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Gender Differences in College Students' Perceptions of Technology-Related Jobs in Computer Science

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ABSTRACT
Demand for computer technology (CT) professionals continues to rise, yet the supply of related majors is insufficient to meet demand. As with science, engineering, and mathematics (technology's STEM field siblings), women's participation in CT fields is abysmally low. While there are many junctures in the "leaky pipeline" for women and STEM careers, college is one of the important pathways to recruit women into CT fields. Wigfield and Eccles' (2000) expectancy-value theory of achievement motivation provides a valuable framework for examining factors that impact women's decisions to pursue CT majors, but no validated survey instruments exist for doing so. A questionnaire (Value, Interests, and Expectations for Success, or VIES) was developed to measure college students' perceptions of CT fields. The VIES was administered to 184 college students at a large public research university in the Midwestern United States. The VIES was found to be valid and reliable, and statistically significant differences were found between males and females on all of the VIES subscales. Female students placed less value on and had lower expectations for success in CT fields. They also had lower personal interest in pursuing advanced studies in CT, and value was the most predictive factor in explaining interest in pursuing a CT degree.

KEYWORDS
Gender; technology; STEM; computer science; computer technology; ICT; IT

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INTRODUCTION

Science, technology, engineering, and mathematics (STEM) careers are expected to be an increasingly significant portion of the workforce of the future, yet research suggests that the number of students who graduate with STEM-related degrees is insufficient to meet this demand (DuBow, 2013; Langdon, McKittrick, Khan & Doms, 2011). Women are an important focus of recruiting efforts because they are highly underrepresented in STEM fields (Sainz, 2011); research shows that women currently hold only 25% of all STEM jobs; a percentage which has remained essentially unchanged over the last four years (Beede et al., 2009).

The problem may be particularly challenging for computer technology (CT) fields, also sometimes referred to as information technology (IT) or information and communications technology. The United States Department of Labor workforce projections indicate that CT jobs are among those occupations expected to grow faster by 2018 (Hill, Corbett, & Rose, 2010; Klawe, Whitney, & Simard, 2009). Yet, while the demand for qualified IT professionals continues to grow, the number of women working in the IT industry continues to decline (Major, Morganson, & Bolen, 2013; Papastergiou, 2008; Zarrett & Malanchuk, 2005; Zarrett, Malanchuk, Davis-Kean, & Eccles, 2006). While computer occupations make up half of all STEM occupations overall, only 26% of CT jobs were held by women (DuBow, 2013; Zarrett & Malanchuk, 2005; Zarrett et al., 2006). Representation of women in computer science occupations has actually declined in the last decade, as has the number of bachelor degrees awarded to women in the last 30 years (Landivar, 2013). The number of women in CT careers is often much lower, even in high-profile companies; only 17% of Google's engineering workforce, 21% of Pinterest's technical team, 15% of Facebook's workforce, and 20% of Apple's global engineering workforce are women (Lien, 2015). Higher education, therefore, has a key role to play here, but institutions awarding computer technology-related degrees in the United States can produce only enough graduates to fill 39% of the expected jobs openings (DuBow, 2013).

A significant body of research indicates that underrepresentation of women in STEM fields, including computer science, is attributable to attitude rather than aptitude (Else-Quest, Mineo & Higgins, 2013). It has long been established that women perceive CT careers as boring, male dominated, geeky, and nerdy (Harris, Cushman, Kruck & Anderson, 2009; Laosethakul & Leingpibul, 2010; Thomas & Allen, 2006). The reasons for the disparities in attitudes of women and men toward STEM areas are varied, but self-efficacy theories are consistently found to be among the most valuable in accounting for differences (Else-Quest et al., 2013). Theories such as social cognitive career theory (SCCT) extend the explanatory power of self-efficacy by incorporating other variables thought to impact career choice (Else-Quest et al., 2013). Like SCCT, Wigfield and Eccles' (2000) expectancy–value theory of achievement motivation also purports that expectancies, values, and interests play a key role in influencing the choice to pursue (or not) a career in CT (Zarrett et al., 2006). This focus on expectancies, values, and interests, we believe, is critical to developing a more complete picture of the reasons that many women choose not to pursue careers in computer technology. The current study explored how interest, values, and expectations for success influence male and female college students' perceptions of CT fields.

LITERATURE REVIEW

What is CT?

According to Anderson, Lankshear, Timms, C., & Courtney (2008), CT jobs usually involve roles such as "designing and developing software and hardware systems; providing technical support for computer and peripheral systems; and creating and managing network systems and databases" (p. 1305). Zarrett and Malanchuk (2005), on the other hand, distinguish between "soft" and "hard" computer-related jobs. They indicate that soft computer jobs include occupations such as help desk, telecommunications, statistics, Internet journalism, research, resource guides and teaching, whereas hard computer jobs include programmer, computer engineer, database administrator, network administrator, systems administrator, and information systems/technology (see also the work of Burger, Creamer, & Meszaros, 2007). The current investigation focuses on "hard" computer jobs because research suggests that women are particularly underrepresented in these jobs (Kirkup, 2011; Valenduc, 2011; Zarrett & Malanchuk, 2005).

Women in CT Majors

Women's underrepresentation in post-secondary computing education, often referred to as computer science, is a major concern in the United States (Cohoon & Aspray, 2006). Between 2000 and 2012, there was a 64% decrease in the total number of first-year undergraduate women who were interested in choosing computer science as their major (DuBow, 2013). In 2012, women earned only 18% of the total number of computer science degrees awarded to undergraduate students nationally: less than half of the number of women who earned computer science degrees 27 years earlier in 1985 (DuBow, 2013).

Despite the decline in the overall enrollments of college women in computer-related courses, some schools in the United States are making progress in this area. Notable among them are Stanford University and the University of California. In 2012, Stanford University registered an equal number of men and women for its introduction to computer science class, as was also the case at the University of California in 2014 (Finley, 2014). According to Barasch (2014), Stanford University in recent years has witnessed a significant growth in the enrollment of women in its computer science programs from 12.5% in 2008 to 21% in 2013, while women's enrollments in computer science majors at the University of California almost doubled to 21% from 2009 to 2013. These trends, if sustained and disseminated to other institutions, could have a major impact in closing the gender gap in the CT workforce. It should be noted, however, that initial interest does not necessarily predict long-term perseverance and that there is little evidence that attrition rates of women in CT majors has or will decline.

