; the other values are extremely low, indicating a great deal of measurement error for individual items.

Overall, the findings highlight the need for more measurement work in this area. The CRMS was unable to capture the complexity of student perceptions of the academic, social, and institutional factors that influence their satisfaction and persistence in CRM. Better and more reliable measures are needed to measure these complex perceptions. However, it is important to note that the variance extracted estimate test is conservative; hence, estimates below .50 are frequently associated with acceptable reliabilities. Given the significant factor loadings and reasonable reliabilities, the model was retained as the final measurement model.

Structural Equation Model

The structural model moves beyond the measurement model by specifying relationships between latent variables (Schumacker & Lomax, 2004). The a-priori hypothesized model is tested to determine model fit. The final step in SEM is the consideration of modifications to achieve a better fit of the observed data to the model. Modifications may include removing non-significant parameters or adding additional paths or correlations. These modifications are technically data-driven, but must be grounded in theory as well. Model modifications should be made sparingly and one at a time. Too many model modifications capitalize on chance aspects of the data (Schumacker & Lomax, 2004).

Hypothesized model/Model 1. The hypothesized conceptual model is included in Figure 4.2. This model was derived from the literature and from pilot data. The structural model includes relationships between latent variables (Schumacker & Lomax, 2004). In this case, the hypothesis was that academic, social, and institutional factors predict, to some extent, student satisfaction and, ultimately, persistence in CRM. This is very similar to general models of student persistence, as discussed in Chapter 2. Hence, only minor model modifications from the hypothesized model were anticipated.

Scales were developed for factors, based upon preliminary analysis using correlations and upon the final measurement model. Scales were created by averaging the values of individual items (from four to six) included in the scale; these were the observed variables. Each exogenous variable (factors) was represented by two to three scales. Endogenous variables (satisfaction and persistence) were also indicated by one scale each. Error variance for outcomes

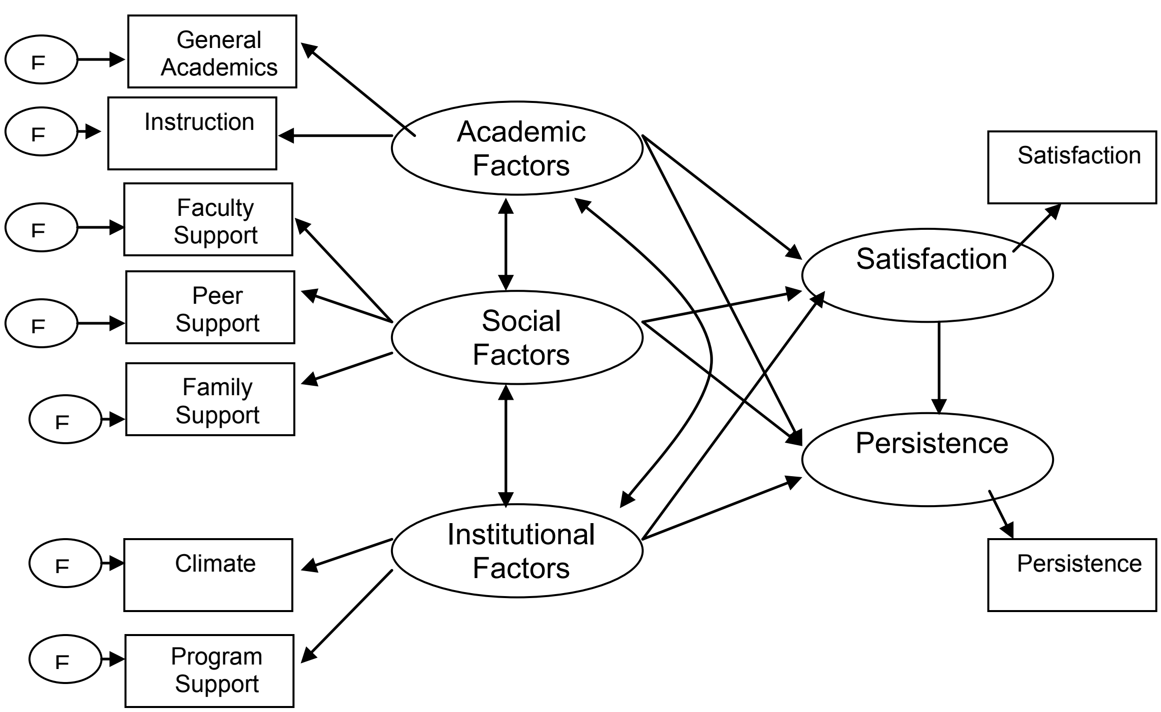


Figure 4.2: Hypothesized Structural Model

was set to zero, since each outcome was measured by a single scale. For this model $X^2(19, N=388) = 126.03$ was significant ($p<.01$), with a chi-square to degrees of freedom ratio of 6.63. This indicates that the model did not adequately account for the relationships among the constructs; this was not unexpected, since the measurement model showed need for improvement. RMSEA of .12 was higher than the desired value of .05. Normed fit indices were acceptable (NFI=.89, NNFI=.81, GFI=.93), and were better, with the exception of PNFI, than the final measurement model. PNFI generally decreases as models become more complex, because it takes into account the parsimony of the model. Examination of path coefficients showed some paths were insignificant. See Table 4.11 for Standardized path coefficients for the hypothesized model. Additional models were examined to determine if minor modifications could lead to a better fit. See Table 4.12 for a comparison of fit indices for these structural models.

In the first model, three paths were statistically insignificant: from social factors to persistence ($\gamma=.05$, $t=.50$, $p>.05$), from institutional factors to persistence ($\gamma=.04$, $t=.65$, $p>.05$), and from institutional factors to satisfaction ($\gamma=-.82$, $t=-.82$, $p>.05$). Since Bentler and Chou (1987) indicate that, in general, is safer to remove parameters than to add new ones when modifying models, the first attempt at modification removed non-significant paths. Changes in chi-square were not significant, and fit indices improved only slightly. This series of modifications led to a model that was over-simplified. Institutional factors had no effect on satisfaction and persistence, and the only direct effect on persistence was indirectly, through satisfaction. These models were not included in Table 4.12; it documents the second, successful series of modifications.

It is important to note that the addition of data-driven model modifications meant that the final model is no longer purely confirmatory in nature. The model is partly confirmatory and partly exploratory. These types of modifications are commonly undertaken when the initial model is not well-fitted. Model modification is more common in the measurement portion of the model since it is typically the main source of misspecification (Schumacker & Lomax, 2004).

Table 4.11: Standardized Path Coefficients for Hypothesized Model (N=388)

Parameters	Coefficient
GAC-ACADEMIC	0.38**
INST-ACADEMIC	0.24**
FAC-SOCIAL	0.21**
PEER-SOCIAL	0.19**
FAM-SOCIAL	0.20**
CLIM-INSTITUTIONAL	0.11**
PROG-INSTITUTIONAL	0.11**
ACADEMIC-SAT	0.41**
SOCIAL-SAT	0.67**
INSTITUTIONAL-SAT	-0.08
ACADEMIC-PERST	-0.16*
SOCIAL-PERST	0.05
INSTITUTIONAL-PERST	0.04
SAT-PERST	0.60

*p<.05

**p<.01

Table 4.12: Comparison of Full Models

Model	df	X^2	X^2 Change	RMSEA	NFI	NNFI	PNFI	GFI	ECVI
1. Hypothesized	19	126.03**	---	.12	.89	.81	.47	.93	.46
2. Correlate error FAC and INST	18	91.48**	34.55**	.10	.92	.86	.47	.93	.38
3. Correlate error FAC and GAC	17	67.31**	24.17**	.088	.94	.90	.44	.96	.32
4. Correlate error CLIM and FAC	16	43.90**	23.41**	.066	.96	.94	.43	.98	.26

**p<.01

Model 2. In the hypothesized model, three paths were statistically insignificant: from social factors to persistence, from institutional factors to persistence, and from institutional factors to satisfaction. Because removal of these paths lead the oversimplified model described above, and inclusion of these paths was theoretically reasonable, they were retained in the second model. For this model, errors for faculty support and instruction were allowed to correlate. This modification was suggested by modification indices in Lisrel. Correlating errors for these scales made sense, since faculty members were directly involved in instruction. Degrees of freedom decreased by one, but chi-square values decreased significantly by 34.55. Fit indices, with the exception of PNFI, improved slightly, but were still below desired benchmarks.

Model 3. For the third model, errors for faculty support were allowed to correlate with errors for general academics. Again, this modification was implied by modification indices in Lisrel, but it was also reasonable, since academics were influenced by faculty. A chi-square decrease of 24.17 was significant for one degree of freedom. Goodness-of-fit was .96, above the benchmark of .95. Other fit indices improved, but still fell short of benchmark values.

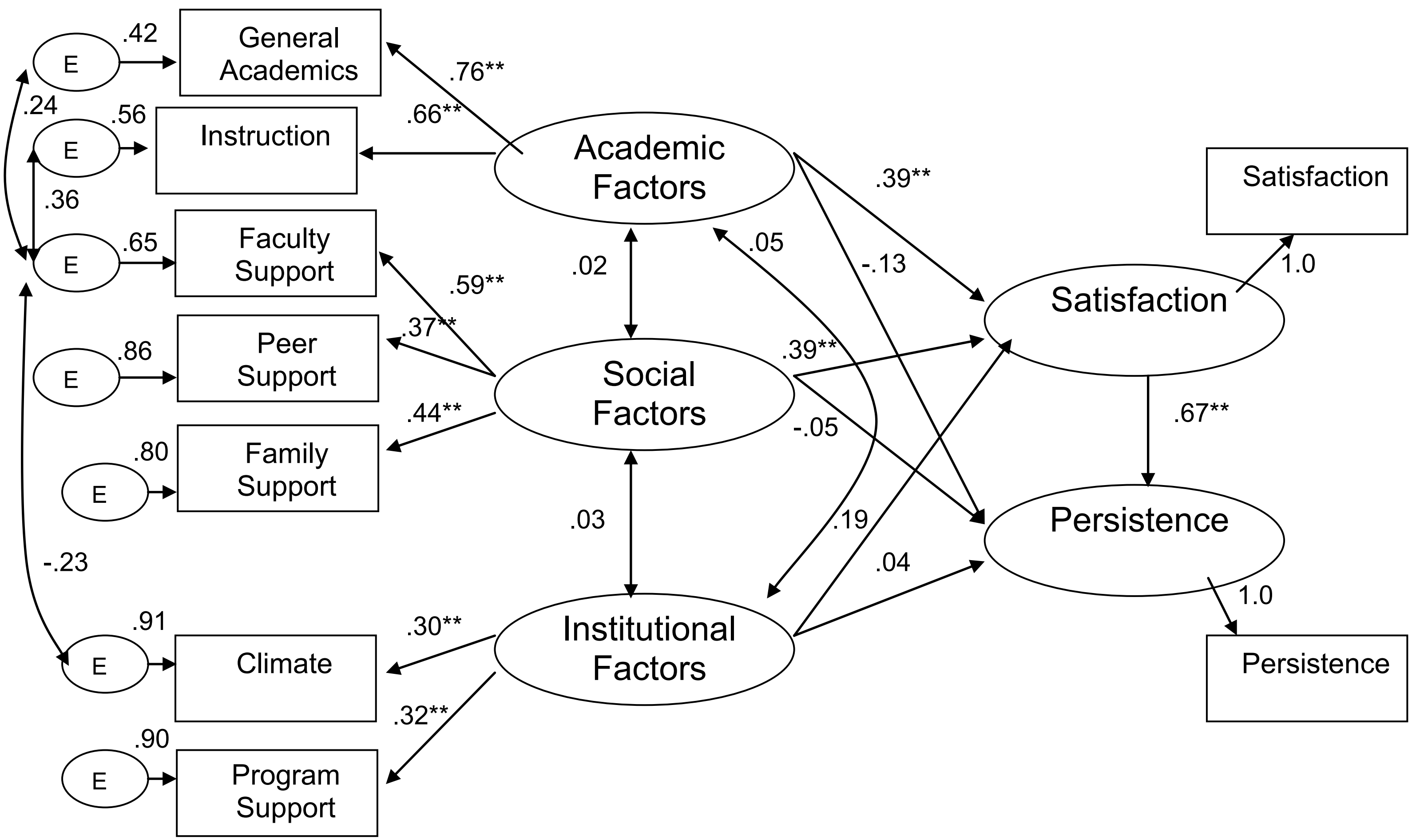
Model 4. In the fourth model, measurement errors for climate and faculty support were correlated. This modification was reasonable, since classroom climate may be affected by instructors. A decrease of one degree of freedom was associated with a significant decrease of 23.41 for chi-square values. NFI was acceptable at .96; other values approached desired values.

One difficulty with model modification is deciding when to quit. It is generally better to err on the side of caution, with fewer modifications rather than many. Too many model modifications can capitalize on chance aspects of the data (Schumacker & Lomax, 2004). Byrne (1998) lists three guidelines for knowing when to stop model fitting: knowledge of theory, assessment of statistical information based on fit indices, and model parsimony.

Final Structural Model

The final structural model is represented in Figure 4.3. Standardized path coefficients for the final model are in Table 4.13. Paths were significantly different from zero with the exception of the one from institutional factors to satisfaction and direct paths from the factors to persistence. Effects of .05 or greater can be considered meaningful, even if they are not statistically significant. These paths may be considered meaningful, with the exception of the path from institutional factors to satisfaction. One path was unexpectedly negative: from academic factors to persistence. This may be due to multicollinearity issues.

The expected cross validation index (ECVI) for the final model was .26, which was the lowest value for all models tested. This index is used when comparing alternative models from a single sample of data. The alternative model with the smallest ECVI value should be the most stable in the population (Schumaker & Lomax, 2004). The low ECVI for the final model indicated that results from this model should be similar to those for another sample in the population.



