Motivating Women to Computer Science Education

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INTRODUCTION

The problem of disproportional representation of women in the computer science (CS) field in post-secondary education has become a major concern (AAUW, 2000; Camp, 2002; Carver, 2000; Varma, 2003). Currently, universities are increasing their focus on retaining women into CS programs. However, the number of women in that field remains low in proportion to males, and many women who are recruited often drop out or switch majors before completing their degree in CS (National Science Board, 2004, pp. 2-6, 3-17). In order to promote retention, it is important to compare possible differences in learning motivation between males and females in CS, examine changes in motivations across the span of CS study, and assess whether recruitment messages and program structures are matched (or mismatched) to the motivations of females. This article investigates the motivations for women to enter into, remain in, and continue the study of CS at the post-secondary level.

BACKGROUND

In recent years, a number of researchers (Chory-Assad, 2002; Kerssen-Griep, Hess, & Trees, 2003; Noels, Clement, & Pelletier, 1999; Postlewaite & Haggerty, 2002; Volet, 2001) have specifically concentrated on motivations for learning in the classroom and the factors that match teaching techniques with student success and satisfaction. Motivation, in the context of learning, refers to stimulation that drives students to derive academic benefits from classroom activities. In a learning setting, motivation can also be described as either trait motivation, a general level of desire to learn across all learning situations, or state motivation, a general level of desire to learn in a particular class, task, or content area (Anderson & Martin, 2002). The present study probes state motivations rather than trait motivations because of the focus on motivations that are particular to choosing and continuing study in the CS field.

Several scholars have posited a variety of theoretical constructs centred on state motivation. One such construct is the achievement goal theory (Dweck & Leggett, 1988), which reasons that goals are either ego oriented, wanting to gain favourable judgments of competence through social comparison, or task oriented, wanting to be competent and master a skill through effort based on internalized standards. In this construct, the general attitude towards reaching the goal is important. Another construct is self-determination theory (Deci & Ryan, 1985), which includes categories of intrinsic and extrinsic motivations. An educationally based construct is that of Pintrich, Smith, Garcia, and McKeachie (1991) who developed the Motivated Strategies for Learning Questionnaire. The bases for these scales are internal and external goal orientations. This instrument is currently the measurement standard for motivation in education.

Demonstrating how the interaction between internal and external attitude orientations and rewards might create a broader range of motivational categories requires a more complete explication. Vallerand and Bissonette (1992) posit a matrix which puts forward three types of extrinsic motivation: (1) external regulation (influences from means outside of the individual such as reward and punishment), (2) introjected regulation (results from outside pressure that the individual has internalized such as guilt or desire to impress others), and (3) identified regula-

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tion (whereby the individual feels that something is personally worthwhile and relates to their value system). This matrix has been related to second language learning, a learning situation similar to CS because it involves a very specific content area where motivational factors may be highly determinate in the success or failure of learning.

Volet (2001) modified Pintrichs et al.'s (1991) "Self-Efficacy and Expectancy of Success" as a measure of motivation. Self-efficacy describes a student making a judgment about his or her own ability to be successful in a learning task. Self-efficacy is posited to be an important motivation for both entering into and continuing in a particular learning context. The Williams and Ivey (2001) case study of motivations in math education also concentrated on an internal motivation orientation that includes self-efficacy as a factor. They highlighted an internal perception of usefulness as an essential part of the motivational matrix. A perception of usefulness is whether the student perceives that the particular skill to be learned will have a current or future utility for them. As with math, a perception of usefulness may also be an important motivational factor in continuing in the study of CS.

Margolis and Fisher (2002) posit that males and females have different motivations for entering the study of CS. They developed a set of seven motivational factors for the study of CS: enjoyment, versatility, math/science related, employment, encouragement by others, exciting field, and the quality of CS department. While both males and females list enjoyment as their top motivation, the most important difference is that females list the versatility (utility and purpose) of computing as their secondary reason, while male's rate this motivation as sixth. In programming, males and females named self-efficacy as a motivation, but males cited this to a lesser degree.