Why Encourage Females in CT Majors/Careers, Specifically?

There are several reasons why it is important to increase the gender balance in CT education and workforces. First, the CT industry offers good career prospects with high pay (Zarrett & Malanchuk, 2005). According to Barker and Aspray, college graduates represent a major source of labor for the CT industry, and in the United States, more than half of the total number of students who graduate are women (Barker & Aspray, 2006; Jeffrey, 2012). However, the proportion of women working in the CT industry is low; as of 2013, for example, only 26% of the CT workforce was women (DuBow, 2013; Kim, 2014). Recruiting more women into the CT industry will thus create better financial opportunities for a large section of the United States populace (Barker & Aspray, 2006).

Second, the CT sector in the U.S. is expected to create as many as 1.2 million computing-related job openings by 2022 (DuBow, 2013; Kim, 2014). Making the IT industry more gender-inclusive would increase the number of qualified candidates who could be employed to fill future CT jobs (Barker & Aspray, 2006). Third, what is designed and built by industry must meet the needs of a diverse United States population. This is best done when the makeup of a given industry reflects the larger makeup of society. The gender gap in CT fields thus presents an economic and societal challenge that must be addressed.

One need look no further than the automotive industry for a powerful example. In the mid-1990s, Ford included more women engineers on the design team for the Windstar minivan (a vehicle mostly used by women). The Windstar had lost market share to minivans from Toyota and Dodge. While there were only 50 women out of 200 engineers on the project, the ratio was nonetheless significantly higher than other automakers. The women engineers added features previous (male) engineers had not considered, including a baby-mode dome light (low power mode designed not to wake sleeping babies when the door was opened), crevice protectors that caught wayward French fries, and a switch to prevent automatic door-locking when a key was in the ignition (for when parents have to jump out of the car to tend to children). Sales of the Windstar quickly rebounded in 1999 and the women engineers were featured prominently in the ad campaigns (Barker & Aspray, 2006).

The software industry has begun to follow suit in this regard, having been criticized for designing game software that appeals predominantly to males. Increasing the number of women in game software development may help to ensure that the design team will incorporate features that are more engaging to women (Barker and Aspray, 2006), but more women will need to pursue IT careers if this is to happen. These two examples provide further evidence for the Kellogg School of Management's study which showed that more diverse teams are able to make better decisions and have a better chance of finding solutions to problems (Phillips, Liljenquist, & Neale, 2010).

The "Leaky Pipeline" Metaphor

A number of studies have investigated why women are underrepresented in IT majors and in the industry (Barker & Aspray, 2006; Burger et al., 2007; Klawe et al., 2009; Singh, Allen, Scheckler, & Darlington, 2007; Thomas & Allen, 2006). The literature indicates that equally capable girls in the United States decide against technology and the other STEM fields before they leave high school (Klawe et al., 2009; Meszaros, Lee, & Laughlin, 2007; Singh et al., 2007). This scenario is not limited to the United States. In Australia, a majority of the female students reported that they dropped IT as a subject by junior high school (Thomas & Allen, 2006). Sáinz and López-Sáez (2010) report that even though girls in Spain tend to excel in technology-related studies when compared to boys, they tend to choose non-technical subjects "while planning their academic and professional future" (p. 578). Similar results have been found in other European countries (e.g., see Palmen, 2011; Sainz, 2011).

Previous studies indicate that the underrepresentation of women in the CT field is essentially a "leaky pipeline" issue. The leaky pipeline metaphor refers to the continued loss of women in CT from courses in elementary school through the tertiary level and from jobs in CT fields. It has been hypothesized that women "leak" from the pipeline either by considering other choices or failing to progress through to the different stages of the pipeline. Consequently, a leak at one stage of the pipeline logically accounts for the shortage in later stages (Soe & Yakura, 2008; Varma, 2010).

This shortage often shows up in student enrollment in advanced computer studies. For instance, in 2007, Harris et al. (2009) reviewed the total student enrollment at James Madison University in the state of Virginia during the fall semester and found that while 61% of the student population was female, the computer information systems department had an enrollment of only 18% female students, while the computer science department had merely 7% female students.

Causes of the Leaks in the Pipeline to Computer Technology
The underrepresentation of women in advanced studies and careers in CT has been attributed to both psychological and social factors. This section highlights some of the main factors related to this perception that have been identified as the causes of the leaks in the pipeline to the field of CT.

The stereotypical "nerd"
One factor that is often cited for the loss of women along the pipeline has to do with the perception that the computer technology profession is filled by stereotypical "nerds," leading some women to choose what they perceive to be more people-oriented majors or occupations (Anderson et al., 2008; Harris et al., 2009; Howe, Berenson, & Vouk, 2007; Papastergiou, 2008; Thomas & Allen, 2006). In a study of male and female first-year students at the University of Melbourne, Australia, for example, Thomas and Allen reported that 85.7% of the female participants said they stopped studying IT at the secondary school level because they "didn't want to be classified a nerd" (p. 170).

Lack of female role models/mentors
Another potential factor is the lack of role models/mentors both in the school environment and in CT fields (American Association of University Women, 2010; Dryburgh, 2000; Harris et al., 2009; Klawe et al., 2009). In the Thomas and Allen (2006) study of Australian students, participants were asked to "name any women

they know who work in the IT industry" (p. 173). The results of the study showed that 59.2% of the participants could not name any female professionals in the IT industry. When participants were also asked to name any IT role models portrayed in the media, more than half of the total number of participants said they did not know any, and 8.2% listed *cartoon characters* as role models! On the basis of this result, Thomas and Allen argued that female IT professionals are not normally reported on in the news, shown on television shows, or portrayed in movies.

The situation may be improving in recent times as there are several more strong female role models in the tech industry than there were a decade ago. American technology executives include Marissa Mayer (the current president and chief operating officer of Yahoo), Sheryl Sandberg (the chief operating officer of Facebook), and Danese Cooper, who was appointed in the spring of 2014 as the first ever head of open source software of PayPal (Barasch, 2014; Finley, 2014; Somerville, 2014). Yet, a recent study (Bell & White, 2013) showed that almost half (45.3%) of the 150 Silicon Valley companies did not have women as executive officers.