**p<.01

Figure 4.3: Final Structural Model

Table 4.13: Standardized Path Coefficients for the Final Model (N=388)

Parameters	Coefficient
GAC-ACADEMIC	.76**
INST-ACADEMIC	.66**
FAC-SOCIAL	.59**
PEER-SOCIAL	.37**
FAM-SOCIAL	.44**
CLIM-INSTITUTIONAL	.30**
PROG-INSTITUTIONAL	.32**
ACADEMIC-SAT	.39**
SOCIAL-SAT	.39**
INSTITUTIONAL-SAT	.19**
ACADEMIC-PERST	-.13
SOCIAL-PERST	-.05
INSTITUTIONAL-PERST	.04
SAT-PERST	.67**

*p<.05

**p<.01

Direct, indirect, and total effects are presented in Table 4.14. Results are categorized by the two endogenous variables, satisfaction and persistence.

Table 4:14: Standardized Direct, Indirect, and Total Effect (N=388) on Satisfaction and Persistence

	SATISFACTION			PERSISTENCE		
	Direct	Indirect	Total	Direct	Indirect	Total
Academic	.39**	---	.39**	-.13	.26**	.13
Social	.39**	---	.39**	-.05	.26**	.21**
Institutional	.19**	---	.19**	.04	.13*	.16**
Satisfaction	---	---	--	.67**	--	.67**

*p<.05

**p<.01

Effects on Satisfaction. Factors influencing student satisfaction had only direct effects. The largest effects on satisfaction were the direct effects of the social and academic factors, at

γ=.39. Student perceptions of the supportiveness of faculty, peers, and family had the greatest effect on their satisfaction with their major and related academic experiences, as did academic factors, such as general academics and instruction. Institutional factors had an effect of γ=.19 on satisfaction.

Effects on Persistence. Persistence was influenced by both direct and indirect effects. The largest effect on persistence was satisfaction, at γ=.67. Social factors also had a large effect of γ=.21, most of which was indirect. Academic factors had a respectable indirect effect of γ=.26, but the total effect was lessened by the insignificant negative direct effect. This negative direct effect was most likely due to multicollinearity within the data. The resulting total effect, although statistically non-significant, is still large enough to be theoretically meaningful. Institutional factors had non-significant direct effects, but their indirect and total effects were statistically significant. Direct effects, with the exception of satisfaction, had non-significant effects on persistence. Most of the effect on persistence was visible indirectly, through satisfaction.

Summary of Effects. Student satisfaction was strongly and directly affected by social and academic factors. Satisfaction had a strong direct effect on persistence; social and academic factors also had significant effects, primarily indirect, on persistence. Institutional factors showed significant effects on both satisfaction and persistence, although their direct effect on persistence was not statistically significant.

The pattern of effects in the final model gave empirical support to the hypothesized model of factors that influence student satisfaction and persistence in CRM. Model fit was not ideal, and insignificant effects, especially those for institutional factors, suggest the need for further refinement of the Computer Related Majors Survey. However, it was evident that a complex interplay of academic, social, and institutional factors influence student satisfaction and persistence in CRM.

Structural Models for Groups

The general intent of this paper was to test a hypothesized model of student satisfaction and persistence, using data from the Computer Related Majors Survey. The results of this analysis were discussed in the preceding sections. An additional goal was to compare structural models for men and women, and for Caucasians and minorities. Although the sample was of reasonable size (N=388 CRM majors), subsamples of women and minorities were insufficiently large to allow further analysis. In general, structural equation modeling techniques require large sample sizes. Schumacker and Lomax (2004) recommend 200 to 250.

Only 42 women who were also CRM majors (or 10.8% of CRM majors) responded to the survey. A slightly larger group (N=99, or 25.5%) of minority students are represented in the CRM sample. Although separate models have not been estimated for these subgroups, examination of t-values (discussed earlier in this chapter) indicates that models for these groups may differ from the general model examined here.

Chapter 5: Summary, Discussion and Conclusions

Introduction

The purpose of this quantitative study was to develop and test a model of factors impacting the satisfaction and persistence of undergraduates in computer related majors at two universities in Virginia. Computer-related majors (CRM) at these schools include Computer Science (CS), Computer Science and Technology (CST), Computer Engineering (CE), Information Science and Systems (ISS), and Business Information Technology (BIT). This chapter begins with a summary and discussion of the results, as well as the implications for educators and policy makers. The contributions of study to the literature are discussed, as well as the study's limitations. Suggestions for future research are included.

Summary of the Findings

Major findings are presented according to the different factors included in the final model. The outcome factors of satisfaction and persistence will be discussed first, followed by general academic factors, social factors, and institutional factors. Finally, differences among various groups and majors will be discussed.

Student Satisfaction and Persistence

The final model in this study had two outcomes: student satisfaction and, ultimately, persistence. Items included in the student satisfaction scale had a moderate reliability (α=.56), and individual items had strong standardized loadings on the construct (ranging from γ=.46 to .62). The strongest influences on student satisfaction were from the social and academic factors, both of which had the same effect size. Social factors incorporated faculty support, peer support, and family support, which relate to students' perceptions of interactions with the people who influence their choices and experiences regarding CRM. Academic factors included general academics and instruction, which relate to students' experiences of coursework and instruction in CRM. Institutional factors, including climate and program support, had a smaller significant effect on student satisfaction. Institutional factors were related to students' perceptions of the climate of CRM and the availability of support systems within the department. All effects on student satisfaction were direct.

Both academic and institutional factors were represented by two scales, while social factors were represented by three. Each scale was developed by averaging responses from four to six individual items. All three factors showed reasonable convergent validity and composite reliability; however, variance extracted was low, which indicates the need for more work in the area of measurement. Fit indices for the final structural model suggested that the model did not satisfactorily capture the complexity of the interaction of academic, social, and institutional factors and their effect on student satisfaction and persistence. However, the theoretical basis of the model was supported in general. The final model provided empirical support for the hypothesis that academic, social, and institutional factors influence student satisfaction and persistence in CRM.

Effects of the factors on student persistence were largely indirect; the best predictor of student persistence was student satisfaction, with a standardized loading of γ=.67. Items included in the student persistence scale had a high reliability (α=.73), and most individual items had strong standardized loadings on the construct (ranging from λ =.34 to .82). Direct effects of factors were not significantly different from zero. The largest magnitude of direct effect comes from an (insignificant) negative loading from academic factors. Social factors had a direct effect of γ=.04 on persistence; this was statistically non-significant, but still had theoretical significance. Institutional factors also a small significant direct effect on persistence. After satisfaction, social factors had the highest total effect, largely indirect, on persistence. Academic factors had a fairly large indirect effect, but the total effect was not statistically significant, because of the negative direct effect. Institutional factors had a small significant total effect of γ=.16 on persistence.

Satisfaction items with the highest loadings included: SAT 1, "I am satisfied with my choice of major," (λ=.59); SAT2, "I enjoy courses in my major," (=.62); and SAT6, "I am satisfied with the occupational opportunities in my field" (λ=.53). Persistence items with the highest loadings included: PERST1, "I will complete my degree, but I don't plan to work in the field after graduation, (reverse coded)", (λ=0.79); PERST3, "I do not plan to work in my field after graduation, (reverse coded)", (λ=0.82); and PERST4, "After graduation, I will seek employment opportunities in my major," (λ=0.80).

Academic Factors

Two indicators of academic factors were included in the final model: general academics, and instruction. General academics had the highest standardized loading (λ=.71). It included items regarding student background preparation, the difficulty of coursework, and student stress levels related to coursework. Items in the general academic scale had the highest reliability of scales included in the model (α=.96), and standardized individual item loadings ranged from λ=.15 to .82. Instruction (λ=.65) also had a significant standardized loading, and included items about the presence of weed-out classes, how comfortable students feel asking questions in class, the need for concrete examples, the quality of teaching, and the fairness of grading. Reliability for the instruction scale was only moderate (α=.43), and individual item loadings ranged from λ=.18 to .62.

The effect of academic factors on student satisfaction and persistence reflected in the final model was consistent with other research. Tinto's (1975) and Bean's (1985) models included "academic integration" constructs, which incorporate the factors included in this model. Eliott and Healy (2001) found instructional effectiveness to be the most important dimension in predicting student satisfaction. Athiyaman (1997) also acknowledged the importance of perceived quality of instruction as a major source of student satisfaction.

General academic items with the highest standardized loadings included: GAC2, "I am stressed because of the difficulty of my classes (reverse coded)," (λ =0.82); GAC3, "I am stressed because of the time demands of my course work (reverse coded), ", (λ =0.77); and GAC6, "The coursework in my major is too time-consuming (reverse coded)," (λ=0.69). Instructional items included: INST4, "Classes need more concrete examples (reverse coded),", (λ=0.53); INST5, "Grading in my courses is fair," (λ=0.62); and INST6, "Teaching in my courses is good," (λ=0.45).

Social Factors

Three scales were included in the social factors construct: faculty support, peer support, and family support. Faculty support had the highest standardized loading (λ=.52) of the social factors. It included items reflecting students' perceived relationship with faculty in their major. The faculty support scale had moderate reliability (α=.49), and standardized loadings for individual items ranged from .09 to .58. Family support had the next highest standardized loading (λ=.45); it included items regarding families' understanding and supportiveness of students' choice of a computer related major. The family scale had a moderately large reliability (α=.54), and most individual items had reasonably large standardized loadings on the construct (ranging from λ=.21 to .74). Peer support's standardized loading was λ=.45. It included items regarding students' relationships with their peers. The peer support scale had a moderate reliability (α=.45), and individual items had standardized loadings (ranging from λ=.33 to .57).

The importance of social factors was consistent with other models of student persistence. Both Tinto's (1975) and Bean's (1985) models incorporated peer and faculty interactions, and Bank et al.'s (1990) study indicated that these three social groups were commonly cited in studies of student persistence. Faculty and peer support factors included in this model were similar to other studies of the influence of faculty and peer interaction on student persistence. However, according to Bank et al. (1990), family influence on student persistence is typically evaluated by measuring status characteristics of parents, such as parental education levels and family income. In this model, family influence was measured in relation to familial understanding and supportiveness of the students' choice of major.

Faculty support items with the highest standardized loadings included: FAC4, "Faculty in my major have given me an opportunity to apply classroom learning to "real-life" issues" (λ=0.51); and FAC5, "I like most of the teachers in my major" (λ=.58). Peer support items included: PEER1, "In general, my peers are friendly" (λ =.47); and PEER2, "I have many friends who are always there for me" (λ=0.57). The highest loadings for individual family support items included: FAM2, "My family does not understand my choice of a computer related major (reverse coded)," (λ=0.48); FAM3, "It was hard to convince my family of the value of my major (reverse coded)," (λ=0.50); and FAM5, "My family is supportive of my choice of major" (λ=0.74).

Institutional Factors

Institutional factors had significant effects on student satisfaction and commitment, although the direct effect on persistence was not significant. Three scales were originally included in the institutional factor: perception of field, climate, and program support. The highest standardized loading on the institutional factor was for program support (λ=.28). This scale included items regarding the availability of tutoring, the ease of switching between programs, and the presence (or lack) of a women's computer club. The program support scale had a moderate reliability (r=.38), and individual item loadings ranged from λ=.22 to .52. Climate had a standardized loading of λ=.24; the scale included items regarding how welcoming the classroom atmosphere was to women and minorities, and how students are treated. This scale had a moderate reliability of α=.50. Individual items loadings ranged from λ=.40 to .85, with a single exception. CLIM5, "I am treated differently because of my race/ethnicity in classes in my department," had a negative loading, despite being reverse coded. Perception of field was not included in the final model. Scale reliability was extremely low (α=.118), and individual items had low correlations with each other. This implies that there was no consistent perception of the field of computing among majors in the sample.

The non-significant direct effect of institutional factors on student satisfaction was unexpected; however, the total effect was significant. Although Tinto (1975) did not incorporate these factors into his Student Integration Model, they were included in Bean's (1985) Student Attrition Model as "environmental factors." Two of Eliott and Healy's (2001) three dimensions predictive of student satisfaction were included in this factor: "student centeredness," which reflects the institution's effort to convey to students that they are welcome and valued; and "campus climate," which reflects the student's sense of campus pride and belonging.

Program support items with the highest standardized loadings on the construct included: PROG3, "Tutoring is readily available in my program," (λ=0.44); PROG5, "Financial support is readily available from my department,“ (λ=0.52); and PROG6, "I have professional role models in my department" (λ=0.49). The highest standardized loadings for climate items included: CLIM2, "The classroom atmosphere is not welcoming to women in particular (reverse coded)," (λ=.45); and CLIM3, "The classroom atmosphere is not welcoming to minorities in particular (reverse coded)" (λ=.85).

The measurement of institutional factors and the components that make up these factors show the need for further future research. It is possible that scales such as program support and climate are distinct in nature and do not correlate, which would indicate the lack of a common latent factor. Perception of field is also an important component in explaining student satisfaction and persistence, although it was not incorporated in this model due to problems with the scale. Although the magnitude of effects were relatively small, institutional factors did have significant effects on student satisfaction and persistence.

Differences Among Groups

A secondary goal of this paper was to compare structural models for men and women, and for Caucasians and minorities. Although the sample was of reasonable size (N=388 CRM majors), subsamples of women and minorities were insufficiently large to allow further analysis. Although separate models have not been estimated for these subgroups, examination of t-values (discussed in chapter four) indicated that models for these groups may differ from the final general model. Differences between majors and non-majors, men and women, Caucasians and minoritiess, and VT and Radford students are discussed, followed by a comparison among CRM majors at each school.

Differences between CRM majors and non-CRM majors. Although the intended sample for this study was CRM majors, 103 students who were not enrolled in computer related majors also took the survey. These students had some interest in computers, since they were enrolled in computer-related courses. There were minor differences between these students and CRM majors in demographics. Non-majors were more likely to plan to complete a higher degree than CRM majors. When asked the most important reason for their choice of major, non-CRM majors were more likely to choose emphasis on applications, hardware, or programming than majors.