Yet scholars have not investigated the role of motivation in both the recruitment and retention of women in CS program. As a synthesis of the various literatures on motivation, and with the specific motivation for CS, this study offers a motivation matrix that can be utilized to measure motivations across time because it encompasses a broad range of state motivational behaviors within a restricted number of concepts. This matrix includes three intrinsic and three extrinsic motivations, listed as intrinsic-self**,** intrinsic-social**,** intrinsic-economic, extrinsic-self, extrinsic-social, and extrinsic-economic.

To analyze motivation in both the recruitment and retention of women in CS, it is essential to investigate possible changes in motivations over time, given the interaction of other factors such as success in the classroom or desires for challenge and fun. Time parameters in the present study are before enrolment and during CS coursework.

METHOD

The present study hypothesizes the following relationships:

- **H1:** Females and males will differ significantly on intrinsic-self motivation in CS study.
- **H2:** Females and males will differ significantly on intrinsic-social motivation in CS study.
- **H3:** Females and males will differ significantly on intrinsic-economic motivation in CS study.
- **H4:** Females and males will differ significantly on extrinsic-self motivation in CS study.
- **H5:** Females and males will differ significantly on extrinsic-social motivation in CS study.
- **H6:** Females and males will differ significantly on extrinsic-economic motivation in CS study.
- **H7:** Motivations to study CS will differ across time based on gender.

The participants in the present study were students in CS at four institutions of higher education designated as minority-serving institutions because existing studies have focused mostly on non-minority institutions. The total sample size was 66, which included 35 female and 31 male participants. The sample was ethnically diverse with 22 White (11 female, 11 male), 15 African American (seven female, eight male), 10 Hispanic (five female, five male), 10 Native American (eight female, two male), and nine Asian American (four female, five male) participants.

The data for this study was gathered in 2002-2003 through in-depth interviews, as part of a larger project on women in information technology. Each student was asked the same 61 questions and 15 of those questions provided the specific data about motivations to study CS. Each interview was audio

taped and transcribed verbatim. Random sampling was used to select subjects representing sufficient numbers of women and men. However, purposive sampling was used when the numbers of students majoring in CS was small (e.g., Native Americans).

A content analysis coding scheme was developed based on six motivation variables: (1) *Intrinsic-self*—"I love the challenge," "Computers are interesting;" (2) *Intrinsic-social*—"I want to be able to use it to help my community," "I'll do programming if it relates to human rights;" (3) *Intrinsic-economic*—"I've always been good at," "I made it work," "I played with it until I figured it out;" (4) *Extrinsic-self*—"I can use it no matter what work I do after this," "They teach you how to think so you can apply it to any situation," "Its something practical;" (5) *Extrinsic-social*""I want to show that I am just as good as the guys," "I do it because I have to," "My dad really encouraged me;" and (6) *Extrinsic-economic*—"I can make a lot of money," "It will be easy to get a job," "I need a good grade."

One category was designated for each type of motivation. This created six categories. Any statements that could be coded in any of the six categories were coded only once in a single category, creating an exclusive coding system. Each respondent was designated with a numeric label (1-66) and each interview question was given an alphabet designation. Therefore, each coded statement was given an alphanumeric label. Designation of the two phases of study was accomplished by separating the types of interview questions into two categories—motivations related to the pre-study stage and motivations during CS study. Two trained coders coded the interviews to ensure coded data are consistent with each other. Intercoder reliability (Lombard, Snyder-Duch, & Bracken, 2002) for each category was assessed using Scott's P, and reliability was established between coder one and coder two. Reliability for intrinsic-self was 0.94; for intrinsic-social was 0.87; for intrinsic-economic was 0.755; for extrinsic-self was 0.925; for extrinsic-social was 0.97; and for extrinsic-economic was 0.80. Overall, reliability was 0.88. All of these values are within the acceptable range for reliability. A total of 495 items were coded.

FINDINGS AND DISCUSSION

Demographic information was gathered in order to self-report socio-economic background of parents, age range for traditional or non-traditional student, prior exposure to computers, marital and family status, occupations of parents, year in school, educational major, student status (full or part time), and employment. A cross tab calculation was performed on all of the demographic variables in relation to gender to check for distribution across the sample. No significant relationships were found, eliminating these for consideration as intervening variables.