Male domain/culture

The literature indicates that girls, college students, and parents perceive that STEM-related fields are male domains (e.g., Archer, 2013; Papastergiou, 2008; Thomas & Allen, 2006). For example, Archer interviewed the parents of young UK students about their views on science-related careers; half of the parents considered science careers as male-dominated areas. Considering the influence that parents have on career aspirations and choices, these findings are troubling, and perhaps are what lead girls to describe STEM fields as "geeky" and "uncool" (Papastergiou, 2008; Thomas & Allen, 2006). The perceptions of parents' and students in this regard are supported by the reality that many women in CT fields experience. As many as 50% of women working in STEM will leave their field because of a hostile work environment (Hewlett, Buck Luce, & Servon, 2008).

Not all studies, however, show that women perceive IT as male domain. According to Black, Jameson, Komoss, Meehan, and Numerico (2005), while men in China dominate the IT field, Chinese women believe that IT is an occupation for both men and women. Surprisingly, graduate-level college women in China even prefer to pursue careers in IT rather than other professions (Black et al., 2005). Similar results can be seen in Malaysia as well, where women dominate computer science classes and IT-related jobs (Lagesen, 2008; Mellstrom, 2009). Culture may, therefore, play a role in these perceptions.

Computer self-efficacy and computer anxiety

The underrepresentation of women in computer technology majors and careers has also been attributed to computer self-efficacy (CSE) and computer anxiety (CA). CSE has to do with an individual's perceptions of his or her ability to accomplish a task using computers, whereas CA refers to the tendency of an individual to be uneasy, apprehensive, or fearful about the current or future use of computers. Previous studies have reported that female students tend to have higher CA than male students and are less positive about computer usage (Laosethakul &

Leingpibul, 2010). In recent times, male and female students have been increasingly exposed to technology both at home and in the school environment. It is possible that increased exposure to technology in formal and informal environments as a learning, social, and leisure toolset may change CSE and CA for women. A study of elementary school-aged girls and their attitudes toward technology, for example, found that girls and boys both feel that technology as a career is appropriate for boys and girls based, in part, on common experiences and exposure to technology (Van Eck & the AIM Lab, 2006). Given the magnitude of the gender disparity in technology majors and professions (DuBow, 2013), the number of computing jobs expected in the next five years (Hill et al., 2010), and the complexity of factors that contribute to CSE and CA as well as major and career selection, merely waiting for the next generation to develop higher CSE and assuming that this will automatically lead to CT career choices by women is unlikely to solve the problem.

Family influence

The influence of family plays a key role in girls' CT career choices. Parents and siblings' attitudes and beliefs about technology can influence a girl's perceptions about computers (Creamer, Lee, & Meszaros, 2007; Zarrett & Malanchuk, 2005). Studies that have explored the influence of parents on children's interest in and attitude toward computing conclude that fathers are more likely to buy computers and to provide support on how to use the machines for their sons; girls rarely receive such assets and support from either parent (Barker & Aspray, 2006). Girls who pursue education and careers in IT tend to be those who received support from their parents. In a study by Virginia Tech on high school and college women who were pursuing CT careers, the majority of the participants indicated that their parents, especially their mothers, played a key role in their CT career choice (The Office of the Vice President for Research, 2006).

Students' relationships with teachers

In the classroom, teachers communicate their attitudes and beliefs about computer technology and appropriate sex roles for males and females to their students through verbal and non-verbal interactions. For instance, boys are considered by their teachers to be more competent in regard to computing than are girls. Consequently, in mixed-gender classes such as computing, science, and mathematics, teachers subconsciously give more support and encouragement to boys than they do to girls. Such attitudes and perceptions of teachers can negatively influence girls' decisions to study computing (Barker & Aspray, 2006).

The impact of computing experience

The stage in life by which children are exposed to computers can influence their attitudes, confidence and interests toward CT fields. For instance, children who are provided with early access to computers are more likely to pursue computer-related courses (Zarrett et al., 2006). According to Cohoon and Aspray (2006), precollege experience with computing has to do with a student's experience with computing classes, computer games, and applications - areas we have already seen in which girls are at a disadvantage. Barker and Aspray (2006) also maintain that there is a positive correlation between a girl's experience with a computer and her attitude toward it: an assertion further confirmed by a team of researchers at Virginia Tech in a study on women in IT careers. They found that women who pursue careers in IT are mostly women who were exposed to computers at a very young age and learned to use computers for various communication purposes (The Office of the Vice President for Research, 2006). In another study of ninth-grade German students, the researchers noted that girls who were given laptops were inclined to learn more about computer software, hardware and the Internet and also used computers at home and school more than those who were not given laptops (Barker & Aspray, 2006). However, compared to males, females often lack the prerequisite computing experience relevant for college IT academic programs, and as a result of this, they often lack confidence and tend to give up on IT academic programs at higher rates than their male counterparts (Barker, Snow, Garvin-Doxas, & Weston, 2006; Cohoon & Aspray, 2006).

Of course, some of these factors may be different now with more prevalent use of Internet in the home. Average daily computer use by children between the ages of 8 and 18 has more than doubled from 1999 to 2009 from an average of 58 minutes to 2 hours and 17 minutes, and the percentage of those who used the computer went from just under half to almost two-thirds of children in that age range (Kaiser Family Foundation, 2010). As many as 93% of children in the United States now have a computer at home, and 84% have Internet access (Kaiser Family Foundation, 2010). This is true in other countries as well. In Spain for example, most young people own personal computers and start to use computers and the Internet more often at home from an early age than they do at school (Sainz, 2011). At the same time, recent research points out that parents still believe technology-related careers are more appropriate for boys than girls (Archer, 2013), which suggests that the exposure to technology in the home may still be likely to be different for girls than for boys. And there is further evidence of a gender gap in daily computer use as girls enter their teen years. Boys between the ages of 8 and 18 spend an average of 15 minutes more per day on computers than girls of the same age; by the time they are between 15 and 18 this gap has risen to 42 minutes per day (Kaiser Family Foundation, 2010). The disparity appears to be attributable primarily to a decrease in the time girls spend playing video games over this time (Kaiser Family Foundation, 2010), which is further evidence for why it is critical to get more women into the computer game industry.