Majors and non-majors had different means on several persistence and satisfaction items. CRM majors were more likely than non-majors to complete their degree but not work in the field after graduation, to feel confident they will complete their degree in their major, and to seek employment opportunities in their major. Non-majors were more likely to continue their education in a different major than CRM majors. CRM majors had higher indicators of overall persistence, and were more likely to express interest in computing due to financial rewards than non-majors. They also reported higher levels of satisfaction overall.

Students in CRMS were more likely to feel that grading in their courses was fair than non-majors; they also had higher overall levels of academic support than non-majors. CRM majors were less likely than non-majors to have been a guest in a professor's home. Non-majors had less difficulty convincing their family of the value of their major than CRM majors; they were also more likely to indicate that their family is a big source of support for their education than CRM majors. CRM majors are more likely to see themselves working in a technical position in a computer related field and to agree that they will spend most of their time working alone and work long hours than non-majors. Students in computer related majors are less likely to agree that it is easy to switch between programs or find professional role models in their department than non-majors.

Many of these differences are not surprising; the CRMS was designed specifically for students in computer related majors, and some items are not readily applicable to students in other majors.

Differences between men and women. There were fewer differences between men and women in CRM than expected. Academically, men were more likely to feel comfortable asking questions in class than women. There were no significant differences in instructional factors.

Family support is significantly more important for women than for men. Women were more likely than men to agree that "I could not have persisted so far in my program without the support of my family," that their family supports their choice of major, and that their family is a big source of support for their education. Overall, women reported higher levels of family support than men. There were no significant differences in faculty or peer support.

For institutional factors, women were more likely than men to see themselves working in a technical position in a computer related field; they were also more likely to agree that women have as much innate ability as men when learning to use and program computers. Women were more likely to feel that they are treated differently due to their gender than men. Women also reported lower perceptions of climate overall than men.

Given the large body of literature regarding the persistent shortage of women in computer related majors, the relative scarcity of differences in means on individual items between women and men is surprising. One possible explanation is that women who have chosen a computer-related major, and have, so far, been successful in their field, have adapted to the current culture and expectations in the major. They often become as comfortable and competent as their male peers because they have adopted the prevailing image of computer science as their own, and are willing to act in ways which enable them to succeed. This phenomenon has been observed in other science fields that have been traditionally male-dominated (Margolis and Fisher, 2002).

Differences between Caucasians and Minorities. There were more differences observed between Caucasians and minorities than in other groups considered. Caucasian students indicated encountering computers at an earlier age than minorite students. Caucasians were more likely to plan to continue their education in a different major than other ethnic groups.

There were significant differences in satisfaction items between Caucasians and minorities. Caucasians reported higher levels of satisfaction in their choice of major and of enjoyment of courses in their major than minorities. The lower mean for minorities indicated that they were more concerned about a non-welcoming workplace than Caucasians. Caucasians were more satisfied with both their coursework and their occupational opportunities than other ethnic groups. Overall, Caucasians reported higher levels of satisfaction than other students.

Caucasians and other ethnic groups differed on academic items. Minorities were more likely to find courses in their major difficult and too time-consuming than Caucasians. Caucasians were less likely to feel that their courses need more concrete examples, to feel grading in their courses is fair, to like their teachers, and to feel they have had the opportunity to apply classroom learning to “real-life” issues than other students. Caucasians also felt more strongly that their family was supportive of their choice of major than minority students.

Most of the differences in perception of climate were between Caucasians and other students. Minority students were more likely than Caucasians to feel that the classroom atmosphere is not welcoming to minorities and that they were treated differently in class because of their race/ethnicity. Minority students were more likely to agree that the work their major has prepared them to do is not socially relevant than Caucasian students. Overall, Caucasian students have more positive perceptions of climate than minority students.

The large number of observed differences between Caucasian and minority students, particularly in satisfaction items, indicated that there may be significant differences between structural models of student satisfaction and persistence for Caucasians and minorities. If a large enough sample of minority students can be obtained, further research on models of student satisfaction and persistence should be conducted.

Differences between schools. There were also observed differences between students from Virginia Tech, who were the majority of the sample, and from Radford. RU students who responded are younger, on average than VT students. VT students reported higher grades in-major, and had higher levels of confidence that they would complete their degree in their current major than RU students.

Academically, VT students felt more strongly that there are weed-out courses in their department than did RU students. Students from VT feel that their family understands their choice of major more than RU students do; however, RU students are more likely to think their instructors know them than VT students. VT students were more likely to see themselves working in a technical position in a computer related field than RU students, and more likely to feel they will spend most of their time working on projects alone.

Students at Virginia Tech were more likely to feel that their department favors students with previous programming experience than students at Radford. Students at Radford found it easier to switch between concentrations in their department and to find readily available tutoring than Virginia Tech students. Although there is a women's computer club at both schools, VT students were more likely to know about it than RU students.

Many of the observed differences between RU and VT students were due to the level of classes that were surveyed. At RU, classes surveyed were first-semester programming classes, which contained many non-majors. At VT, most classes surveyed were upper-level classes, since several of the computer-related majors are restricted majors that only admit upper classmen. These differences are not unexpected; one university represented a broader range of academic levels, which provided a more accurate and complex view of student perceptions.

Differences Among Majors. Most of the observed differences among majors were observed at Virginia Tech. All of the VT majors had differences in year in school: CS majors had the lowest academic level, while BIT majors had the highest. CE had the fewest women; BIT the most. CE majors were more likely to pursue a Master's degree than CS majors. Majors differed on the most important reason for their choice of major. Computer Science students reported the highest grades; Computer Engineering majors reported the lowest.

CS and CE students were more likely to intend to complete their degree, but not work in the field after graduation than BIT students. BIT students were more confident they will complete their degree in their major than either other VT major; they were also less likely to work in their field after graduation. CS students were more likely than BIT students to pursue a graduate degree in their current major. BIT students had a higher overall rate of persistence than CS students.

CS students had higher levels of satisfaction with their choice of major than CE or BIT students. Computer Science students were more likely to enjoy courses in their major than BIT students, and more satisfied with their coursework than either CE or BIT. BIT and CS students were more satisfied with the occupational opportunities that CE majors. Overall, CS majors reported higher levels of satisfaction than either BIT or CE majors.

Academically, CE majors were more stressed because of the difficulty and time demands of their courses than either CS or BIT students; they also found the courses more difficult than CS or BIT majors. BIT students were the most likely to find their courses boring. Overall, BIT and CS majors had a more positive perception of general academics than CE majors.

Computer Engineering majors were more likely to feel their department has weed-out courses than CS; both were more likely that BIT. CE also had more classes in which the primary mode of instruction was lecture than either CS or BIT; they were more likely to feel that classes need more concrete example. BIT students were most likely to feel the grading in their courses is fair; both BIT and CS majors were more likely to feel the teaching in their courses is good than CE. Overall, BIT had the most positive perception of instruction, followed by CS and CE.

All differences in social factors among majors were associated with faculty support. BIT students were most likely to feel that their instructors know them and to have received emotional support and encouragement from faculty. CE students were most likely to have received negative feedback about their academic work. BIT majors were most likely to like the teachers in their major, followed by CS and CE majors; they also reported the highest level of faculty support.

Virginia Tech majors differed in their perceptions of the field. CE majors were most likely to agree that computer majors are nerdy, followed by CS and BIT majors. CS and CE majors were more likely to see themselves working in a technical position in a computer related field than BIT majors; they were also more likely to feel they will spend most of their time working alone. All three majors felt they will be required to work long hours; CE was most likely to agree, followed by BIT and CS. Overall, Computer science and BIT majors had more positive perceptions of the field than Computer Engineering majors.

BIT majors had the most positive view of their departmental climate; CE majors had the least. CE students were the most likely to agree that their department favors students with previous programming experience, followed by CS and BIT. BIT students felt the classroom atmosphere was welcoming to women, followed by CS and CE majors. Overall, the climate scale indicated BIT majors perceive the most positive climate.

Departmental personnel were most likely to know CE students, followed by CS and BIT majors; CE and CS students were more likely to find readily available tutoring than BIT students. VT has a women's computer club; CS and CE majors were more likely to know about it than BIT majors. CS students felt they have professional role models in their department; CE and BIT were less likely to agree. Overall, CS students had the highest level of program support, followed by CE and BIT.

At Radford, there were few perceived differences among majors. CST students were more confident they will complete their degree than ISS students. ISS students reported higher levels of satisfaction with their choice of major than CST students. The lack of differences may simply be a factor of the small number of respondents at RU; the sample contained only 23 Computer Science and Technology and 18 Information Science and Systems majors.

The observed differences among majors are not unexpected. Each major has a different focus and emphasis, and attracts a different kind of student. The number of significant differences implied that, given sufficient sample sizes, structural models among majors will be significantly different.

Discussion and Implications

The purpose of this study was to develop and test a model of factors impacting the satisfaction and persistence of undergraduates in computer related majors. As such, it was successful. The data provided empirical support for the hypothesis that academic, social, and institutional factors influence student satisfaction and persistence in CRM. The final model emphasizes the effect of academic and social factors on student satisfaction and persistence. Academic and social factors had the greatest effect on student satisfaction and persistence, while institutional factors had a smaller effect.

Model fit indices suggest that, although this model was reasonable, it could be improved. Several paths that have theoretical significance were not statistically significant, and one case, was inexplicably negative. Other questions remain unanswered, largely due to the limitations of the sample. Samples of subpopulations were too small to allow separate analysis for women and minorities, so separate models were not developed for these groups. However, comparison of means on individual items and scales suggested significant differences in models for Caucasians and minorities, and among the various computer related majors.

The strong direct effect of social factors on student satisfaction, and, indirectly, persistence, highlighted the importance of support networks for students in computer related majors. When a strong support network is in place, either formal or informal, students are more likely to be successful. This is a recurring theme in studies of women in computer related majors. Studies by Cohoon (2001, 2002) found that CS department retained more women when there were sufficient numbers of women students in classes to support each other. Staehr et al. (2000) report improved retention rates for women when mentoring programs are in place, and Besana and Dettori (2004) report the positive effect of an informal learning community and support program for women. In addition, social integration is a major part of the general persistence models of Tinto (1975) and Bean (1985).

Academic factors also had a strong direct effect on student satisfaction, and indirectly, persistence. This result highlighted the need for evaluation of the content emphasis and instruction in computer majors. Recent research has called for computer educators to evaluate the pedagogy and environment of computing majors (Howles, 2007; Miliszewska, Barker, Henderson, & Sztendur (2006); Turner, Albert, Turner, & Latour, 2007; Varma & Lefever, 2007). The academic system and academic factors are also components of the general persistence models of Tinto (1975) and Bean (1985).

Although institutional factors had smaller effects on student satisfaction and persistence in the final model, analysis of the scale structure and measurement model suggested that the problem was not associated with the theoretical model, but rather with the measurement aspects of the survey instrument. Institutional factors, including climate and program support, had small but meaningful effects on student satisfaction and persistence. If the classroom atmosphere (or anticipated workplace atmosphere) is perceived to be unwelcoming, students are more likely to switch majors or not seek employment in the field upon graduation. Climate issues affect not only retention, but also selection of majors in the first place. These effects are echoed in the literature. Weinberger (2004) found that at least one-third of the women indicated that they would not go into IT because of an unwelcoming classroom (or workplace) atmosphere. West and Ross (2002) found that women in computer science found the environment cold and unresponsive. Environmental factors are also a substantial component of Bean's (1985) Student Attrition Model.

The model provided empirical support for the hypothesized theoretical model. Yet, more work is needed to explain the complexity of interactions between academic, social, and institutional factors and their effect on student satisfaction and persistence in computer related majors. However, it is clear that these factors do have an effect on satisfaction and persistence.

Implications for Educators and Policy Makers

The largest effects on student satisfaction and persistence came from social and academic factors. It should be noted that faculty support was a crucial component in the model; it is also a component that educators can influence by changes in policies and practices. Faculty members in CRM should consider the level of support they provide to their students. In the qualitative pilot, every student mentioned a key faculty member who was instrumental in their persistence. When students began to doubt that they could be successful in their chosen computer related major, a faculty member provided emotional support and encouraged them to persist. This finding highlighted the importance of faculty in student retention and persistence.

Peer and family support also contributed significantly to the model. However, these components are much harder to influence. Peer support may be increased by the establishment of computing clubs, and by more widely advertising pre-existing computing clubs. Peer mentoring, paired programming experiences, and informal learning communities have proven successful in the retention of students (Besana & Dettori, 2004; McDowell et al., 2006; Staehr et al., 2000). Family support may be increased by making computing careers and what is involved in them more visible to the public. Many students, and presumably their families, do not have accurate perceptions of what careers in computing entail (Berry et al., 2006; Lee & Lee, 2006).

Academic factors, such as student perceptions of coursework and instruction, had a significant effect on both student satisfaction and persistence. Of all factors in the model that affect satisfaction and persistence, academic factors are the most accessible to change. Student attrition in computer majors is highest in the first two years (Howles, 2007). This early attrition rate is usually attributed to "weed out" courses and early courses that focus entirely on programming, without showcasing the broader impact of the discipline. Recent research calls for computer educators to evaluate the pedagogy and environment of computing majors (Howles, 2007; Miliszewska, Barker, Henderson, & Sztendur, 2006; Turner, Albert, Turner, & Latour, 2007; Varma & Lefever, 2007). Re-evaluation of content and instructional methods has the potential to increase student retention and, ultimately, the size of the computer workforce.

Although institutional factors were found to have smaller effects on student satisfaction and persistence, this was due to the low reliabilities of the measures. Faculty and student interactions help shape classroom climate. West and Ross (2002) found that women in computer science found the environment cold and unresponsive; women were uncomfortable asking questions of male CS instructors. Although educators cannot directly affect the quality of peer interactions, instructors can have a direct influence on the atmosphere in their classrooms.