Hypotheses two, six, and seven were supported; hypothesis one was not supported but a near-significant difference was noted; hypotheses three, four, and five were not supported (Table 1). The second hypothesis predicted that females and males would differ significantly on the measure of intrinsic-social motivation. There was a significant difference between females and males in intrinsic-social motivation in the enrolment phase of CS (X^2=5.128, p<.05). Males were more likely to cite motivations for enrolment that indicated the importance of CS as personally worthwhile and relating to their own value system. There was no significant difference in this measurement during CS study

Table 1. Bivariate relationship for gender and motivation for pre-enrolment and during study in computer science

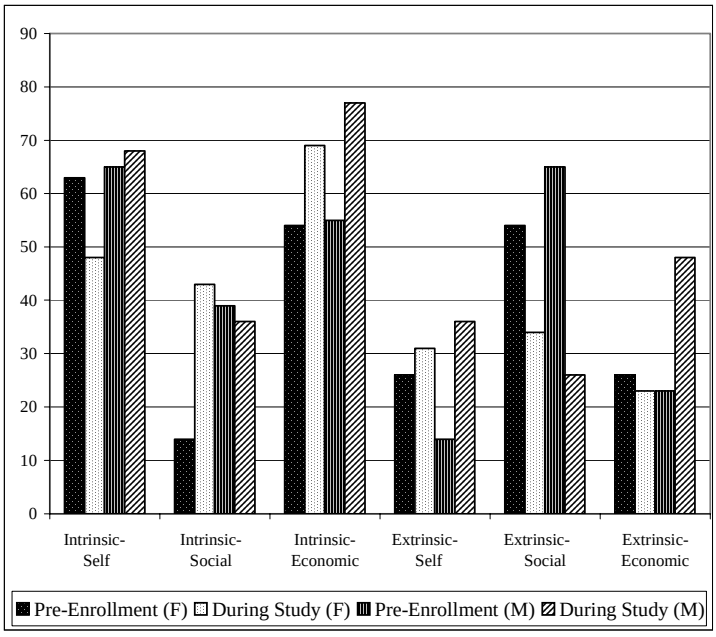
	Intrinsic-Self χ^2	Intrinsic-Social χ^2	Intrinsic-Economic χ^2	Extrinsic-Self χ^2	Extrinsic-Social χ^2	Extrinsic-Economic χ^2
Gender- Pre-Enrolment	0.020	5.128	0.002	0.004	0.712	0.088
Gender-During Study	3.41	0.374	0.649	0.122	0.560	4.71

Note: Significant relationships (p<.05) are shaded.

phase. Hypothesis six predicted that females and males would differ significantly on the measure of extrinsic-economic motivation. There was a significant difference between females and males in extrinsic-economic motivation during the CS study phase (X^2=4.71, p<.05). Males were more likely than females to cite the anticipation of a tangible positive result (a job) as a motivation for continuing the study of CS. The first hypothesis that predicted females and males would differ significantly on the measure of intrinsic-self was not supported, but showed a near-significant difference (X^2=3.411, p<.05).

Hypothesis seven posits that motivations differ depending on whether they are measured when contemplating enrolment in CS or during actual engagement in CS study and it was supported (Table 2). For females, there was a drop in their motivation based on intrinsic reward (In-Self) from 63% pre-enrolment to 48% during study. Statements regarding loving the challenge or thinking that computers were interesting dropped by 15%, while for males these statements increased by 3%. Motivation statements also decreased for females but went up for males judging tangible material rewards (extrinsic-economic). Females' statements dropped by 3%, while males' statements increased by 25%. This difference is consistent with the difference in the respondents reporting work in the field of computers during study. Only 57% of females had related jobs while 87% of males did. Motivation based on a match between personal values and the study of CS (Intrinsic-social) increased 29% for females, while there was a slight drop (3%) for males. Motivation based on females' perceived fit between their own values and what CS could do for them increased dramatically once they were in the field of study. There was an increase for both males and females from pre-enrolment to course study in their personal judgments of their own ability (intrinsic-economic) in CS. Although both females and males were at about the same level prior to enrolment, male judgments of success increased by 22% while female judgments of success increased by only 15%. The perceived utility of CS skills (extrinsic-self) also increased for both males and females, but less so for females (5%). Male motivation statements regarding perceived utility increased by 22%. Extrinsic social influences as a motivation (i.e., impressing friends and family), went down for both males and females once they started their studies. However, it fell more for males (39%) than for females (20%). Outside social influences remained a higher motivation for females than for males.