PURPOSE OF THE STUDY

It is clear that there is a need to explore the causes of the leaks in the computer technology pipeline further. One gap in the literature appears to be a lack of research evidence on how college students, in particular, value computer technology fields, what their interest in pursuing a degree in computer technology is, and what their expectations for success are in the computer technology field. This study sought to develop a quantitative instrument based on Wigfield and Eccles' (2000) and Eccles' (2005) work to measure values, interest, and expectations and to test and compare whether male and female college students differ in terms of their perceptions of the computer technology field within these constructs.

THEORETICAL FRAMEWORK, RESEARCH QUESTIONS AND HYPOTHESES

The current study was influenced by Wigfield and Eccles' (2000) expectancy-value theory of achievement motivation, which has been used to successfully predict and explain gender differences in attitude toward and pursuit of IT fields and careers. According to the expectancy-value theory of achievement motivation, individuals' educational and vocational choices are significantly guided by their values, interests and expectations for success (Eccles, 2005; Wigfield & Eccles, 2000; Zarrett & Malanchuk, 2005). Zarrett and Malanchuk sampled almost 1500 adolescents (49% female) in a study of attitudes, beliefs, and expectations about IT fields using Wigfield and Eccles' theory and found significant empirical support for the theory. One of the challenges facing researchers in this field is that there is no practical, validated survey instrument based on expectancy-value theory that can be used to quickly survey large populations such as those in college. The current study sought to develop such an instrument in the process of answering our primary research question about women and CT majors or professions at the college level. Based on Eccles' theory and prior research on women and IT careers/education, the research questions and hypotheses for this study can be stated as follows:

1. Is there any difference between male and female college students in terms of how they value the computer technology field?

    H1: Men in non-CT majors will value computer degrees/fields more than will women in non-CT majors.

2. Is there any difference between male and female college students regarding their interest in pursuing a degree in CT?

    H2: Men in all non-CT majors will be more interested in pursuing a degree in computer technology than will women in non-CT majors.

3. Is there any difference between male and female college students in terms of their expectations for success in CT fields?

    H3: Men in non-CT majors will have higher expectations for success than will women in non-CT majors.

4. Does a student's academic major influence his/her perception of CT fields?

    H4: Computer science majors will have more positive perceptions of CT fields.

5. Does value of CT fields and expectations for success in CT fields predict male and female college students' interest in a degree in CT?

    H5: Those who value CT and have higher expectations for success will be more likely to be interested in a degree in CT.

METHOD

Participants

A purposeful sampling method was employed to recruit 200 students from a large Midwest university in the USA. Of these students, 184 completed the survey, yielding a response rate of 92%. The sample consisted of 42.9% male and 57.1% female. The majority of the participants were undergraduate students (72.1%), with the rest (27.9%) being graduate students. Approximately 86% of the participants identified themselves as United States nationals, with an average age of 23.58 years (*SD* = 7.31). Since the purpose of the study was to understand college students' perceptions toward CT fields, we targeted students from all major academic fields of study. Participants represented 39 different academic majors, including accountancy, aviation, biology, chemistry, communication, social work, psychology, electrical engineering, educational foundations and research (EFR), nursing, computer science, teacher education, etc. The full list of majors and number of students in each major can be seen in Table 1.

Aviation, EFR, nursing, psychology, social work, and teaching and learning were the most frequently reported majors (9, 12, 14, 29, 16, and 20, respectively). The frequency for the rest of the reported majors was between 1 and 7, with a mode of 1. Psychology students receive credit for participating in research studies, and EFR and Teaching and Learning are both departments in the College of Education and Human Development (the authors' home college), which may account for the higher number of responses in those majors.

Table 1 Frequency and Percentage of Respondent by Major

Major	Frequency	Percent
Other	5	2.7
Accounting	1	0.5
Anatomy and Cell Biology	2	1.1
Aviation	9	4.9
Biology	2	1.1
Business	4	2.2
Chemistry	2	1.1
Communication Sciences	5	2.7
Computer Science	3	1.6
Criminal Justice	2	1.1
Educational Leadership	1	0.5
EFR	12	6.5
Engineering	7	3.8
English	1	0.5
Entrepreneurship	2	1.1
Fisheries and Wildlife	1	0.5
Geology	1	0.5
Graphic Design	1	0.5

Major	Frequency	Percent
Health and Social Sciences	1	0.5
History	5	2.7
Kinesiology	5	2.7
Languages	1	0.5
Law	1	0.5
Management	1	0.5
Marketing	3	1.6
Mathematics	1	0.5
Medicine	2	1.1
Microbiology and Immunology	6	3.3
Nursing	14	7.6
Occupational Therapy	3	1.6
Physical Education	1	0.5
Political Science	2	1.1
Psychology	29	15.8
Public Administration	2	1.1
Science	6	3.3
Social Work	16	8.7
Sociology	1	0.5
Teacher Education	3	1.6
Teaching and Learning	20	10.9

However, the College of Education is the second largest college on campus in terms of enrolled students, so these numbers are proportional to the size of the college. In addition, psychology and aviation are two of the largest majors in the University by enrolled students, with 465 and 800 majors, respectively. Accordingly, the differences in number of response by major generally reflect the size of the majors sampled. Mean scores by major were also calculated and found to be consistent (within 20% of the overall mean) across majors, regardless of the number of responders. Kinesiology (n = 5), marketing (n = 3), and medicine (n = 2) were more than 20% below the overall mean on Value and Interest; public administration (n = 2) was more than 20% lower on Interest; and marketing and medicine were more than 20% lower on Success. As there is no evidence that these numbers are atypical of these majors, and given that they were not flagged as extreme values and had low *n*s, they were retained for all analyses.

Procedure

An e-mail was sent to instructors of both graduate and undergraduate courses to ask for permission to administer the paper and pencil survey during a class session. The survey was given to consenting students to complete at the beginning of the class period. Completion of the survey took approximately 5–10 minutes. Students were assured of their anonymity and were informed that participation was voluntary and that they would receive no compensation for participating in the study. A student's participation was thus taken as consent.

Instruments

In the absence of an existing instrument that measured perceptions related to the research questions, a questionnaire called VIES (Value, Interest, and Expectations for Success) was created by the researchers. After the initial construction of the VIES, which was based on Wigfield and Eccles' (2000) work, two experts (one in psychology and one in the field of technology education) examined the scale for face validity, and ten students were chosen to help test and clarify the wording of each statement as needed. The individual in psychology was chosen because of his experience in educational testing, quantitative research methods and statistics, while the other expert was selected because of his background in human performance and instructional design and technology. Overall, the VIES consisted of three subscales made up of twenty-two items assessed on a five-point Likert-type scale (1 = strongly disagree, 5 = strongly agree). See Table 2 for the VIES items.

