LEARNING FROM YOUNG WOMEN
A MULTI-YEAR NCWIT RESEARCH STUDY

RESEARCH TEAM

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OVERVIEW

The NCWIT “Learning from Young Women” study identified and explored the circumstances under which some women pursue, or persist in, computing fields and some do not. The study was a longitudinal, mixed methods research project that followed participants from high school to college and, for some, into the workforce. The extended nature of the project allowed NCWIT researchers to study a large, diverse sample of women from around the United States who spanned the computing ecosystem over a period of six years. The study, completed in 2019, was multi-faceted. Data collection consisted of:

**Surveys**

an online survey administered at three points in time (matched total across three points in time=531)

**Interviews and Focus Groups**

89 in-depth telephone, video conference, or in-person interviews

**Virtual Community**

more than 13,000 posts and reactions in an online social media group
BACKGROUND & RESEARCH QUESTIONS

SURVEYS

The survey segment of the study examined trends among matched respondents across three surveys (2013, 2016, 2018). For this portion of the study, we developed a survey instrument that was originally based on Social Cognitive Career Theory (SCCT) constructs: Computing Interest, Computing Self-efficacy/Confidence, Computing Outcome Expectations, Intent to Persist in Computing, and Perceived Social Supports in Computing (Lent et al, 2008, 2011). The data best fit a model that used regression analysis to predict persistence in computing based on the computing domains of Game Design, Programming, and Inventing New Applications. (See Appendix 1 for more information on methods.)

For our analyses, we defined Persistence in Computing as the pursuit of computing or engineering as a college major, a college minor, or a professional computing or engineering job. Our survey sample included two groups: [1] women involved with the NCWIT Aspirations in Computing program (58 percent) and [2] those who had no connection to NCWIT programs (42 percent). The NCWIT Aspirations in Computing program provides award recognition to women in high school and college for their computing aspirations and achievement. The women in our sample who had “no connection” to NCWIT had provided their contact information on the NCWIT website while in high school, but did not win an Aspirations in Computing award, and in many cases, did not apply at all. All survey responses were compared by Awardee/NonAwardee status, Persister/Nonpersister status, and disaggregated by Race/Ethnicity. The final matched dataset (n=531) was 7 percent African American/Black, 26 percent Asian/Pacific Islander, 9 percent Hispanic/Latina, 10 percent multiracial, and 48 percent White.
SURVEY RESEARCH QUESTION

1) Which variables related to high school experience with computing predict high school women’s persistence in computer science and technology-related college majors?
INTERVIEWS & FOCUS GROUPS

The qualitative data collection was nearly evenly split between interviews with women involved with the NCWIT Aspirations in Computing program (n=49) and those who had no connection to NCWIT programs (n=40). Of the 89 women interviewed, 26 percent were African American/Black, 12 percent were Asian American/Pacific Islander, 17 percent Hispanic/Latina, 1 percent Native American, 4 percent multiracial, and 36 percent White. The goal was to understand women’s educational and career trajectories, especially in regard to choices about computing.

INTERVIEW RESEARCH QUESTIONS

1) What factors influence women’s perceptions of computing?

2) What kinds of experiences did these women have in computing?

3) How, if at all, did their perceptions and experiences vary by background characteristics (e.g., race, geographic location, parental education, etc.)?
LEARNING FROM YOUNG WOMEN

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VIRTUAL COMMUNITY
Since 2008, NCWIT has hosted a private Facebook group for women of the Aspirations in Computing Community. Originally just for high school award winners, the Facebook group evolved along with the program. The posts we studied primarily included women who had received a high school Aspirations in Computing award of some sort (i.e., regional or national, winner or runner-up), the original target group for the NCWIT Aspirations in Computing program. In fall 2015, women in college who had a computing-related major and had never won an Aspirations in Computing award were also admitted to the group. During the time period we analyzed (2008-2015), the group consisted of more than 2,000 women and 13,000 posts with a variety of comment and like activity associated with each post. The aim of this portion of the study was to understand the ways in which this private, virtual group for women in computing influenced women’s participation in the field, if at all. While casual observation suggested the group encouraged women’s persistence, no systematic study had been undertaken.