Table 2. Changes in motivation to study CS across time by gender



The purpose of the study was to investigate motivation factors among genders in the study of CS at two stages of post-secondary education and to investigate how motivations vary. First, this study proposed a new matrix of state motivations broad enough to measure consistently across time periods, yet confined to six categories of motivation. These six motivational constructs examined both intrinsic and extrinsic motivations and were measured across time. The results indicate that motivations change between contemplation of studying CS and the actual engagement in study. This suggests that varying strategies, aimed at different motivations, can be utilized to recruit and then to retain women in CS.

The findings in the current study correspond with the findings of Margolis and Fisher (2002) in which both males and females cited intrinsic-self (e.g., enjoyment) as their primary motive for enrolment. However, this did not hold true for motivation during study when ability (intrinsic-economic) became the top motivation for both. Additionally, Margolis and Fisher (2002) found that extrinsic-self (e.g., versatility) was the secondary motivation for females, but the sixth motivation for males. In contrast, the present study indicated no significant difference between males and females on this measure during enrolment or study. However, there was a significant difference between males and females in the enrolment motivation that Margolis and Fisher (2002) attribute to respondents wanting to enter a field that matches their values. Males were much higher on this measure in the enrolment phase and then levelled out with females during the study phase of CS. Females did not cite this as an initial motivation, yet this area had the highest increase for females once they began study in the field. Therefore, it may be that CS programs need to incorporate connections between CS skills and female social values, or demonstrate in practical terms how social values can be met through the field of CS.

Second, while there was no significant difference between males and females during enrolment based on judgments of intrinsic interest in computers and CS, there was near-significant difference once they began CS study. Female estimations of loving computers and finding the challenge rewarding dropped a great deal more than it did for males. To retain women in CS, this factor needs further assessment.

Finally, the appraisal of tangible material rewards during study showed a significant difference between males and females. Female judgments of tangible reward remained fairly stable while male estimations jumped upwards. As noted earlier, this coincides with information about males having more employment and internships in computer related fields than females while they are studying. There is some indication that work opportunities do not fit the lives and schedules of female students. Childcare and family responsibilities may be a factor in whether or not women get internships or available jobs. This could subsequently affect their motivation to remain in the CS field.

FUTURE TRENDS

In the past, efforts at recruiting and retaining women in CS have concentrated on providing early hands-on computer experiences and recruitment into programs. This approach supposes that a critical mass of women will provide a community of scholars that will support each other. Some of these efforts have been successful, but do not consider other possible factors, including the motivations that students have for studying CS and how these motivations are, or are not, matched to recruitment and retention strategies. Faculty, advisors, and administrators need to take a careful look at these factors when modifying programs that are not acting to retain women in CS field.

CONCLUSION

The study shows that it is not enough to look at a single time construct of motivation. As experiences and contexts change students modify their own estimations of the motivations that drive them. Recruitment techniques that concentrate on appealing to women's needs to enjoy and find a challenge in computers does not work to retain them once the reality of spending hours in front of a computer sets in. At that point, an increase in the activities that connect computing to both real world problems and real world employment need to be the focus of retention efforts.

ACKNOWLEDGMENT

This research was supported by a grant from the National Science Foundation (EIA-0120055).

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KEY TERMS

Extrinsic-Economic: Refers to motivation that is determined through means outside of the individual such as a tangible positive result.

Extrinsic Motivation: Refers to as motivation that is determined through means outside of the individual; behaviours that are performed in order to arrive at some instrumental end.

Extrinsic-Self: Refers to motivation that is a result of projecting into the future as to whether a skill will have an utilitarian purpose.

Extrinsic-Social: Refers to motivation that is a result of an outside force that the individual has internalized such as guilt or desire to impress others.

Intrinsic-Economic: Refers to personal judgment of ability to do and be successful at a particular activity.

Intrinsic Motivation: Refers to the performance of an activity for the pleasure and satisfaction that accompany that action; fulfilling innate needs for competence and self-determination.

Intrinsic-Self: Refers to the performance of an activity for the pleasure and satisfaction that accompany that action.

Intrinsic-Social: Refers to motivation whereby the individual feels that something is personally worthwhile and relates to their value system.