The model supported the hypothesis that academic, social, and institutional factors affect student satisfaction and persistence in computer related majors. The findings highlighted the need for evaluation of existing programs to determine which factors can be modified in order to retain more students and, ultimately, increase the workforce available for computer related careers.

Contributions of the Study

A large body of research has been developed in recent years concerning student attraction and retention in computer related majors. Much of this work focuses on increasing the small number of women and minorities who choose to enter the field of computing. Many studies are qualitative, small in scale and scope, or exploratory in nature. This study began with a conceptual model, derived from the existing literature, to determine factors that influence student satisfaction and persistence in computer related majors. Although general student persistence models exist, none were found that were specific to computing fields.

Use of structural equation modeling (SEM) allowed examination of a complex model of interconnections between academic, social, and institutional factors and their influence on student satisfaction and persistence in computer related majors. In addition, use of SEM made it possible to estimate the construct validity of the constructs of the model, and highlighted the constructs for which more measurement work is needed.

Results of this study were based upon a relatively small sample of students at two universities; however, the findings had broader implications. Analysis of the final structural model provided empirical support for the hypothesized model of student satisfaction and persistence. This model should be tested with data collected from other samples of students, to further refine the conceptual model.

Limitations of the Study

Although this study contributes to the existing research on student satisfaction and persistence in computer related majors, application of the results are limited due to the nature of the data and the sample. The data itself was cross-sectional in nature; at best, it gave us a "snapshot" of student perceptions at a single point in time. Relationships among factors were tentative, rather than confirmatory. Student satisfaction and persistence is fluid in nature—every experience, positive or negative, influences the outcome. Satisfaction and persistence change over the four (or more) years it takes to complete a degree. Longitudinal research is necessary to develop a more causal model of the process.

The sample consists of students from only two schools, and most were from a single university. The model may generalize only to students at similar institutions. This model should be cross-validated with samples from other universities.

Samples of women and minorities were very small, because their proportions were small in the population. Some majors were better represented than others, due to varying class size and levels of cooperation from instructors. Comparison of means indicated that significant differences may exist between Caucasians and minorities and among majors; sample sizes were insufficient to allow this analysis.

Suggestions for Further Research

As is often the case, this study raised more questions than it answered. Comparisons of means in the current sample suggested significant model differences between Caucasians and minorities and among computer majors at Virginia Tech. This analysis was not feasible due to limitations of sample size. It may be possible to obtain a large enough sample of minorities from various institutions to carry out a separate structural analysis of minorities versus Caucasians. If additional samples from similar populations can be obtained, separate models for gender and ethnically based groups should be examined.

Several paths that were theoretically significant proved to be statistically non-significant, especially those associated with direct effects on persistence. This indicated that more conceptual and empirical work needs to be done to develop reliable and valid measures. Additional work needs to be done to improve the measurement aspects of various constructs such as program support, climate, and perceptions of the field.

Much of the current body of research in student retention in computer related majors is either qualitative or small in scale. There is a lack of large-scale, empirical studies on student satisfaction and persistence in computer related majors. Additional data should be collected from students at other colleges and universities to further examine the factors that affect student satisfaction and persistence in computing fields.

Conclusion

The field of computing is rapidly expanding, and student enrollment and graduation is not keeping up with the demand for workers in computing fields. There has been a great deal of research done in recent years to determine why certain populations, especially women, are underrepresented in both the workforce and in computing majors. This study developed and tested a model of the effects of academic, social, and institutional factors on student satisfaction and persistence in computer related majors. Results indicate that these factors have significant and substantive effects on satisfaction and persistence. They highlight the importance of faculty, peers, and family support for student satisfaction and retention, and the need to examine instruction and content in computer related majors. The findings suggest the need for further work in the measurement of the constructs, and for further refinement of the final model. In addition, comparison of individual item means suggest that models may vary significantly among majors and between Caucasian and minority students. Future research should continue to test and refine the model for the influence of academic, social, and institutional factors on student satisfaction and persistence in computer related majors so that educators and policy makers can enhance the academic and social support structures for students in these majors.

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APPENDIX A: Computer Related Majors Survey (CRMS)

Thank you for taking the time to complete this survey. Your participation is appreciated.

I. DEMOGRAPHICS. Please answer the following questions about yourself.

1. Year in college:
   1 = Freshman *2 = Sophomore* *3 = Junior* *4 = Senior* *5 = Other*

2. Gender:
   1 = Male *2 = Female*

3. Race/ethnicity:
   1 = American Indian or other Native American
   2 = Asian or Pacific Islander
   3 = Black or African American
   4 = Hispanic
   5 = White
   6 = Other

4. Highest degree you intend to complete:
   1 = Bachelor's degree *2 = Master's degree* *3 = Doctoral or professional degree*

5. Do you think you will continue graduate studies in your current major?
   1 = Yes *2 = No* *3 = I don't know*

6. When did you first encounter computers?
   1 = Before kindergarten
   2 = Kindergarten through second grade
   3 = Third through fifth grade
   4 = Sixth through eighth grade
   5 = High school
   6 = College

7. Prior to entering college, did you take any computer classes? In what?
   1 = I did not take any classes
   2 = Hardware
   3 = Keyboarding
   4 = Networking
   5 = Programming
   6 = Spreadsheets and databases
   7 = Web design
   8 = Other

8. Prior to entering college, which computer did you most use?
   1 = Your own computer
   2 = A family computer
   3 = A friend's computer
   4 = Computers at school
   5 = Computers available to the public (i.e., library)
   6 = No access

9. What is your major?
   1 = Business Information Technology (VT)
   2 = Computer Science (VT)
   3 = Computer Science and Technology (RU)
   4 = Electrical and Computer Engineering (VT)
   5 = Information Science and Systems (RU)
   6 = Other

10. Who most influenced you to choose your major?
   1 = A family member
   2 = A friend
   3 = A high school teacher
   4 = No one
   5 = Other

11. What is the most important reason for your choice of major?
   1 = Emphasis on computer applications
   2 = Emphasis on hardware
   3 = Emphasis on programming
   4 = I had a specific job in mind
   5 = My interest in the area
   6 = The amount of money I could make after graduation
   7 = The prestige of the field
   8 = Other

12. Which best describes your grades in your major?

   1 = All A's
   2 = Mostly A's
   3 = Mostly B's
   4 = Mostly C's
   5 = Mostly D's
   6 = Mostly F's

II. MAJOR. Please answer the following questions about your department and major.

13. Females have as much innate ability as males when learning to use and program computers.
   1 = Strongly Disagree *2 = Disagree* *3 = Agree* *4 = Strongly Agree*

14. My department favors students with previous programming experience.
   1 = Strongly Disagree *2 = Disagree* *3 = Agree* *4 = Strongly Agree*

15. My instructors know me.
   1 = Strongly Disagree *2 = Disagree* *3 = Agree* *4 = Strongly Agree*

16. I had the background to be successful in classes early in my major.
   1 = Strongly Disagree *2 = Disagree* *3 = Agree* *4 = Strongly Agree*

17. There are weed-out courses in my department.
   1 = Strongly Disagree *2 = Disagree* *3 = Agree* *4 = Strongly Agree*

18. In general, my peers are friendly.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

19. I will complete my degree, but I don't plan to work in the field after graduation.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

20. The office personnel in my department know who I am.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

21. I am satisfied with my choice of major
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

22. I can count on my family for financial support.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

23. Computer majors are nerdy.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

24. The classroom atmosphere is not welcoming to women in particular.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

25. Faculty in my major have given me emotional support and encouragement.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

26. I am stressed because of the difficulty of my classes.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

27. I feel comfortable asking questions in class.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

28. I have many friends who are always there for me.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

29. I feel confident I will complete my degree in my major.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

30. It is easy to switch between concentrations and/or special programs within my department.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

31. I enjoy courses in my major.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

32. My family does not understand my choice of a computer related major.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

33. I can see myself working in a technical position in a computer related field.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

34. The classroom atmosphere is not welcoming to minorities in particular.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

35. Faculty in my major have given me negative feedback about my academic work.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

36. I am stressed because of the time demands of my course work.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

37. The primary mode of instruction is lecture.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

38. Social connections with peers are important to me.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

39. I do not plan to work in my field after graduation.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

40. Tutoring is readily available in my program.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

41. I would like to work in a computer field because of the financial rewards.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

42. It was hard to convince my family of the value of my major.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

43. It will be difficult to combine my computing career with raising a family.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

44. I am treated differently because of my gender in classes in my department.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

45. Faculty in my major have given me an opportunity to apply classroom learning to "real-life" issues.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

46. The courses in my major are difficult for me.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

47. Classes need more concrete examples.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

48. My classmates are sympathetic when I do poorly on an assignment or test.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

49. After graduation, I will seek employment opportunities in my major.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

50. There is a women's computer club at my school.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

51. I don't expect the workplace atmosphere to be welcoming to me in a computer related field.
1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

52. I could not have persisted so far in my program without the support of my family.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

53. I will spend most of my time working on projects alone in a computer related career.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

54. I am treated differently because of my race/ethnicity in classes in my department.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

55. I like most of the teachers in my major.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

56. The courses in my major are boring to me.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

57. Grading in my courses is fair.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

58. I am mainly friends with people outside my major.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

59. I plan to pursue graduate studies in my current major.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

60. Financial support is readily available from my department.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

61. I am satisfied with the coursework in my major.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

62. My family is supportive of my choice of major.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

63. I will be required to work long hours in a computer related career.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

64. The work that my major has prepared me to do is not socially relevant.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

65. I have been a guest in a professor's home.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

66. The coursework in my major is too time-consuming.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

67. Teaching in my courses is good.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

68. I frequently study and/or work with other students in my department.
    1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

69. I plan to continue my education but not in my current major.
    1 = Strongly Disagree *2 = Disagree* *3 = Agree* *4 = Strongly Agree*

70. I have professional role models in my department.
    1 = Strongly Disagree *2 = Disagree* *3 = Agree* *4 = Strongly Agree*

71. I am satisfied with the occupational opportunities in my field.
    1 = Strongly Disagree *2 = Disagree* *3 = Agree* *4 = Strongly Agree*

72. My family is a big source of support for my education.
    1 = Strongly Disagree *2 = Disagree* *3 = Agree* *4 = Strongly Agree*

APPENDIX B: Institutional Review Board Documentation

Cover Letter for CRMS at Virginia Tech

Computer Related Majors Survey

You have been selected to respond to the Computer Related Majors Survey. The purpose of this survey is to identify factors that influence the satisfaction and persistence of students in computer-related majors like yours. Your participation is strictly voluntary, but will be greatly appreciated. All responses are completely confidential; the only personal information collected is basic demographic information you will provide, like major, race/ethnicity, and gender. Risks involved in participation are minimal; questions are not sensitive, and all responses are voluntary. Your participation will help me identify what students like about their major, and what they would like to see changed. If you have any questions or concerns about this study, feel free to contact me or my advisor. Again, your participation in the survey will be greatly appreciated. Thank you.

Lisa Darlington, doctoral student
ldarling@vt.edu

Kusum Singh, faculty advisor
ksingh@vt.edu

VirginiaTech

Institutional Review Board

Initial Review Application

Directions

- **Type responses to all questions / requests below. It is recommended that you read through this document before completing.**
- **Do not leave a question blank unless directed. If a required question is not applicable to your study, explain why.**
- **Do not restrict your responses to the space provided. Provide a thorough response to each question. Be as specific as possible, keeping in mind that you are introducing the study to the IRB. Incomplete applications will result in requests for clarification from researchers and will cause delays in review and final approval.**
- **Type responses in the designated shaded boxes or check the designated check boxes.**
- **Use non-technical language throughout your application. Federal regulations require IRB applications to be written in lay language at an 8th grade reading level. Do not use jargon or scientific terms in your explanations/descriptions.**
- **Check for grammatical or typographical errors before submitting. Protocols with substantial errors will be returned for corrections.**
- **This form must be completed and submitted (as a Word document) electronically. Submit all required documents (e.g., Review Form, Initial Review Application, all study forms requested within this application, and bio-sketches) to irb@vt.edu. For questions, contact Carmen Green, IRB Administrator, at ctgreen@vt.edu or (540) 231-4358.**

Section 1: General Information

What is the Study Title: Factors That Influence The Satisfaction And Persistence Of Undergraduates In Computer Related Majors

[Note: If this protocol has been submitted to a federal agency for funding, the title of that application **must** match the title of this submission.]

☐ Check this box if this study **only involves the collection or study of existing data,** documents, records, pathological specimens, or diagnostic specimens **and respond only to the following sections within this document:** Section 1: General Information; Section 2: Justification; Section 8: Confidentiality / Anonymity; Section 14: Research Involving Existing Data; and Section 15: Additional Information below (Note: Section 15 is optional).

1. Will this research involve collaboration with another institution?
   ☐ No
   ☒ Yes

   If yes,

   A. Provide the name of the institution(s): **Radford University**

   B. Indicate the status of this research project with the other institution's IRB:
   ☒ Pending approval
   ☐ Approved [submit approval letter with this IRB application]
   ☐ Other institution does not have a human subject protections review board
   ☐ Other, explain:

Section 2: Justification

2. Describe the background of this study, including supporting research: **Recent years have seen a rapid increase in the demand for workers with college level training in computer related fields. Careers requiring advanced computer skills are projected to be among both the fastest growing occupations through 2014, and the most economically advantageous (Bureau of Labor Statistics, 2007). Although the number of**

computer science jobs is increasing rapidly, the supply of graduates in computing fields is not keeping up with the demand. Universities with well-known computer science (CS) programs, such as Carnegie Mellon, Rutgers, Stanford, and the University of California at Berkley, have reported a significant decline in CS applicants and degrees awarded (Carter, 2006).