VIRTUAL COMMUNITY RESEARCH QUESTIONS

1) In what ways can these online conversations help us understand the experiences of young women in computing in the U.S.?

2) What kinds of conversations do they engage in, and how do these interchanges support their persistence in the field of computing?

3) How does this virtual women-in-computing group function for its participants?
This study reinforced prior findings about what influences the pursuit of, or persistence in, computing and contributed new findings to the field’s knowledge base. Taken together, our different datasets confirmed prior research findings about: [1] the importance of access to computing classes and knowledge about computing careers while in middle or high school (e.g., Margolis et al, 2008) [2] the critical role adult influencers play in providing encouragement (e.g., Google, 2014, Robnett & Leaper, 2012), and [3] the many obstacles women face in their journey to be part of the computing world (e.g., Kanny et al, 2014, Ong et al, 2018).1 In addition, the study broke new ground, as described in the pages that follow. Refer to the articles published from this study for more detail on the findings outlined in Appendix 2.

1 Full literature reviews are contained in the articles listed in Appendix 2: Peer-Reviewed Articles Published from This Study.
RESULTS HIGHLIGHTS: SURVEY ANALYSIS

In our sample, an expressed intent while in high school to study computing predicts future pursuit of computing. This has implications for K-12 computing interventions aimed at girls, as they almost universally lack the ability to track their participants over time to see what field they end up pursuing. This study suggests these programs can have more confidence that high school girls’ reports of intent to persist in computing does often translate into a computing major in college.

Prior experience with computer programming (i.e., coding) is the most important predictor of later pursuit of computer science or computer engineering for women in our sample. In other words, experience with game design, web design, or hardware — while touted as a great introduction to computing — do not, on their own, seem to have the desired effect of directing women into the field.

High school Aspirations in Computing Awardees are significantly more likely than non-Awardees and non-applicants to end up working or majoring in computer science or computer engineering, despite both groups expressing some interest in

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computing during high school (expressed by investigating or applying for the high school Aspirations in Computing award. Being an Awardee is also highly correlated with the pursuit of other technology majors, such as information technology or other engineering fields.*

Independent of other factors, a sense of belonging in the field of computing was a significant predictor of working or majoring in computer science or computer engineering in our sample.

We also looked at outcomes in 2018 for women who were in college during 2016. In this analysis, women from races and ethnicities historically underrepresented in computing (e.g., Black, Hispanic, Native American) were less likely than White or Asian women to major or work in computer science or computer engineering, regardless of whether or not they had won an Aspirations in Computing award or had prior experience with computer programming. This suggests that these women may face greater environmental hurdles than White or Asian women in the field of computing during the transition from college to the workplace.*

* All findings marked with an asterisk have not been published elsewhere.
RESULTS HIGHLIGHTS: INTERVIEWS AND FOCUS GROUPS ANALYSIS

The interviews surfaced supports to computing, including having family members in computing, having access to computing opportunities, growing up in technology-saturated regions of the country, along with receiving encouragement from teachers.

The interviews also surfaced barriers to the pursuit of computing, which included overt and covert discouragement from adult influencers and peers, as well as hostile computing classroom climates or destructive instructional approaches. The data also revealed the pervasiveness of stereotypes about gender and/or about persons of certain races/ethnicities that women had to fight not to internalize.

We found that the women often subscribed to a belief in meritocracy in the computing field (i.e., work hard and you will succeed) and that this was interwoven through many of their narratives. This belief was observed regardless of the woman’s race/ethnicity. This is both notable and somewhat alarming in that the myth of meritocracy shifts the onus of social change onto the individual by focusing on individual strengths and shortcomings. This results in less attention to the structural and institutional factors of racism and sexism, and the potential for victim blaming, even toward themselves.*

* All findings marked with an asterisk have not been published elsewhere.
RESULTS HIGHLIGHTS: VIRTUAL COMMUNITY ANALYSIS

// Analysis of content codes showed the most frequent topics discussed were: Opportunities (technology-related and other), Psycho-social Support, followed by Gender-related, Education-related, and Work-related topics, and Technology Activities. We observed a pattern where content coded as Education-related and Opportunities was also coded as Psycho-social Support, suggesting that participants used the online group as support for moving forward on their educational and career trajectories (as opposed, e.g., to more personal or social forms of psycho-social support).*

// The online group provided an alternative community to that experienced by the women at their high schools and universities. While virtual, it still enabled them to provide intellectual and professional support to one another. Participants shared CS-related opportunities in explicit efforts to grow their professional networks. When they needed to crowd-source something, participants sought to leverage the built-in network of the group. Among the most commented on posts were those from high school juniors and seniors asking for guidance about college.