For each scale, participants were asked to rate a series of statements that measured one of three constructs. The first construct was labeled value of computer technology field (VCF), and was made up of seven items (four positively worded and three negatively worded items) which assessed the importance students attach to the computer technology field. A sample item of this scale is "Working in a computer technology field would be a waste of my time". The second construct was labeled "interest in a computer technology degree" (ICD) and comprised seven items (four positively worded and three negatively worded items) which measured the extent to which students were desirous of pursuing a degree in computer technology. A sample item of this scale is "I am not interested in a degree in computer technology."

Table 2 Descriptive Statistics for the VIES Questionnaire

Subscale	Item	*M*	*SD*
"Value of computer technology field"			
val1_1	Working in a computer technology field would be a waste of my time (R)	3.78	0.94
val1_2	I would take a course in computer technology even if it were not required	3.23	1.09
val1_3	I find computer technology related jobs very interesting	3.21	0.95
val1_4	I don't think working as a computer technology person would help me achieve my professional aspirations (R)	3.11	1.01
val1_5	Computer technology is an important field to me	3.19	1.05
val1_6	I would enjoy working in a computer technology field	2.90	1.06
val1_7	I would rather do something else than take on a computer technology job (R)	2.46	1.10
Interest in a degree in computer technology:			
int1_1	I am not interested in a degree in computer technology (R)	2.60	1.13
int1_2	Computer technology would be a good college major for me	2.39	1.03
int1_3	Computer technology classes are boring (R)	3.21	0.95
int1_4	Being in a computer technology class would be fun for me	3.07	0.97
int1_5	The idea of being in a computer technology class excites me	2.63	0.92
int1_6	I would enjoy taking computer technology courses	3.05	1.00
int1_7	I dislike computer technology courses (R)	3.31	1.05
Expectations for success in computer technology field:			
succ1_1	I feel I have what it takes to succeed as a computer technology professional	2.93	1.16
succ1_2	I would certainly feel useless in a computer technology-related job (R)	3.28	1.07
succ1_3	I feel I have a number of good qualities to be successful in the field of computer technology	3.33	1.05
succ1_4	I don't think I can make an impact if I take on a computer job (R)	3.20	1.04
succ1_5	I feel I would have something to be proud of as a computer technology practitioner	3.18	0.94
succ1_6	I don't think I will succeed in the computer technology field (R)	3.15	1.09
succ1_7	I would be able to succeed in a computer technology field as well as most other people	3.33	1.07
succ1_8	I do not think I can achieve anything meaningful as a computer technology professional (R)	3.41	1.07

Note: Participants responded on a scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). "R" indicates that item was reverse-coded prior to analysis.

The last construct was labeled expectations for success in computer technology field (EFS) and was made up of eight items (four positively worded and four negatively worded items) which measured students' perceptions of their ability to accomplish career goals in the computer technology field". A sample item of this scale is "I would be able to succeed in a computer technology field as well as most other people." See Table 2 for the full scale and item descriptive statistics. All the negative items were reverse-coded prior to analysis. As Table 2 shows, means for responses to the questionnaire items tended to be at the middle (3) of the scale or lower. Students scored highest on the EFS subscale (an average of 3.21 per item), followed by the VCF subscale (3.11 per item) and ICD subscale (2.89 per item). These results seem to imply that the college students, on average, did not have a high perceived value, interest, or Expectations for success toward the computer field in general, and that all three factors were relatively equal in influencing attitudes toward computing and IT fields.

ANALYSIS

To test the quality of the newly constructed scales, all of the 22 items were included in an exploratory factor analysis. A varimax rotation in SPSS was used to determine if the scales measured different constructs. An item was retained if it loaded greater than .40 on the relevant scale, because we realized that the correlation between the variables was significant. The factor analysis indicated three distinct factors with strong item loadings (.61 to .86). Internal reliability was found to be sufficient for all the subscales and, therefore, no items were removed. The Cronbach's alpha for coefficients were .87 for the value of computer technology field scale, .90 for the interest in a degree in computer technology scale, and .89 for the expectations for success in computer technology field scale (see Table 3). To test for normality of the distribution of the data, descriptive statistics for individual items were calculated and examined, and all scale distributions were found to approach normality (that is, skewness and kurtosis were less than or equal to ±1.00). The scale items were then averaged into their respective scales.

Table 3 Rotated Factor Loads for the Three Subscales of the VIES Questionnaire

Item	VCF		ICD		EFS
val1_1_r	.67				
val1_2	.78				
val1_3	.84				
val1_4_r	.61	α =.87			
val1_5	.74				
val1_6	.81				
val1_7_r	.76				
int1_1_r			.63		
int1_2			.79		
int1_3_r			.82		
int1_4			.85	a = .90	

(table continues)

Table 3 (continued).
Rotated Factor Loads for the Three Subscales of the VIES Questionnaire

Item	VCF	ICD	EFS	
int1_5		.86		
int1_6		.86		
int1_7_r		.80		
succ1_1			.73	
succ1_2_r			.77	
succ1_3			.83	
succ1_4_r			.76	a = .89
succ1_5			.64	
succ1_6_r			.80	
succ1_7			.80	
succ1_8_r			.73	
Eigenvalue	10.59	1.86	1.17	
% of Variance	30.62	16.11	15.20	

Note: Total variance explained = 61.93%. "R" indicates that item was reverse-coded prior to analysis.

To examine differences in gender for value, interest, and expectations for success toward CT fields, independent samples *t*-tests were calculated. Gender was used as the independent variable, whereas value of computer technology field, interest in a degree in computer technology and expected success in computer technology field scale scores were used as the dependent variables for each test. Bivariate correlational analyses were also performed to determine the degree of relationships among the subscales. A standard convention level of $p < .05$ was used for evaluating statistical significance of all the quantitative analyses performed in this study.

RESULTS

Correlations of the Subscales of the VIES Questionnaire

It was envisaged that the subscales would be at least moderately related if they are influencing a common variable (e.g., perceptions of CT fields; Chang, 2008). As anticipated, the correlational analyses revealed positive correlations among the subscales. The strongest construct correlations were between value of CT and interest in a degree in CT: r (170) = .81, $p < .05$. The correlation between value of CT and expectations for success in CT fields was moderate: r (170) = .69, $p < .05$. Another moderate correlation also existed between expectations for success in CT fields and interest in a degree in CT: r (173) = .65, $p < .05$.