In the wake of decreasing enrollment increasing demand, programs in computing must assess their current state of affairs to determine where change may be beneficial in increasing the number of computing degrees awarded. One aspect of the problem is increasing enrollment, which can be addressed by evaluating the image of computer majors. Several studies indicate that students do not understand what is involved in computing majors (Berry et al., 2006; Lee & Lee, 2006). Some students associate CS with writing programs, while others believe that it involves finding information on the web or using computers for daily tasks (Courte and Bishop-Clark, 2007).

A second factor in increasing the number of graduates in computing fields is in retaining those students who originally choose computing majors. Student attrition in these majors is highest in the first two years (Howles, 2007). In fact, women who initially enroll in computer majors are more likely than men to drop out in the freshman or sophomore years (Cohoon, 2001). This early attrition rate is usually attributed to "weed out" courses and courses that focus entirely on programming. Recent research calls for computer educators to evaluate the pedagogy and environment of computing majors (Howles, 2007; Miliszewska, Barker, Henderson, & Sztendur (2006); Turner, Albert, Turner, & Latour, 2007; Varma & Lefever, 2007).

Before seeking ways to address the problem of decreasing enrollment and high attrition rates in computing majors, it is important for educators and researchers to understand the current state of affairs in computer related majors (CRM). This is being done in small steps, often by individual departments of computer science or information technology (Besana and Dettori, 2004; McDowell et al., 2006; Pioro, 2006; Turner, Albert, Turner, & Latour, 2007; Varma & Lefever, 2007).Many studies are based on small, non-random samples and single-site case studies, which do not permit in-depth analysis of the complexity of components that affect students' decisions to persist or drop out of computer related majors.

In order to increase enrollment and decrease attrition in CRM, educators and policymakers need to examine factors that influence student persistence and commitment to CRM. The majority of the literature on student persistence focuses on two theories: Tinto's Student Integration Theory (1975, 1982, 1993) and Bean's Student Attrition Model (1985). They are often cited as competing theories, although Cabrera et al. (1992, 1993) have studied the convergence of the two models and proffered a model that integrates both theories. Both models have several commonalities: persistence is seen as a result of a complex set of interactions over time; precollege characteristics affect how well students later adjust to their institutions; and persistence is affected by a successful match between the student and the institution.

According to Bank, Slavings, and Biddle (1990), three types of people are commonly cited as influential in student's decisions to stay or leave school: peers, faculty, and parents. Most studies that look at peer influence on retention focus on such measures as the number of friends a student has on campus, the time the student spends with other students, and the student's satisfaction with his or social life in college. Similarly, the influence of faculty members on student attrition tends to focus on the amount of contact a student has with faculty, the student's evaluation of faculty, and the level of satisfaction the student has with these interactions. Parental influence on student persistence is usually evaluated by measuring status characteristics of parents, such as parental education levels and family income.

The present study will result in an analysis of factors impacting the satisfaction and persistence of undergraduates in CRM. In order for the supply of graduates in these majors to meet the growing demand, the climate and pedagogy of CRM need to be considered. Dependent variables will include student satisfaction with academics and instruction, commitment to major, and persistence. Increased student satisfaction and commitment are associated with higher persistence rates in general (Tinto, 1982; Bean, 1985; Caberra et al., 1992, 1993; Bank et al., 1990; Suhre, Jansen, Harkskamp, 2007). Little work has been done focusing on the unique factors influencing student satisfaction and persistence in CRM.

Factors potentially impacting the dependent variables of satisfaction, commitment, and persistence are largely derived from the literature pertaining to women and minorities in CRM. These independent variables include academic factors (general academics and instruction); social factors (faculty, peer, and family support); and institutional factors (perception of the field, climate, and program support). Choice of these variables is supported by general literature for persistence models at the postsecondary levels (Tinto, 1982; Bean, 1985; Caberra et al., 1992, 1993; Bank et al., 1990).

Data for the study will be collected via a pencil-and-paper survey from undergraduates in CRM at two universities in southwestern Virginia. Two or three majors will be represented at each university to allow for comparison across and between majors. Attempts will be made to over-sample women and minority students to allow for separate analysis for these populations; however, the percentage of these groups in the population is sufficiently small enough that this analysis may not be possible. The study in limited in that data will only be collected from two institutions.

3. Describe the purpose / objectives of this study and the anticipated findings/contributions: **The purpose of this quantitative study is develop and test a model of factors impacting the satisfaction and persistence of undergraduates in computer related majors at two universities in Virginia. Computer-related majors (CRM) at these schools include Computer Science (CS), Computer Science and Technology (CST), Computer Engineering (CE), Information Science and Systems (ISS), and Business Information Technology (BIT).**
Research Questions:
1) Do academic factors (courses, instruction, pedagogy, etc.) influence student commitment and satisfaction in CRMs?
2) Do social factors (peer support, faculty support, family support, etc.) influence student commitment and satisfaction in CRMs?
3) Do institutional factors (perception of the field, climate, program support, etc.) influence student commitment and satisfaction in CRMs?
4) Does the model for student commitment and satisfaction differ among computer related majors?
5) Does the model for general student commitment and satisfaction in CRMs differ from the model for women?
6) Does the model for general student commitment and satisfaction in CRMs differ from the model for minorities?

4. Explain what the research team plans to do with the study results (e.g., publish, use for dissertation, etc.): **The primary utilization of the study results will be for the Co-Investigator's dissertation. Results will also be incorporated into at least one article that will be submitted for publication.**

5. Briefly describe the study design: **The purpose of this quantitative study is to develop and test a model of factors influencing the satisfaction and persistence of undergraduates in computer related majors at two universities in Virginia. Computer-related majors (CRM) at these schools include Computer Science (CS), Computer Science and Technology (CST), Computer Engineering (CE), Information Science and Systems (ISS), and Business Information Technology (BIT).**

Outcome variables are satisfaction and persistence, which represent student commitment to their major and computing occupations. Satisfaction items focus on student satisfaction with their choice of major and occupational opportunities in the computing field (e.g, I am satisfied with my choice of major). Persistence items assess the student's intent to complete a degree in their current major and to seek employment in the computing field (e.g, After graduation, I will seek employment opportunities in my major).

Academic factors include two subscales: general academics and instruction. General academics includes items assessing the student's perceptions of the academic background, difficulty levels, and time demands of coursework (e.g., I had the background to be successful in classes early in my major). Instruction includes items focusing on student views of instruction, group work, and teaching (e.g., I feel comfortable asking questions in class).

Social factors include three subscales: faculty support, peer support, and family support. Faculty support includes items focusing on the student's relationship with faculty and instructors (e.g., Faculty in my major have given me an opportunity to apply classroom learning to "real-life" issues). Peer support includes items assessing the student's relationship with classmates and peers, both within and outside of their major (e.g, I frequently study and/or work with other students in my department). Family support includes student perceptions of the supportiveness and understanding of their family with regards to their choice of major (e.g., My family is supportive of my choice of major).

Institutional factors include three subscales: perceptions of the field, climate, and program support. Perceptions of the field includes items dealing with student views of computer majors and computing careers (e.g, Computer majors are nerdy). Climate includes items focusing on perceptions of how students are treated in the classroom and in the department (e.g, My department favors students with previous programming experience). Program support includes items that assess student views of support mechanisms within the department, such as tutoring and financial support (e.g, It is easy to switch between concentrations and/or special programs within my department).

The sample will be largely a convenience sample. With cooperation of each department, two or three classes at differing academic levels will be identified to complete the Computer Related Majors Survey (CRMS). Sample size will be a maximum of 150 students per major for each major at Virginia Tech and a maximum of 100 students per major at Radford (for a combined total of approximately 650 students). With the assistance of instructors, the CRMS will be administered during regularly-scheduled class sessions.

Data Analysis

Initial data analysis will be conducted using SPSS 12.0. Frequencies, descriptive statistics, and distributions will be examined for all variables, at both the aggregate level and by major, gender, and race/ethnicity.

Primary data analysis will be conducted using structural equation modeling (SEM) techniques via Lisrel 8.80. The goal of SEM analysis is to determine the extent to which a previously specified theoretical model is supported by sample data. This theoretical model is generally derived from the relevant literature (Schumacker & Lomax, 2004). In this study, the theoretical model was derived from the literature on women and minorities in CRM and from qualitative pilot interviews. Outcome variables are student persistence and satisfaction in CRM. There are three major independent constructs: academic, social, and institutional factors. In this case, the hypothesis is that academic, social, and institutional factors predict, to some extent, student satisfaction and persistence in CRM.

The model for student satisfaction and persistence in CRM will be evaluated in terms of model fit indices. Direct and indirect effects of each factor on persistence and satisfaction will be examined. A general model of student satisfaction will be tested. Minor model modifications may be made as indicated by fit indices. This general model will then be compared to models for individual majors to determine unique effects of each major. If sufficient numbers of women and minorities are included in the sample, the fit of the structural model will be compared on separate samples of men and women, as well as white and minority students.

Section 3: Recruitment

6. Describe the subject pool, including inclusion and exclusion criteria (e.g., sex, age, health status, ethnicity, etc.) and number of subjects: **Population and Sample**

Virginia Tech. Virginia Polytechnic Institute and State University (Virginia Tech), located in Blacksburg, Virginia, was founded in 1872 as a land-grant college. It offers sixty bachelor's degree programs and 140 master's and doctoral degree programs. Over 25,000 full-time students are enrolled in its eight colleges and graduate school (Virginia Tech, 2007). Virginia Tech offers three computer-related majors: computer science (CS), computer engineering (CE), and business information and technology (BIT).

The Department of Computer Science is located in the Department of Engineering. According to the departmental website, the major is software oriented, in contrast to the hardware-oriented computer engineering major. "Computer science majors design and develop software, from the software systems that control the functioning of the computer such as operating systems and compilers to applications software for areas such as numerical analysis, graphics, and data bases" (Computer Science @ VT, 2007). In fall 2007, 292 students were enrolled as undergraduates with declared CS majors, either full or part time. Of these, only 4.5% were female; 68.2% were White (VT Institutional Research, 2007).

The department of Electrical and Computer Engineering is also located in the Department of Engineering at Virginia Tech. According to the departmental website, "as one of the country's larger ECE departments, The Bradley Department offers strong education and research opportunities in diverse areas, including computers, control systems, communications, electronics, electromagnetics, and power" (The Bradley Department …, 2006). For fall 2007, 296 students were enrolled as undergraduates with declared CE majors, either full or part time. Of these, only 4.7% were women; 59.1% were White (VT Institutional Research, 2007).

The Department of Business Information Technology is located in the Pamplin College of Business at Virginia Tech. According to the departmental website, the BIT major is "designed to provide our students with expertise in the development and use of computer systems and quantitative modeling techniques for solving business problems and making managerial decisions. […] The degree program especially focuses on the practical application of computing to business problem-solving" (Pamplin College of Business, 2007). In fall 2007, 287 students were enrolled as undergraduates with declared BIT majors. Of these, only 16.7% were female; 66.9% were White (VT Institutional Research, 2007).

Radford University. Radford University (Radford), located in Radford, Virginia, was founded in 1910 as a women's university. Now coeducational with over 9,000 students, Radford offers 153 graduate and undergraduate degree options in seven colleges. (Radford University, 2007). Radford offers two computer-related majors: Computer Science and Technology (CST) and Information Science and Systems (ISS).

Both CST and ISS majors are located in the Department of Information Technology in the College of Science and Technology. Within the CST program, students choose from four concentrations: Computer

Science, Database, Software Engineering, or Networks. Within the ISS program, students choose from three concentrations which include additional courses in business: Information Systems, Enterprise Systems Development, or Web Development. (College of Science and Technology, 2007). For fall 2007, 121 students were enrolled as undergraduates with declared ISS majors. Of these, only 14.0% were female; 80.1% were White. In fall 2007, 196 students were enrolled as undergraduates with declared CST majors. Of these, only 7.1% were female; 87.2% were White. (RU Institutional Reseach, 2007).

Sample and Data Collection.

The sample will be largely a convenience sample. With cooperation of each department, two or three classes at differing academic levels will be identified to complete the Computer Related Majors Survey (CRMS). All students attending class on the selected day will be asked to complete the survey, unless they self-identify as having taken the online pilot. (Participation is voluntary.) Sample size will be a maximum of 150 students per major for each major at Virginia Tech and a maximum of 100 students per major at Radford (for a combined total of approximately 650 students). Actual sample size may be smaller, depending on the degree of cooperation provided by each department. With the assistance of instructors, the CRMS will be administered during regularly-scheduled class sessions. Attempts will be made to over-sample women and minorities through campus clubs, such as the Association of Women in Computing at Virginia Tech and the Women in Computing Club at Radford.

7. How will subjects be identified to participate in this research study (If searching existing records to identify subjects, indicate whether the records are public or private. If private, describe the researcher's privileges to the data)? **Each department will be asked to identify two or three classes at differing academic levles to complete the survey. The only identifying information known the researcher will be demographic information self-reported on the survey.**

8. The IRB must ensure that the risks and benefits of participating in a study are distributed equitably among the general population and that a specific population is not targeted because of ease of recruitment. Provide an explanation for choosing this population: **The population of undergraduates in computer related majors was chosen because it is the target population. Both Virginia Tech and Radford were included to ensure a large enough sample population to ensure statistical significance within and across major.**

9. Describe recruitment methods, including how the study will be advertised or introduced to subjects [submit all advertising / recruitment forms (e.g., flyers/posters, invitation letter/e-mail, telephone recruitment script, etc.) with this IRB application]: **Participating classes will be identified by each department. Students attending class on the day the survey is administered will be asked to partcipate. A cover sheet for the survey will provide consent information (see attached).**

Section 4: Requesting a Waiver for the Requirement to Obtain Signed Consent Forms from Participants

This section (Section 4) <u>not</u> required for studies qualifying for exempt review

Many minimal risk socio-behavioral research studies qualify for a waiver of the requirement for the investigator(s) to obtain signed consent forms from subjects [i.e., researcher does obtain verbal or implied (i.e., consent implied from the return of completed questionnaire) consent from subjects; however, does not obtain written consent from subjects]. Examples of types of research that typically qualify for this type of waiver are as follows: internet based surveys, anonymous surveys, surveys not requesting sensitive information, and oral history projects. You may request a waiver of signed consent for either some or all of the study's procedures involving human subjects.