// In this alternative community, the participants provided reliable social-emotional support to one another. A top theme in their conversations was the sexism they encountered in the technology field, followed by discussions about whether or not to be in computing, given the many obstacles. This support took many forms, ranging from empathy to “cheerleading” to outrage and included problem-specific, tactical recommendations. The group actively created community and belonging for its members.

// While conversations contained a lot of personal encouragement, they also frequently urged individuals to recognize the systemic factors at play rather than interpret a situation as a one-off, person-centered problem. The ubiquity of negative experiences the women posted about, such as implicit and explicit sexism, further supported the recognition of the systemic nature of exclusion. Some participants highlighted these systemic inequities to counter the meritocracy narrative also prevalent in the group. Importantly, these conversations often succeeded in taking the onus off of the individual and instead put them where they belong: on systemic sexism or racism.

* All findings marked with an asterisk have not been published elsewhere.
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RESULTS HIGHLIGHTS: VIRTUAL COMMUNITY ANALYSIS cont.

// The content analysis of the online group conversations revealed the importance of women having a safe space within which to construct an oppositional discourse that could counter the narrative of exclusion many encountered in computing from high school through college. Interestingly, the virtual aspect of the group seemed to have a leveling effect, where women of different backgrounds could safely counter narratives (that occurred both within and outside the group) of socioeconomic privilege or whiteness, for example.

// Another component of this study was a social network analysis of big data (i.e., the online group’s posts and likes). This analysis revealed that while the NCWIT staff-generated content was critical to the group conversations in the first few years, participant-generated content soon took over. The group became self-sustaining with many support-seeking and opportunity-related themes repeating year to year, initiated by different members of the group.*

// Our analyses of the patterns of posting and commenting also revealed that what members discussed was different given how much they participated in the group. Those who did not participate much (1-50 posts, comments or likes) were more likely to join in gender-related and education threads and were less likely to join in tech-related and opportunity threads. The opposite was true for highly active members (500 or more posts, likes or comments); these women were more likely to discuss tech-related activities and opportunities, and less likely to join in threads about gender and psychosocial themes.*

* All findings marked with an asterisk have not been published elsewhere.
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CONCLUSIONS

Our findings underscore the importance of recognizing the institutional and cultural factors that reinforce and maintain exclusionary practices. While some individual women will always succeed in computing, our findings suggest that women will not succeed in computing en masse without having consistent opportunities to learn computer science (specifically programming) and without the field addressing its systemic biases.

Additionally, actively dismantling the notion of gender- and ethnicity-blind meritocracy would help place the agency of discrimination on the groups, structures, and policies that perpetuate systemic biases rather than on aspiring computer scientists. To ensure that the structures within which college students learn are welcoming and fair, classroom conduct expectations, structured group work that develops the abilities and skills of all students to work in diverse teams, and other inclusive pedagogical techniques are needed. Students will take their cues in large part from the department’s and faculty’s expectations and behaviors, and thus culture may change.

Another instructive aspect of our study was observing the explicit support many women needed to navigate the post-secondary world of computing. From asking about which computing departments were right for them, to how to deal with bias from fellow students, faculty, and administrators, many women in the online group learned through discussion in the group that the source of the issues did not lie with them as individuals, but rather with the larger societal biases surrounding them.