Correlations of the Subscales Among Male and Female Participants

We ran bivariate correlation analysis for males and females independently to look at gender differences or similarities in the pattern of correlations among the three factors. Correlations among the subscales for both male and female participants were nearly identical, indicating that both sexes saw the relationships among items and subscales in similar ways (see Table 4). As expected, the correlational analysis revealed significant positive relationships among the factors for both male and female groups of college students. In all cases, the correlation coefficients were above 0.50, which are considered large relationships (Cohen, 1988).

Table 4 Bivariate Correlations Among VCF, ICD, and EFS for Male and Female Groups

	Male		
Subscale	VCF	ICD	EFS
VCF	–		
ICD	.79*	–	
EFS	.65*	.55*	–
	Female		
	VCF	ICD	EFS
VCF	–		
ICD	.79*	–	
EFS	.67*	.66*	–

Note: The pattern of correlations for the male group among the three factors appears on top, whereas that for the female group appears at the bottom. Correlations marked with an asterisk (*) were significant at the p < .05 (2-tailed). n = 79 for males; n = 105 for females.

Gender Comparisons of Students' Perceptions of the Computer Technology Field

To examine gender differences in students' perceptions of CT fields, the study compared male and female students' scores on the three subscales of the VIES questionnaire. The results of the *t*-tests and their effect sizes are presented in Table 5.

Table 5 Gender Comparisons on the Subscales of the VIES

Subscale	Gender	*M*	*SD*	*t*	(*df*)	*p*	*d*
VCF	Male	23.68	5.60	4.28	139	0.000*	0.66
	Female	23.30	4.52				
ICD	Male	22.47	5.66	5.01	175	0.000*	0.75
	Female	18.51	4.84				
EFS	Male	28.10	6.06	4.60	177	0.000*	0.69
	Female	23.87	6.13				

*Note: n = 79 for males; n = 105 for females. *Statistical significance; p <.05 (2-tailed).*

The *t*-test results revealed statistically significant differences between the means of male and female students on the VCF subscale: t (139) = 4.28, p < .05; d =.66. The effect size for this analysis (d =.66) was found to exceed Cohen's (1988) convention for a medium effect (d = .50). The results indicate that male college students (M = 23.68, SD = 5.60) reported higher value of CT fields than their female counterparts (M = 20.30, SD = 4.52).

The *t*-test results also revealed statistically significant differences between the means of male and female students on the ICD subscale: t (175 = 5.01, $p < .05$); $d = .75$. The effect size for this analysis ($d = .75$) was found to be close to Cohen's (1988) convention for a large effect ($d = .80$). The results suggest that male students ($M = 22.47$, $SD = 5.66$) reported higher interest in pursuing a degree in CT than their female counterparts ($M = 18.51$, $SD = 4.84$).

The *t*-test analysis also revealed statistically significant differences between the means of male and female students on the EFS subscale: *t (177 = 4.60, p < .05);* $d = .69$. The effect size for this analysis ($d = .69$) was found to exceed Cohen's (1988) convention for a medium effect ($d = .50$). The results indicate that male college students ($M = 28.10$, $SD = 6.06$) reported higher expectations for success in CT fields than their female counterparts ($M = 23.87$, $SD = 6.13$).

Students' Perceptions of CT Fields by Academic Majors

We grouped the participants into various academic majors including business, humanities, languages, science, and social sciences and carried out ANOVA tests to look at whether differences or similarities in scale scores were due to academic majors. The results indicated no differences by major.

Multiple Regression Analyses

It may be presumed that one's value and expectations for success regarding computing technology-related jobs both precede and predict one's interest in pursuing a degree in computing. Therefore, to test the mediating roles of VCF and EFS in the prediction of interest in a degree in computer technology, a multiple regression was conducted. The resultant model $R = .82$ ($R^2 = .68$) was statistically significant, $F(2, 167) = 177.31$, $p < .05$, indicating that the two-predictor model was able to account for 68% of the variance in interest in a degree in computer technology. Value, not surprisingly, was the best predictor of interest in a degree in computer technology ($\beta = .68$; $t = 11.40$; $p < .05$); EFS also had some predictive value ($\beta = .19$; $t = 3.18$; $p < .05$).

A multiple regression was also conducted to test the mediating roles of ICD and EFS in predicting VCF. The resultant model $R = .84$ ($R^2= .70$) was statistically significant $F(2, 167) = 194.19$, $p < .05$. ICD was the best predictor of value in computer technology field ($\beta = .64$; $t = 11.40$; $p < .05$); EFS had the following results ($\beta = .26$; $t = 4.6$; $p < .05$). A multiple regression was also conducted to test the mediating roles of VCF and ICD in predicting expectations for EFS. The resultant model $R = .70$ ($R^2 = .50$) was statistically significant $F(2, 167) = 82.13$, $p < .05$. VCF was the best predictor of EFS ($\beta = .44$; $t = 4.65$; $p < .05$); and ICD had the following results ($\beta = .30$; $t = 3.18$; $p < .05$).

However, it is harder to explain why interest in a computing degree would predict either value or expectancy for success in computing; to do so presupposes the possibility that some may be interested in a degree irrespective of the value they perceive or their expectancy for success. These latter two multiple regression findings, therefore, should be interpreted with caution.

DISCUSSION

A new multi-item survey instrument was developed to test the perceptions of male and female college students toward the computer technology field within the constructs of value, interest, and expectations for success. These three constructs were positively correlated with each other, suggesting that the participants perceived value, interest, and expectations for success to be similar factors that each influenced their IT career decisions. This finding appears to lend support for the rationale of the study and also supports the expectancy-value theory, which holds that individuals' educational and career choices are influenced by their values, interests, and expectations for success (Eccles, 2005; Wigfield & Eccles, 2000; Zarrett & Malanchuk, 2005).

It is not surprising that the results of the study showed that female college students had less interest in CT fields than did their male counterparts. As the literature suggests, girls often give up on computing before they graduate from high school (Klawe et al., 2009; Meszaros et al., 2007; Singh et al., 2007; Thomas & Allen, 2006). Thus, it may be that most of the female college students in this study may have already dropped the idea of getting into the computer technology field before they entered college.