10. Are you requesting a waiver of the requirement to obtain signed consent forms from participants?
☐ No, consent forms will be signed by all research participants prior to participating in all research procedures [submit consent document template(s) with this IRB application]
☐ Yes

If yes,

A. Select **<u>one</u>** of the criteria listed below and describe how your research meets the selected criteria:

☐ **Criteria 1:** [Typically used for anonymous surveys] The only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject's wishes will govern:

Or

☐ **Criteria 2:** The research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context (e.g., sitting down and talking with someone, calling someone at home and asking everyday questions, mall survey, mail survey, internet survey, etc.):

Either selection of either Criteria 1 or Criteria 2 above, the IRB suggests and may require the investigator to provide subjects with a written or verbal (for telephone interviews) statement regarding the research, which should provide subjects with much of the same information that is required within a consent document. This is typically accomplished by providing subjects with an information sheet (i.e., a document similar to a consent form; however, does not request signatures), supplying the information within the invitation letter, or reading the information sheet to the subject over the phone.

B. Will you be providing subjects with a written or verbal statement regarding the research?
☐ Yes [submit supporting document(s) (e.g., information sheet, invitation letter) with this IRB application]
If yes, check all methods that will be utilized to provide subjects with a statement regarding the research:
☐ Information sheet physically provided to subjects
☐ Information sheet will be read to subject over the phone
☐ Information captured within the invitation document
☐ Other, describe:
☐ *No, provide justification for not supplying subjects with this information:*

C. Does this waiver of written consent cover all study procedures involving human subjects?
☐ Yes
☐ No, list the study procedures for which this waiver is being requested to cover (Note: a consent document may be required for the study procedures not included under this waiver):

Section 5: Consent Process

11. Check all of the following that apply to this study's consent process:
☐ Verbal consent will be obtained from participants
☐ Written consent will be obtained from participants
☒ Consent will be implied from the return of completed questionnaire (if the study only involves implied consent, skip to Section 6 below)
☐ Other, describe:

12. Provide a general description of the process the research team will use to obtain and maintain informed consent **and** respond specifically to A-D below:

. A. Who, from the research team, will be overseeing the process and obtaining consent from subjects?

B. Where will the consent process take place?

C. During what point in the study process will consenting occur (Note: unless waived, participants must be consented before completing any study procedure, including screening questionnaires)?

D. If applicable [e.g., for complex studies, studies involving more than one session, or studies involving more of a risk to subjects (e.g., surveys with sensitive questions)], describe how the researchers will give subjects ample time to review the consent document before signing:

☐ Not applicable to this study

Section 6: Procedures

13. ***Provide a step-by-step thorough explanation of all study procedures expected from study participants, including the length of sessions involved, and total time commitment:*** *Participants will be asked to complete the Computer Related Majors Survey. This will take place during a regular scheduled class session and will take approximately 20 minutes.*

14. ***Describe how data will be collected and recorded [submit all data documents (e.g., questionnaire, interview questions, etc.) with this IRB application]:*** *Responses will be recorded on scantron forms provided by Testing Services.*

15. ***Where will the study procedures take place?*** *Surveys will be complted in the classroom during regularly scheduled class sessions.*

Section 7: Risks and Benefits

16. What are the potential risks (e.g., emotional, physical, social, legal, economic, or dignity) to study participants? (do **not** state, "There are no risks involved." Acceptable language = "There are no more than minimal risks involved.") **Risks involved are minimal. Surveys are completely anonymous; the only identifying information is demographic information that is self-reported. Questions do not involve sensitive information.**

17. Does this study involve (check one box): ☒ minimal risk or ☐ more than minimal risk to study participants? *Minimal risk means that the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily activities or during the performance of routine physical or psychological examinations or tests.*

18. Explain the study's efforts to reduce the potential risks to subjects? **Surveys are completely anonymous.**

19. What are the direct or indirect anticipated benefits to study participants and/or society? **Pursuing these questions will lead to insights that can assist policy makers in determining potential changes to CRM that will encourage more students, especially women and minorities, to persist and enroll in these fields. Increased enrollment and persistence will lead to higher graduation rates and an increased workforce to meet the growing need for computer workers.**

Section 8: Confidentiality / Anonymity

20. Will the study release personally identifying study results to anyone outside of the research team (e.g., participants identified in publications with individual consent)?
☒ No
☐ Yes

If yes,

To whom will identifying data be released?

21. Will researchers be collecting and/or recording identifying information (e.g., name, contact information, etc.) of study participants?
☒ No (identifying information of participants will not be recorded in study files [including signature on consent form])
☐ Yes

If yes,

The IRB strongly suggests and may require that all data documents (e.g., questionnaire responses, interview responses, etc.) do not include or request identifying information (e.g., name, contact information, etc.) from participants. If you need to link subjects' identifying information to subjects' data documents, use a study ID/code on all data documents.

A. Describe if/how the study will utilize study codes:

B. If applicable, where will the linked code and identifying information document (i.e., John Doe = study ID 001) be stored and who will have access (Note: this document must be stored separately from subjects' completed data documents and the accessibility should be limited)?

22. Where will data documents (e.g., questionnaire, interview responses, etc.) be stored? **Anonymous survey results will be stored electronically.**

23. Who will have access to study data? **The PI, Co-PI, and members of the Co-PI's dissertation committee.**

24. Describe the study's plans for retaining or destroying the study data: **Upon completion of the dissertation and publication of results, study data will be deleted.**

25. Does this study request information from participants regarding illegal behavior?
☒ No
☐ Yes

If yes,

Does the study plan to obtain a Certificate of Confidentiality [visit our website at http://www.irb.vt.edu/pages/studyforms.htm#COC for information about these certificates]?
☐ No
☐ Yes (Note: participants must be fully informed of the conditions of the Certificate of Confidentiality within the consent process and form)

Section 9: Compensation

26. Will subjects be compensated for their participation?
☒ No
☐ Yes

If yes,

A. What is the amount of compensation?

Unless justified by researcher (in letter B below), compensation should be prorated based on duration of study participation. Payment must not be contingent upon completion of study procedures. In other words, even if the subject decides to withdraw from the study, he/she must be compensated, at least partially, based on what study procedures he/she has completed.

B. Will compensation be prorated?
☐ Yes, please describe:
☐ No, explain why and clarify whether subjects will receive full compensation if they withdraw from the study?

Section 10: Audio / Video Recording

27. Will your study involve video and/or audio recording?
☒ No
☐ Yes

If yes,

A. Select from the drop-down box → select one

B. Provide compelling justification for the use of audio/video recording:

C. How will data within the recordings be retrieved / transcribed?

D. Where will tapes be stored?

E. Who will have access to the recordings?

F. Who will transcribe the recordings?

G. When will the tapes be erased / destroyed?

Section 11: Research Involving Students

28. Does your study include students as participants?
☐ No (if no, skip to Section 12 below)
☒ Yes

If yes,

A. This study involves (select all that apply):
☐ Students in elementary, junior or high school (or equivalent)
☒ College students (select all that apply):
☒ College upperclassmen (Juniors, Seniors or Graduate Students)
☒ College freshmen – please note that some college freshmen may be minors (under the age of 18).
If the study meets the specified criteria, the IRB may grant a waiver of parental permission to include
these minors without individual guardian permission [see question 32B for further information].
Select one of the following:
☒ These minors will be included in this research
☐ Minors will be excluded from this study. Describe how the study will ensure that minors will not be included:

B. Does this study involve conducting research with students of the researcher? (Note: If it is feasible to use students from a class of students not under the instruction of the researcher, the IRB recommends and may require doing so):
☒ No
☐ Yes, describe safeguards the study will implement to protect against coercion or undue influence for participation:

C. Will the study need to access student records (e.g., SAT or GRE scores, or student GPA scores)?
☒ No
☐ Yes [if yes, a separate signed consent/assent form (for student's approval) and permission form (for parent's approval if subject is a minor) must be obtained and submitted to the Registrar's office] [submit consent form template(s) with this IRB application]

Section 11A: Students in Elementary, Junior, or High School
[Answer questions 29 & 30 below if your study involves students in **elementary, junior or high school (or equivalent)]**

29. Will study procedures be completed during school hours?
☐ No
☐ Yes

If yes,

A. Students not included in the study may view other students' involvement with the research during school time as unfair. Address this issue and how the study will reduce this outcome:

B. Missing out on regular class time or seeing other students participate may influence a student's decision to participate. Address how the study will reduce this outcome:

30. You will need to obtain school approval. This is typically granted by the Principal or Assistant Superintendent and classroom teacher. Approval by an individual teacher is insufficient. School approval, in the form of a letter or a memorandum should accompany the approval request to the IRB. Is the approval letter(s) attached to this submission? ☐ Yes or ☐ No, if no, explain why:

Section 11B: College Students

[Answer question 31 below if your study involves **college students**]

31. Will extra credit be offered to subjects?
☒ No
☐ Yes

If yes,

A. Include a description of the extra credit to be provided in Section 9: Compensation above

B. What will be offered to subjects as an equal alternative to receiving extra credit without participating in this study?

Section 12: Research Involving Minors

For more information about involving minors in research, visit our website at http://www.irb.vt.edu/pages/newstudy.htm#Minors

32. Does your study involve minors (under the age of 18) (Note: age constituting a minor may differ in other States)?
☐ No
☒ Yes

If yes,

A. The procedure for obtaining assent from these minors and permission from the minor's guardian(s) should have been described in **Section 5** (Consent Process) in this form.

Researchers may request a waiver of parental permission if the study meets the criteria specified under letter B below. Requesting a waiver for the requirement to obtain informed permission from guardians may be helpful when recruiting college students for minimal risk socio/behavioral research. Most studies involving minors must obtain parental permission prior to the recruitment of minors.

B. Are you requesting a waiver of parental permission?
☐ No, parents/guardians will provide their permission
☒ Yes, describe below how your research meets **all** of the following criteria:
A) The research involves no more than minimal risk to the subjects: **Survey questions are not sensitive in nature, and responses are completely anonymous.**
B) The waiver will not adversely affect the rights and welfare of the subjects: **Survey questions are not sensitive in nature, and responses are completely anonymous. The only minors potentially involved will be college freshmen.**
C) The research could not practicably be carried out without the waiver: **Surveys will be conducted during regular class sessions. Most of the sample will be over age 18; the only minors potentially involved will be college freshmen. It would be more complicated to single out freshmen under age 18 and ask them not to participate.**
D) (Optional) Subjects will be provided with additional pertinent information after participation:

C. Does your study reasonably pose a risk of reports of current threats of abuse and/or suicide?
☒ No
☐ Yes, thoroughly explain how the study will react to these reports (Note: subjects must be fully informed of the fact that researchers must report reasonable threats of abuse or suicide to the appropriate authorities/persons in the Confidentiality section of the Consent or Permission documents):

Section 13: Research Involving Deception

For more information about involving deception in research and for assistance with developing your debriefing form, visit our website at http://www.irb.vt.edu/pages/newstudy.htm#Deception

33. Does your study involve deception?
☒ No
☐ Yes

If yes,

A. Describe the deception:

B. Why is the use of deception necessary for this project?

C. Describe the process of debriefing [submit your debriefing form with this IRB application]:

D. By nature, studies involving deception cannot provide subjects with a complete description of the study during the consent process; therefore, the IRB must waive a consent process which does not include, or which alters, some or all of the elements of informed consent. Provide an explanation of how the study meets **all** the following criteria for an alteration of consent:
   A) The research involves no more than minimal risk to the subjects:
   B) The alteration will not adversely affect the rights and welfare of the subjects:
   C) The research could not practicably be carried out without the alteration:
   D) (Optional) Subjects will be provided with additional pertinent information after participation (i.e., debriefing for studies involving deception):

The IRB requests that the researcher use the title "Information Sheet" instead of "Consent Form" on the document used to obtain subjects' signatures to participate in the research. This will adequately reflect the fact that the subject cannot fully consent to the research without the researcher fully disclosing the true intent of the research.

Section 14: Research Involving the Collection or Study of Existing Data Documents, Records, Pathological Specimens, or Diagnostic Specimens

34. Will your study involve the collection or study of existing data?
☒ No
☐ Yes

If yes,

A. From where does the existing data originate?

B. Provide a description of the existing data that will be collected:

Section 15: Additional Information

35. Provide additional information not captured within this worksheet here [response to this question **not** required]:

Request for Exempt Review

Directions

This form must be typed and submitted (as a Word document) to the IRB office electronically along with the other required documents (e.g., Initial Review Application, all study forms relating to human subjects, and bio-sketches of investigators) to irb@vt.edu. In addition to submitting electronically, this form, signed by all appropriate parties, must be received by the IRB office before the submission is processed. Mail or deliver the original signed copy of this form to: IRB, Virginia Tech, Office of Research Compliance, 2000 Kraft Drive, Suite 2000 (0497), Blacksburg, VA 24060. To speed up the approval process, signed Review Forms may be scanned or faxed [(540) 231-0959] to the IRB office; however, the original signatures must also be mailed or delivered to the IRB office for documentation.