We arrive at these broader conclusions from our findings across the different data sources and methods we used in this study and the vantage point that its longitudinal examination offered. Taken together, findings from this multi-faceted study emphasize the systemic nature of exclusionary practices in the computing field at the secondary and post-secondary levels.
FUTURE RESEARCH

To better understand students’ educational and career trajectories in computing, more research is needed in the following areas:

- Longitudinal tracking of participants (of all genders) who have experienced different kinds of computer programming instruction at the secondary level (e.g., formal and informal education and via specific programs such as Girls Who Code, CS Principles, Code.org, NCWIT AspireIT, etc.) to better understand the factors that influence pursuit of computing and to answer questions about what types of exposure are the most influential.

- To understand the overlapping and different experiences of obstacles and encouragement experienced at the various decision junctures in a computing trajectory, we need more qualitative data from individuals in computing and engineering from both majority and underrepresented groups.

- Surveys of all high school and college students (i.e., all genders, race/ethnicities) regarding their experiences in college majors and new careers, including but not limited to STEM fields, in order to compare predictors of major/career field, and understand other environmental influences on educational and career trajectories.

- Additional mixed methods explorations of the transition from college to the computing/information technology workplace for students from historically underrepresented racial/ethnic groups.

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REFERENCES


APPENDIX 1. METHODOLOGY

SURVEYS

Sample
In March 2013, the researchers invited 9,886 women to participate in the first phase of the study, an online survey. Anyone who registered on the Aspirations in Computing website between 2009–2013, or who won the award in 2007 or 2008, was eligible to be included in the sample. The sample included women involved with the NCWIT Aspirations in Computing program and a comparison group of those who had no connection to the NCWIT programs. In the final sample matched across all three surveys (n=531), 37 percent reported having taken the CS Advanced Placement exam, while over half (58 percent) did not either because it wasn’t offered at their school or they chose not to do it. In the final sample, 42 percent of the respondents had not been Aspirations awardees.

Data Gathering
All participants were asked to complete a 38-item survey to examine five SCCT constructs: computing interest, self-efficacy, outcome expectations, perceived social supports and barriers, and intent to persist in computing. [The original and revised survey constructs can be sent upon request.] All items were measured on a four-point Likert scale. In our analyses, all survey responses were compared by Awardee/NonAwardee status, Persister/Nonpersister status, and disaggregated by Race/Ethnicity.

We defined the dependent variable, persistence in computing, several ways depending on the research question. For some analyses, persistence was defined as the pursuit of computing or engineering as a college major, a college minor, or a professional computing or engineering job. For other analyses, we looked at computer science persistence in comparison with a more general technology persistence. In all of our analyses, survey responses were compared by Awardee/NonAwardee status, Persister/Nonpersister status, and disaggregated by Race/Ethnicity. We also conducted analyses on three non-overlapping groups based on college major/minor and degree: (1) CS-Persister – those who were pursuing, or who had graduated, at the time of the second survey with a Computer Science or Computer
Engineering degree, (2)

Tech-Persister — anyone who was pursuing an information technology-related major (other than CS or Computer Engineering) in college, or who graduated with a degree in these fields or has minored in one of these fields, and (3) Non-Persisters — all remaining respondents.

Data Analysis

We used multinomial logistic regression (MLR) to predict persistence with independent variables derived from the survey and from the application data, as well as independent variables for URM Status, Awardee Status, Took CS AP exam, and Time in college (Early/Late).

This appendix describes a truncated version of the methodology for this multi-faceted study. For more detail, go to the Google Doc here: bit.ly/Appx1Methodology.
INTERVIEWS AND FOCUS GROUPS

Sample
The interview sample was initially constructed from a random sample of the 1,500 respondents from the first survey, but as non-Awardees proved more difficult to recruit, we expanded our invitations to all non-Awardees who had completed the surveys. In the end, the interview portion of the study included 20 non-Awardees and 44 Awardees.

Data Gathering
All interviews and focus groups followed a similar semi-structured protocol, using video-conferencing platforms or by phone, with seven in-person interviews. Both the focus groups and interviews explored the five SCCT constructs, experiences with and perceptions about computing, their sense of belonging or identity relative to computing or engineering, as well as the interaction of their Awardee/non-Awardee status with their attitudes and behaviors toward computing.

Data Analysis
All conversations were recorded and transcribed, with transcripts uploaded to Dedoose, a cloud-based qualitative analysis program.