Given the general notion that the IT profession is a male domain, it is also no surprise that male college students showed higher interest in pursuing a degree in computer technology than did female students. This supports Barker and Aspray's (2006) assertion that female students are less likely to enrol in a class where the majority of the students are males. The result also supports Zarrett and Malanchuk's (2005) assertion that "computer programs favor male interests and male identification" (p. 79). Female college students' lack of interest in pursuing advanced degrees in CT is also consistent with the theories that females generally are not interested in computer-related programs and jobs because of social and psychological factors (e.g., the nerdy image of the IT profession; Anderson et al., 2008; Harris et al., 2009; Howe et al., 2007; Papastergiou, 2008; Thomas & Allen, 2006; Zarrett & Malanchuk, 2005).

Apart from the negative stereotypes associated with CT careers that make the field unattractive to women, Berenson, Williams, Michael, and Vouk (2007) also noted that females are attracted to and value future careers that are people-oriented and promise more flexibility in work schedules. With the general belief that IT professionals sit for long hours working alone with a computer (Howe et al., 2007), it is logical that female college students place less value on the computer technology field than do their male counterparts, as the study revealed. While we did not ask this question directly, our results are consistent with this prior finding.

Zarrett and Malanchuk (2005) also argued that individuals will choose careers they have the highest personal value for and for which they feel confident in their potential success. Wigfield and Eccles (2000) also maintain that "individuals' choice

…of an activity can be explained by their beliefs about how well they will do on the activity and the extent to which they value the activity" (p. 68). According to Howe et al. (2007), many women believe that computing classes are difficult. Since women do not see themselves as being as capable as their male counterparts in terms of acquiring advanced computing skills (Zarrett & Malanchuk, 2005), there may also be the tendency for women to think that they might not be able to do well in computer technology-related jobs. This may explain why the female college students in this study had less expectation for success in the computer technology field than the male students.

It is worth noting that the study found no differences in perception toward the computer technology field based on academic majors. This result is interesting because one would expect students in computer science and other scientific fields to show more interest in computing than those enrolled in humanities, for example. This suggests that some of the students may have the interest and ability to pursue computing but may have dropped the idea of going into computing at the precollege level probably because of the negative perception attached to the IT profession. This result thus suggests that through education and intervention programs aimed at disabusing the minds of the public about the negative perceptions associated with the IT profession, more women graduates could be attracted and encouraged to enter the IT industry through the "transitional" and "self-directed" career pathways. These concepts are discussed in detail later under "implications of the study."

The multiple regression analysis suggests that value and expectations for success are good predictors of interest in a degree in CT. What we can deduce from this result is that if we direct efforts at helping girls at the precollege level to develop high value and expectations for success for CT fields (Laosethakul & Leingpibul, 2010), we can get more girls to develop interest in computing classes at the precollege level, which in the long run will reflect in higher enrollment of women in computer programs at the college level. But how can we help girls to develop high value for the computer technology field?

The results of the multiple regression analyses further revealed that interest and expectations for success are good predictors of value. What this means is that once we succeed in attracting more women to computing classes at the precollege level, and with their CSE already high, they will be more likely to develop value for computer technology as a matter of natural sequence.

Finally, the multiple regression analysis also revealed that value and interest are good predictors of expectations for success. The implication of this result is that individuals who attach high value to and have interest in advanced studies in computer technology are more likely to feel confidence in themselves to succeed in CT fields.

Based on the above analyses, we recommend that all of these variables—value, interest, and expectations for success—be taken into account when designing intervention programs for encouraging and changing the perceptions of females toward the computer technology field. Each is related to the others and must therefore be attended to, albeit at different points in the educational path. The predictive relationships among the three variables suggest the potential to target interventions more effectively. Because interest is the most likely candidate for promoting the pursuit of CT courses, majors, and careers, we believe that early interventions should focus on promoting value and expectations for success (which our research suggests are good predictors of interest). One possible path to doing so might be to focus on self-efficacy; it is hard to imagine having a high expectation for success without also having high self-efficacy for the domain. Activities that build self-efficacy in CT areas, should therefore increase expectations for success which should then build value (we tend to value the things we are good at). With higher value and expectations for success, students may be more receptive to interventions that are designed to build interest. Of course, any interventions should address all three areas where and when possible, and future research will have to determine which factors (and activities) are most important to focus on for different students at different times. Knowing each student's values, expectations for success, and interest should at the very least provide a more nuanced picture of career interest in CT than interest alone. The results of this study provide further validation for Wigfield and Eccles' (2000) expectancy-value theory of achievement motivation, in this case at the college level.

Implications, Limitations, and Future Directions

While this study does not provide clear evidence for the *specific* reasons that women do not value or pursue careers in IT, it does lend support to theories that account for the gender disparity between men and women in IT careers. Further, it suggests that the scale developed for this study is valid and reliable, which will have future contributions for the many additional studies which must be done in this area. The results of the study also suggest that in order to increase participation of women in CT fields, we need to adopt two main strategies. First, there is the need to target female students at the precollege level who have yet to choose a career path. Second, we need to amend certain academic policies and/or plan intervention programs for female students at the college level.

Targeting female students at the precollege level

A study by Archer (2013) reveals that parents, teachers, schools, and the media are significant sources of influence on young students' aspirations. Archer explored the career aspirations of over 1400 young UK students between the ages of 10 and 13 and found that most of the participants aspired to careers in business, with STEM-related careers being the least popular aspirations. This suggests that in order to attract more girls into CT careers, we need to influence their career aspirations at an early age.

One way to do this is for non-profit computing organizations such as the American Association of University Women (AAUW), the National Center for Women and Information Technology (NCWIT), the Computer Clubs for Girls, (CC4G), and the European Centre for Women and Technology (ECWT) to increase their efforts to work with teachers, parents, school counselors, and the media. Such organizations have a major influence on young students (Harris et al., 2009; Thomas & Allen, 2006).