Section 1: Contact Information

Principal Investigator [Faculty or Faculty Advisor] (all fields required) **HST = Human Subjects Training**

Name: **Kusum Singh**	PID: **ksingh**	HST completed through: VT blackboard course
Department: **EDRE**	Email: **ksingh@vt.edu**	Mail Code: **0302**
______ Signature of Principal Investigator		______ Date

Co-Investigator(s) [Faculty or Student] (all fields required for each Co-Investigator)

Co-Investigator #1		
Name: **Lisa Darlington**	PID: **ldarling**	HST completed through: VT blackboard course
Organization Name: **EDRE**	Email: **ldarling@vt.edu**	
______ Signature of Co-Investigator #1		______ Date

Co-Investigator #2		
Name:	PID:	HST completed through: select source
Organization Name:	Email:	
______ Signature of Co-Investigator #2		______ Date

Co-Investigator #3		
Name:	PID:	HST completed through: select source
Organization Name:	Email:	
______ Signature of Co-Investigator #3		______ Date

Co-Investigator #4		
Name:	PID:	HST completed through: select source
Organization Name:	Email:	

Signature of Co-Investigator #4	Date

Departmental Reviewer: (not required for all departments)
Name: PID:

Signature of Departmental Reviewer Date

Section 2: General Information

1. Project Title: **Factors That Influence The Satisfaction And Persistence Of Undergraduates In Computer Related Majors**

Enter title as you would like it to appear on the official IRB approval letter.

2. Number of Human Subjects: **approx. 650**

3. Do any of the investigators on this project have a reportable conflict of interest? No If yes, explain:

☒ All investigators of this project are qualified through completion of human subject protections education. Visit our website at http://www.irb.vt.edu/pages/training.html to view training opportunities accepted by the VT IRB. (Note: Do not submit your IRB application until all investigators are qualified)

☒ All investigators listed on this project, along with the departmental reviewer (if applicable), have reviewed this IRB application and all requested revisions from these parties have been implemented into this submission. (Note: Do not submit your application until all parties have reviewed and signed off on the final draft of the materials)

Section 3: Source of Funding

4. Source of Funding Support (check one box):
   ☐ Departmental Research [if Dept. Research, skip to Section 4]
   ☐ Sponsored Research, including VARIOUS funds & OSP/VT foundation funds [if Sponsored Research, respond to letters A-D below]
   A. Name of Sponsor [if NIH, specify department]**:**
   B. Title of study as listed on OSP application:
   C. OSP number: * Proposal # (enter 8 digit number, **no** dashes/spaces): , OR
      * Grant # (enter 6 digit number, **no** dashes/spaces): , OR
      * OSP # pending (check box if pending): ☐
   D. Is this project receiving federal funds (e.g., DHHS, DOD, etc.)? select one

Section 4: Exemption Criteria

***Note*:** To qualify for Exemption, the research must meet **all** of the following criteria (a – f):
(a) Be of minimal risk to the subjects; AND
(b) Must not involve pregnant women, prisoners or mentally impaired persons; AND
(c) Must not include survey research with minors unless involving standard educational activities (e.g., educational tests) within the particular education system; AND
(d) Must not include observation of a minor's public behavior unless there is no researcher interaction, AND
(e) Research must not involve video or audio recording of subjects; AND
(f) must be in one or more of the following categories:

5. Please mark/check the appropriate category or categories below which qualify the proposed project for exemption:

☐ 1. Research will be conducted in established or commonly accepted educational settings, involving normal educational practices, such as (a) research on regular and special education instructional strategies, or (b) research on the effectiveness or the comparison among instructional techniques, curricula, or classroom management methods.

☒ 2. Research will involve the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, **unless** the subjects can be identified directly or through identifiers linked to the subjects **and** disclosure of responses could reasonably place the subjects at risk or criminal or civil liability or be damaging to the subjects' financial standing, employability or reputation.

☐ 3. Research will involve the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under item (2) above, **if** (a) the subjects are elected or appointed public officials or candidates for public office; **or** (b) Federal statute(s) require(s) that the confidentiality or other personally identifiable information will be maintained throughout the research and thereafter.

☐ 4. Research will involve the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified directly or through identifiers linked to the subjects.

☐ 5. Research and demonstration projects which are conducted by or subject to the approval of federal agency sponsoring the research, and which are designed to study, evaluate or otherwise examine (a) public benefit or service programs, (b) procedures for obtaining benefits or services under those programs, (c) possible changes in or alternatives to those programs or procedures, or (d) possible changes in methods or levels of payment for benefits or services under those programs.

☐ 6. Taste and food quality evaluation and consumer acceptance studies, if (a) wholesome foods without additives are consumed, or if (b) a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

Approval Letter – Virginia Tech

VirginiaTech

Office of Research Compliance
Institutional Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24061
540/231-4991 Fax 540/231-0959
e-mail moored@vt.edu
www.irb.vt.edu

FWA00000572(expires 1/20/2010)
IRB # is IRB00000667

DATE: November 29, 2007

MEMORANDUM

TO: Kusum Singh
Lisa Darlington

Approval date: 11/28/2007
Continuing Review Due Date:11/13/2008
Expiration Date: 11/27/2008

FROM: David M. Moore

SUBJECT: **IRB Expedited Approval:** "Factors that Influence the Satisfaction and Persistence of Undergraduates in Computer Related Majors" , IRB # 07-586

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective November 28, 2007.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtained re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

Important:
If you are conducting **federally funded non-exempt research**, this approval letter must state that the IRB has compared the OSP grant application and IRB application and found the documents to be consistent. Otherwise, this approval letter is invalid for OSP to release funds. Visit our website at http://www.irb.vt.edu/pages/newstudy.htm#OSP for further information.

cc: File

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

An equal opportunity, affirmative action institution

Cover Letter for CRMS at Radford

Computer Related Majors Survey

You Students in your class have been selected to respond to computer the Computer Related Majors Survey. The purpose of this survey is to identify factors that influence the satisfaction and persistence of students in computer-related majors like yours. Your participation is strictly voluntary, but will be greatly appreciated. All responses are completely confidential; the only personal identifying information collected is basic deomographic information you will provide, like major, race/ethnicity, and gender. Risks involved in participation are minimal; questions are not sensitive, and all responses are voluntary. Your participation will help me identify what students like about their major, and what they would like to see changed. If you have any questions or concerns about this study, feel free to contact me or me or my advisor. Again, your participation in the survey will be greatly appreciated. Thank you.

Questions?

Lisa Darlington, doctoral student
ldarling@vt.edu
ldarling@vt.edu

Kusum Singh, faculty advisor
ksingh@vt.edu
Rebecca Scheckler, RU faculty adviser
rscheckler@radford.edu
(540) 831-7663

Complaints and concerns?

Dr. Rick Slavings
Vice-Provost for University Planning and Research
(540) 831-5844.

Request for Initial Review of Research Protocol

Radford University Institutional Review Board

Instructions

- **Provide a thorough TYPED response to each question in the space provided. Be as specific as possible, keeping in mind that you are introducing a new study to the IRB. Incomplete applications will cause delays in review and final approval.**
- **Use non-technical language throughout your application. <u>**Note: Do not use jargon or scientific terms in your explanations/ descriptions.</u>**
- **Submit this application, along with all required documents to the IRB Coordinator, 201 Walker Hall, Box 6926. Questions should be directed to the IRB Coordinator, at irb-iacuc@radford.edu or (540) 831-5290.**

☒ **Check here if you are submitting this application electronically. The last page must be printed, signed and mailed to the IRB office before final approval of the protocol will be granted.**

****Adjunct faculty must have the sponsorship of the appropriate department Chair before the protocol will be reviewed by the IRB****

Section 1: Background Information		
Project Title: Factors that Influence the Satisfaction and Commitment of Undergraduates in Computer Related Majors		
Principal Investigator: Rebecca Scheckler		RU ID#: 770484
Department: WALDRON COL HLTH & HUMAN SRVS		
Phone: 831-7663		Email: rscheckler@radford.edu
Address: BOX 6970		
Co-Investigator(s):	Lisa Darlington	Email: ldarling@vt.edu
	Kusum Singh	Email: ksingh@vt.edu
		Email:
Student Investigator(s):		Email:
		Email:
		Email:
☐ Check this box if additional investigators are involved with the project. Please attach names, email addresses and signatures to this form.		

Signature of Principal Investigator ____________________ **Date** __/__/__

Signature of Co-Principal Investigator/ Student Investigator ____________________ **Date** __/__/__

Signature of Co-Principal Investigator/ Student Investigator ____________________ **Date** __/__/__

Signature of Co-Principal Investigator/ Student Investigator ____________________ **Date** __/__/__

Section 2: Type of Research

1. This study is being conducted as part of (*Check all that apply*)**:**

☐ Tenure Track Faculty Research
☐ Non-Thesis Graduate Student Research
☐ Masters Thesis
☐ Honors Project
☐ Capstone Project
☐ Class Project
☐ Adjunct Faculty
☒ Other (specify):doctoral dissertation

Department:
Adjunct faculty must be sponsored by the department chair before any research will be reviewed by the IRB

2. Type of Study (*Check all that apply*):

☐ Course Activity
☐ Intervention/Clinical
☒ Survey
☐ Program Assessment
☐ Secondary Data Analysis
☐ Experimental/ Laboratory
☐ Record Review
☐ Other:

3. Does this research involve the use of: (*Check all that apply*):

☐ Existing data **not** available via public archives/sources?
If so, how does the researcher have access to this private data?
☐ Existing identifiable data, documents, records or biological specimens available via public archives/ sources?
☐ Pathological or diagnostic specimens?
☐ Observation of public behavior?
☐ Use and disclosure of identifiable health information?
☒ None of the above

4. Is the information recorded in such a manner that subjects can be identified from the information provided directly or through identifiers linked to the subjects? ☐ **YES** ☒ **NO**

5. Does the research deal with sensitive aspects of the subject's behavior; sexual behavior, alcohol use or illegal conduct such as drug abuse? ☐ **YES** ☒ **NO**

6. If the information about the individual became known outside the research, could it:

Place the subject at risk of criminal or civil liability? ☐ **YES** ☒ **NO**
Damage the subject's financial standing, reputation or employability? ☐ **YES** ☒ **NO**

Section 3: Funding

7. How is this research project funded?

☒ Research is **not funded** **(Go to 8)**
☐ Research is funded **(Go to 7a)**
☐ Funding decision has not been made **(Go to 7a)**

7a. What is the type of funding source? (*Check all that apply*)

- ☐ Federal Grant or Contract
  - Agency Proposal Number:
  - Grant Start Date (mm/dd/yy): / / Grant End Date (mm/dd/yy): / /
- ☐ State or Municipal Grant or Contract
- ☐ Radford University Foundation Grant
- ☐ Other Private Foundation Grant
- ☐ Corporate Contract
- ☐ Other (specify):

7b. Who is the contact person at the funding source?

Name:
Telephone:
Email:
Mailing Address:

Section 4: Research Dates

8a. Date you wish to start research (mm/dd/yy): 12/01/07

8b. Date you plan to end research (mm/dd/yy): 12/01/08

** Note: This is the end date for data collection and analysis

****Protocols are approved for a maximum of one (1) year. If the proposed project is intended to last beyond the approval period, continuing review and re-approval will be necessary.****

Section 5: Research Location

9. Where will the research be conducted? (*Check all that apply*)

- ☒ Radford University Campus
- ☐ Carilion Affiliated Medical Center
- ☐ VA Medical Center
- ☐ Elementary or Secondary School (School name):
- ☐ Off-campus site (Provide address):
- ☒ Other (specify): Virginia Tech Campus

Section 6: Human Subjects Review by Other Institutions

10. Will this project be in collaboration with another institution?

- ☒ YES
- ☐ NO **(If NO, go to SECTION 7)**

10a. If YES, is Radford University the primary IRB reviewing the research protocol?

- ☐ YES
- ☒ NO **(If NO, go to 10b)**

10b. Indicate the status of this research project with the other institution's IRB:

- ☒ Pending approval
- ☐ Approved (submit approval letter with this application)
- ☐ Other institution does not have human subjects protections review board
- ☐ Other, explain:

Section 7: Rationale

11. Briefly describe the background of this study, including supporting research:

Recent years have seen a rapid increase in the demand for workers with college level training in computer related fields. Careers requiring advanced computer skills are projected to be among both the fastest growing occupations through 2014, and the most economically advantageous (Bureau of Labor Statistics, 2007). Although the number of computer science jobs is increasing rapidly, the supply of graduates in computing fields is not keeping up with the demand. Universities with well-known computer science (CS) programs, such as Carnegie Mellon, Rutgers, Stanford, and the University of California at Berkley, have reported a significant decline in CS applicants and degrees awarded (Carter, 2006).

In the wake of decreasing enrollment increasing demand, programs in computing must assess their current state of affairs to determine where change may be beneficial in increasing the number of computing degrees awarded. One aspect of the problem is increasing enrollment, which can be addressed by evaluating the image of computer majors. Several studies indicate that students do not understand what is involved in computing majors (Berry et al., 2006; Lee & Lee, 2006). Some students associate CS with writing programs, while others believe that it involves finding information on the web or using computers for daily tasks (Courte and Bishop-Clark, 2007).

A second factor in increasing the number of graduates in computing fields is in retaining those students who originally choose computing majors. Student attrition in these majors is highest in the first two years (Howles, 2007). In fact, women who initially enroll in computer majors are more likely than men to drop out in the freshman or sophomore years (Cohoon, 2001). This early attrition rate is usually attributed to “weed out” courses and courses that focus entirely on programming. Recent research calls for computer educators to evaluate the pedagogy and environment of computing majors (Howles, 2007; Miliszewska, Barker, Henderson, & Sztendur (2006); Turner, Albert, Turner, & Latour, 2007; Varma & Lefever, 2007).

Before seeking ways to address the problem of decreasing enrollment and high attrition rates in computing majors, it is important for educators and researchers to understand the current state of affairs in computer related majors (CRM). This is being done in small steps, often by individual departments of computer science or information technology (Besana and Dettori, 2004; McDowell et al., 2006; Pioro, 2006; Turner, Albert, Turner, & Latour, 2007; Varma & Lefever, 2007).Many studies are based on small, non-random samples and single-site case studies, which do not permit in-depth analysis of the complexity of components that affect students’ decisions to persist or drop out of computer related majors.

In order to increase enrollment and decrease attrition in CRM, educators and policymakers need to examine factors that influence student persistence and commitment to CRM. The majority of the literature on student persistence focuses on two theories: Tinto’s Student Integration Theory (1975, 1982, 1993) and Bean’s Student Attrition Model (1985). They are often cited as competing theories, although Cabrera et al. (1992, 1993) have studied the convergence of the two models and proffered a model that integrates both theories. Both models have several commonalities: persistence is seen as a result of a complex set of interactions over time; precollege characteristics affect how well students later adjust to their institutions; and persistence is affected by a successful match between the student and the institution.

According to Bank, Slavings, and Biddle (1990), three types of people are commonly cited as influential in student’s decisions to stay or leave school: peers, faculty, and parents. Most studies that look at peer influence on retention focus on such measures as the number of friends a student has on campus, the time the studen

12. Describe the purpose/ objective of this study:

The purpose of this quantitative study is develop and test a model of factors impacting the satisfaction and persistence of undergraduates in computer related majors at two universities in Virginia. Computer-related majors (CRM) at these schools include Computer Science (CS), Computer Science and Technology (CST), Computer Engineering (CE), Information Science and Systems (ISS), and Business Information Technology (BIT).

Research Questions:

1) Do academic factors (courses, instruction, pedagogy, etc.) influence student commitment and satisfaction in CRMs?
2) Do social factors (peer support, faculty support, family support, etc.) influence student commitment and satisfaction in CRMs?
3) Do institutional factors (perception of the field, climate, program support, etc.) influence student commitment and satisfaction in CRMs?
4) Does the model for student commitment and satisfaction differ among computer related majors?
5) Does the model for general student commitment and satisfaction in CRMs differ from the model for women?
6) Does the model for general student commitment and satisfaction in CRMs differ from the model for minorities?

13. How do the principal investigator(s) plan to use the results of this study?

The primary utilization of the study results will be for the Co-Investigator's dissertation. Results will also be incorporated into at least one article that will be submitted for publication.

Section 8: Study Design

14. Briefly describe the study design (e.g., longitudinal, cross sectional, etc) and outline the rationale behind using this design. You are encouraged to include a discussion of statistical procedures used to determine the sample size:

The purpose of this quantitative study is to develop and test a model of factors influencing the satisfaction and persistence of undergraduates in computer related majors at two universities in Virginia. Computer-related majors (CRM) at these schools include Computer Science (CS), Computer Science and Technology (CST), Computer Engineering (CE), Information Science and Systems (ISS), and Business Information Technology (BIT).

Outcome variables are satisfaction and persistence, which represent student commitment to their major and computing occupations. Satisfaction items focus on student satisfaction with their choice of major and occupational opportunities in the computing field (e.g, I am satisfied with my choice of major). Persistence items assess the student's intent to complete a degree in their current major and to seek employment in the computing field (e.g, After graduation, I will seek employment opportunities in my major).

Academic factors include two subscales: general academics and instruction. General academics includes items assessing the student's perceptions of the academic background, difficulty levels, and time demands of coursework (e.g., I had the background to be successful in classes early in my major). Instruction includes items focusing on student views of instruction, group work, and teaching (e.g., I feel comfortable asking questions in class).

Social factors include three subscales: faculty support, peer support, and family support. Faculty support includes items focusing on the student's relationship with faculty and instructors (e.g., Faculty in my major have given me an opportunity to apply classroom learning to "real-life" issues). Peer support includes items assessing the student's relationship with classmates and peers, both within and outside of their major (e.g, I frequently study and/or work with other students in my department). Family support includes student perceptions of the supportiveness and understanding of their family with regards to their choice of major (e.g., My family is supportive of my choice of major).

Institutional factors include three subscales: perceptions of the field, climate, and program support. Perceptions of the field includes items dealing with student views of computer majors and computing careers (e.g, Computer majors are nerdy). Climate includes items focusing on perceptions of how students are treated in the classroom and in the department (e.g, My department favors students with previous programming experience). Program support includes items that assess student views of support mechanisms within the department, such as tutoring and financial support (e.g, It is easy to switch between concentrations and/or special programs within my department).

The sample will be largely a convenience sample. With cooperation of each department, two or three classes at differing academic levels will be identified to complete the Computer Related Majors Survey (CRMS). Sample size will be a maximum of 150 students per major for each major at Virginia Tech and a maximum of 100 students per major at Radford (for a combined total of approximately 650 students).

With the assistance of instructors, the CRMS will be administered during regularly-scheduled class sessions.

Data Analysis

Initial data analysis will be conducted using SPSS 12.0. Frequencies, descriptive statistics, and distributions will be examined for all variables, at both the aggregate level and by major, gender, and race/ethnicity.

Primary data analysis will be conducted using structural equation modeling (SEM) techniques via Lisrel 8.80. The goal of SEM analysis is to determine the extent to which a previously specified theoretical model is supported by sample data. This theoretical model is generally derived from the relevant literature (Schumacker & Lomax, 2004). In this study, the theoretical model was derived from the literature on women and minoritie

Section 9: Study Population

15. Proposed Sample Size: 650

16. Population: Proposed Inclusion Criteria (*Check all that apply*):

- ☒ Males
- ☒ Females
- ☐ Adolescents (12-17 years of age)
- ☐ Children (under 12 years of age)
- ☐ Pregnant Women/ Fetuses
- ☐ Elderly (over 65 years of age)
- ☐ Prisoners
- ☐ Cognitively Impaired
- ☒ Radford University Students
- ☐ Carilion Affiliated Medical Center Patients staff, or records (inpatient or outpatient)
- ☒ Other, specify: Virginia Tech Students

****If your study involves minors, additional assent and consent documents are required.**

17. The risks and benefits of participating in a study should be equitably distributed throughout the general population; therefore specific populations should not be targeted for ease of recruitment. Provide an explanation for choosing the target population of this study. Enumerate any defining characteristics, including age, of the subject population (e.g., socio-economic status, history, symptomatology):

The population of undergraduates in computer related majors was chosen because it is the target population. Both Virginia Tech and Radford were included to ensure a large enough sample population to ensure statistical significance within and across major.

The sample will be largely a convenience sample. With cooperation of each department, two or three classes at differing academic levels will be identified to complete the Computer Related Majors Survey (CRMS). All students attending class on the selected day will complete the survey, unless they self-identify as having taken the online pilot. Sample size will be a maximum of 150 students per major for each major at Virginia Tech and a maximum of 100 students per major at Radford (for a combined total of approximately 650 students). Actual sample size may be smaller, depending on the degree of cooperation provided by each department. With the assistance of instructors, the CRMS will be administered during regularly-scheduled class sessions. Attempts will be made to over-sample women and minorities through campus clubs, such as the Association of Women in Computing at Virginia Tech and the Women in Computing Club at Radford.

Section 10: Recruitment Process

18. Describe the recruitment process, including how the study will be advertised to subjects. Attach recruitment/ advertising forms to this application.

Participating classes will be identified by each department.

Section 11: Study Procedures

19. Briefly describe the study procedures in sequential order (i.e. from beginning to end). Outline intervention methods (if applicable).

Participants will be asked to complete the Computer Related Majors Survey. This will take place during a regular scheduled class session and will take approximately 20 minutes. Responses will be recorded on Scantron forms. Data will be analyzed by the Co-PI with the assistance of her dissertation committee.

20. Will any aversive or painful procedures be employed (e.g., experimentally induced stress, the threat of punishment, etc)?

☐ **YES (IF YES, specify and justify below)**
☒ **NO**

21. Will the deliberate deception of research participants be involved as part of the experimental procedure?

☐ **YES**
☒ **NO (IF NO, go to SECTION 12)**

21a. Explain the nature of the deception:

21b. Why is the use of deception necessary?

21c. What are the possible risks that may result from the use of deception in this study?

21d. Clearly describe the debriefing process associated with the use of deception in this study. Attach the debriefing document to this application.

Section 12: Risks and Benefits

Definition of minimal risk:

"Minimal risk means the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily activities or during the performance of routine physical or psychological examinations or tests." **45 CFR 46 §102(i)**

22. Does this study involve more than minimal risk? ☐ **YES** ☒ **NO**

23. What are the potential risks (i.e. emotional, physical, social, dignity, legal and/or economic) to the study participant?

Risks involved are minimal. Surveys are completely anonymous; the only identifying information is demographic information that is self-reported. Questions do not involve sensitive information.

24. Describe the measures employed to minimize risk to study participants:

Surveys are completely anonymous.

25. What are the direct and indirect benefits to the study participants and/or society?
Pursuing these questions will lead to insights that can assist policy makers in determining potential changes to CRM that will encourage more students, especially women and minorities, to persist and enroll in these fields. Increased enrollment and persistence will lead to higher graduation rates and an increased workforce to meet the growing need for computer workers.

Section 13: Compensation

26. How much time will be required of each subject? The survey will take approximately 20 minutes. Students will be asked to complete the survey during regularly scheduled class sessions.

27. Will subjects be compensated for their participation in this study?

☐ **YES**
☒ **NO (IF NO, go to 28)**

27a. What type of compensation will be used?

27b. What is the amount of compensation?

27c. What is the payment schedule for compensation (i.e., will participants be paid at the end, or will there be prorated compensation)?

If payment is not prorated, is there language present in the consent document that they will still receive full compensation if they withdraw?

☐ **YES**
☐ **NO (IF NO, go to 27d)**

27d. IF NO, explain why and outline how participants will be compensated.

28. Are there penalties for subjects who do not show up for a research session?

☐ **YES (IF YES, specify and justify below)**
☒ **NO**

Section 14: Informed Consent

29. Do you intend to obtain informed consent from subjects?

☐ **YES (IF YES, go to 30)**
☒ **NO (IF NO, Fill out Request for Waiver of Informed Consent form)**

30. Select the method of documentation that will be employed in this study's consent process (*Check all that apply*):

☐ Verbal Consent
☐ Written Consent
☒ Consent will be implied from return of questionnaire
☐ No documentation will be used **(Fill out Request for Waiver of Informed Consent Documentation Form)**

**** Attach the applicable consent form (verbal script or written form) to this application.****

31. Who (on the research team) will be obtaining informed consent from the participants?
Consent will be implied from return of the survey questionnaire.

32. Where will the consent process take place?
Consent will be implied from return of the survey questionnaire.

Section 15: Protection of Anonymity

33. Will researchers be collecting and/or recording identifying information (name, contact information, etc) of study participants?

☐ **YES**
☒ **NO (IF NO, go to SECTION 16)**

34. Describe in detail the procedures for protecting the anonymity of the research subjects. If anonymity is impossible, then describe in detail the procedures for safeguarding data and confidential records. These procedures relate to how well you reduce the risk that a subject may be exposed or associated with the data.
Surveys are completely anonymous. No identifying information will be collected, only self-reported demographics.

35. Does this study request information from participants regarding illegal behavior?

☐ **YES**
☒ **NO (IF NO, go to SECTION 16)**

35a. Does the study plan to obtain a Certificate of Confidentiality? (See the Radford University IRB website for more information on these certificates)

☐ **YES** (Participants must be informed of the conditions of the Certificate of Confidentiality within the consent process and form)
☒ **NO**

Section 16: Training

36. Briefly explain the nature of the training and supervision of anyone who is involved in the actual data collection, research design, or in conducting the research. This information should be sufficient for the IRB to determine that the PI and research assistants possess the necessary skills or qualifications to conduct the study.
The PI has a doctorate in Educational Technology and Social Foundations of Education. She is a faculty member at RU and has conducted resrearch at VT, Radford University, University of Cincinnati, and Indiana University.
The Co-PI is a doctoral candidate in Educational Research and Evaluation. She has completed her coursework in research methodology; this study is part of her dissertation.
The other co-PI, Dr. Singh, is a professor at VT in Educaional Research and Evalauation. She has conducted survey research for many years.

Section 17: Audio/Video Recording

37. Will your study involve video and/or audio recording?

☐ **YES**
☒ **NO**

38. Provide justification for the use of audio/ video recording.

39. How will data within the recordings be retrieved/ transcribed?

40. Where will the tapes be stored?

41. **Who will have access to the recordings?**

42. **Who will transcribe the recordings?**

43. **When will the tapes be erased/ destroyed?**

****Please make sure that you have answered all pertinent questions and that you have attached the required documents for submission to the IRB****

Approval Letter – Radford

College of Arts and Sciences
Department of Psychology

RU
RADFORD
UNIVERSITY

P.O. Box [illegible]
Radford, VA [illegible]

[illegible]

Appalachian Studies
Biology
Chemistry and Physics
Communication
Computer Science
Criminal Justice
English
Foreign Languages and Literatures
Geography
Geology
History
Mathematics and Statistics
Media Studies
Military Science
Philosophy and Religious Studies
Political Science
Sociology and Anthropology

December 11, 2007

TO: Rebecca Scheckler, Ph.D. (rscheckler@radford.edu)
Educational Technologist, Waldron College of Health and Human Services

FROM: Nora Reilly, Ph.D. (nreilly@radford.edu) Nora Reilly
Professor of Psychology
Chair, Institutional Review Board for the Review of Human Subjects Research

RE: FY08-119 Factors that influence the satisfaction and commitment of undergraduates in computer related majors

We have determined that the above-named project for which you have requested review meets the criteria for exemption as set out in the relevant Federal and State guidelines. Specifically, the activity is research involving the use of educational tests, survey procedures, interview procedures or observation of public behavior, covered under 45 CFR 46.101(b)(2). The information to be obtained must be recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects *and* disclosure of the subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

If your protocol should change, please submit a request for modification. If you wish to continue your research past 12/10/08, you must request a continuance.

Best of luck with your project!

Cc: REVIEWER – Thomas W. Pierce, Ph.D.