According to Weber (2011), girls' exposure to role models tends to influence their educational and career choices. Thus, IT female role models portrayed through the media and the schools can play a key role in enhancing female students' perceptions of the IT profession. This presents a kind of "chicken-or-the-egg" conundrum, however, as the only way to get more role models is to encourage more women to pursue, enter, and remain in CT fields. Girls should also be encouraged to use computers early in their formative years, which is one of the main objectives of CC4G (Palmen, 2011), as well as be exposed to different types of computer applications beyond blogs and social networks such as Facebook and Skype (Meszaros & Kahle, 2007; Sainz, 2011). Again, there is strong evidence that girls and boys do not differ in computer use until their later teenage years, that their differences appear to be attributable to a decrease in video game play by girls when compared to boys (thus suggesting the need for more women video game designers), and that many of the women who do enter the CT arena eventually leave it because they find it to be a hostile, male-dominated environment (Kaiser Family Foundation, 2010; Lien, 2015).

It is also important for school administrators, particularly those in the middle and high schools, and agencies interested in promoting females' interest in technology to consider after-school initiatives like the Build IT program. Build IT, which was launched in the United States in 2005, is an after-school program which, among other things, encourages middle school girls to develop IT skills and knowledge of the IT professions. Available data suggest that Build IT has been successful in increasing girls' perceptions of the value of the computer technology field, as well as helping them pursue IT careers (Koch & Gorges, 2012).

Academic policies and intervention programs at the college level
To encourage more female college students to select computing majors, college administrators may want to follow the example of Carnegie Mellon University (CMU). According to Burger et al. (2007), CMU was able to recruit more women into computing majors because they waived the admission requirement for prior experience with computer programming. As noted earlier in the literature review section, women often lack the computing experience required for college IT programs in comparison to men (Barker et al., 2006; Cohoon & Aspray, 2006). Thus, by waiving this computing requirement, more female applicants are given the opportunity to select computing majors.

Another way to increase women's participation in IT careers is to educate female college students and graduates, school administrators, counselors, and parents about the different pathways by which individuals can enter the IT industry. These pathways are labeled as "traditional", "transitional", and "self-directed" (Burger et al., 2007; Leventman, 2007; Soe & Yakura, 2008). According to Leventman, the traditional pathway has to do with individuals who obtain IT degrees in a formal school setting and go on to work in the IT industry or any technical field. The transitional pathway concerns individuals who initially obtain a degree in a non-IT field and go on to work in a nontechnical or non-IT-related field but then transition to work in an IT field after acquiring a graduate degree in IT or related area. The self-directed pathway is similar to the transitional pathway. The only difference between the two is that individuals who transition to work in IT-related jobs through the self-directed pathway do not have formal graduate IT (or related) degrees.

Alternatively, Valenduc (2011) distinguishes between three entry pathways of women into IT careers including direct paths, indirect paths, and postponed entry paths. Valenduc's idea of the direct and indirect paths is similar to Leventman's traditional and transitional paths, respectively. Postponed entry paths refer to individuals who enter IT-related jobs following "a period of unemployment, or a career break, or a voluntary occupational conversion" (p. 495). Thus, recruiting efforts and opportunities should also be made to women in non-CT majors throughout college as well as in the workforce: not just in formal, pre-college education environments. Organizations such as the AAUW and the NCWIT have a significant role to play in this regard; most parents, teachers and students remain unaware of these possibilities.

CT industry reform

The final piece in this puzzle is to address the number of women in CT professions overall. It is not possible to provide more role models for female college, high school, or middle school students with industry-wide gender gaps of between 15 and 25% (Lien, 2015) and when as many as 50% of women in CT careers will leave their professions (Hewlett et al., 2008).

It may not be possible to increase computer usage for girls between the ages of 15 and 18 when the gender gap in computer use per day is attributable to video game play (Kaiser Family Foundation, 2010) if we don't get more women involved with the design process as was done by Ford with the Windstar minivan. An important potential use of our scale would be to survey women in CT careers in a cross-sectional or longitudinal fashion to see what changes. We would expect that expectations for success would fall for those who choose to leave the profession.

Limitations

There are several aspects of this study that limit its generalizability. First, although the sample was representative in terms of various academic disciplines, the study was limited to a small sample taken from a single institution. Thus, the issues explored should be investigated further with a larger sample size and with students from different institutions. Women made up 57% of the sample, which is disproportionate when considering that 51% of the United States population is women (U.S. Census Bureau, 2013). However, given that the population of interest in this study was women, the findings about women's attitudes, expectancies, and values are not diminished. Thus, the primary limitation of this disparity lies in generalizing to the larger population as a whole, as is the case here.

Results should also be interpreted with caution because the sample comprises data from students who, in most cases, have already selected their majors. Results might reflect initial attitudes and expectations that determined their choice of major, of course, but results might just as well reflect the impact that choice of a major can have on attitudes, beliefs, and expectations. Choosing a perceived "low-technology" major, for example, may influence attitudes and expectations about technology as a career or its importance to future success. Majors were not all equally represented in this sample, with psychology, and teaching and learning making up one-quarter of the sample. While these percentages reflect the actual percentages of these majors at this institution, there is nonetheless the potential for them to have an undue influence on the results if these majors might either attract different students, or change the expectations or beliefs of majors regarding technology in that field. Future studies should pay particular attention to first-year students and attempt to balance the number of participants by major.

This study was also survey-based, which limits its explanatory power. According to Lund (2012), a mixed-method design tends to provide a better picture of the research problem, so future researchers are encouraged to include qualitative data. Such an approach could make valuable contributions to understanding the specific reasons that college women may not pursue careers in IT as well as highlighting promising interventions which could change this. Finally, future research should also focus on exploring whether female students' lack of interest in CT fields has something to do with the way CT is taught in schools, as noted by Tahmincioglu (2008). Again, it will be interesting for future research to find out if socioeconomic status and ethnicity have an influence on female college students' decision to pursue an IT education or career. These variables were not examined in this study.

Conclusion

Female students' low interest in pursuing advanced studies in CT as compared to their male counterparts is consistent with the data reported in the research literature, thus adding to the repertoire of knowledge in this area. The positive, and at least moderate, correlations between value, interest, and expectations for success support Wigfield and Eccles' (2000) expectancy-value theory of achievement motivation, which posits that the individuals' educational and career choices are greatly influenced by their values, interests, and expectations for success. As expected, female college students had low perceptions about value, interest, and expectations for success on all the subscales, and value was the most predictive factor in explaining interest in pursuing a computer-related degree. If our goal is to increase the number of people pursuing CT-related careers and to target women as a significantly underrepresented population in doing so, it seems clear that addressing the issue of value may be among the more productive strategies.

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