The qualitative research team met regularly to develop codes, discuss their meanings, and work toward inter-rater agreement. Each transcript was coded by at least two researchers, and all new subcodes were reviewed by a second member of the team to ensure they were consistently applied to the data.
ONLINE COMMUNITY

Sample
This portion of the study analyzed conversations that took place between 2011–2015 in a closed Facebook group for Aspirations in Computing Awardees. For the social network analysis, we included all postings. For the content analysis, we focused on the “top 25” posts. Following the familiar format of Facebook postings, data for the content analysis consisted of an initial post and comments written in response to that post. All threads were exported into Excel through a custom written script.

Data Analysis
Data were analyzed using the software Access, Excel, SPSS and R, depending on the question we were asking of the data. Access was primarily used for descriptions of the overall dataset, while R and SPSS were used to conduct a social network analysis and other descriptive analyses of the Facebook group. The top 25 posts were exported from the Access dataset into a PDF.

We took a hybrid approach to analyzing the threaded conversations, including emergent coding and grounded theory approaches.

ONLINE COMMUNITY: SOCIAL NETWORK ANALYSIS

Sample
Data came from the Aspirations in Computing Facebook group for the years 2011 to 2015. The full dataset contained 227,083 records for 2,869 women who participated in the group. The dataset contained 16,436 threads; all textual posts and comments were also contained in the data.

Data Analysis
The Social Network Analysis (SNA) used the software R to examine the roles of NCWIT staffers and Aspirations in Computing Award Winners in the Facebook group. SNA diagrams describe the connections between people in terms of centrality to a network and the density of connections between each person.

Other descriptive analyses were used to examine how participation in the group grew over time, the frequency of thematic codes, and relative frequency of codes over time. Sample diagrams are available in the Methodology Appendix here: bit.ly/Appx1Methodology.
APPENDIX 2.
PEER-REVIEWED ARTICLES PUBLISHED FROM THIS STUDY


ARTICLE ABSTRACTS & KEY WORDS


A B S T R A C T

While demand for computer science and information technology skills grows, the proportion of women entering computer science (CS) fields has declined. One critical juncture is the transition from high school to college. In our study, we examined factors predicting college persistence in computer science and technology-related majors from data collected from female high school students. We fielded a survey that asked about students’ interest and confidence in computing as well as their intentions to learn programming, game design, or invent new technology. The survey also asked about perceived social support from friends and family for pursuing computing as well as experiences with computing, including the CS Advanced Placement (AP) exam, out-of-school time activities such as clubs, and internships. Multinomial regression was used to predict persistence in computing and tech majors in college. Programming during high school, taking the CS Advanced Placement exam and participation in the Aspirations awards program were the best predictors of persistence three years after the high school survey in both CS and other technology-related majors. Participation in tech-related work, internships or after school programs was negatively associated with persistence, and involvement with computing sub-domains of game design and inventing new applications were not associated with persistence. Our results suggest that efforts to broaden participation in computing should emphasize education in computer programming.

CCS Descriptors:
• Social and professional topics ~ Computing education

Additional Key Words and Phrases: survey research, diversity, broadening participation, women and computing


A B S T R A C T

This paper analyzes conversation threads from a closed Facebook group for women in computing. The dataset contains more than 13,000 posts and spans five years during which time the group greatly expanded in membership. Drawing on research about online forums as well as the research on obstacles and supports for women in computing, the authors use qualitative analysis and take a feminist perspective to show the various ways in which the group provides a locus of oppositional discourse. This discourse highlights the systemic nature of exclusionary practices in the computing field at the secondary and post-secondary levels, providing a way for group members to see past individual circumstances and, thereby, find ways to oppose the cultures in which they live, study and work. Understanding how this oppositional discourse serves women,
a group sorely underrepresented in the field of computing, can help identify promising levers for making the culture of computing more inclusive.

Keywords: Gender; Broadening participation in computing; Online communities; Qualitative analysis; Counterpublic; Counterspace


**ABSTRACT**

Purpose – This paper aims to investigate what factors influence women’s meaningful and equitable persistence in computing and technology fields. It draws on theories of learning and equity from the learning sciences to inform the understanding of women’s underrepresentation in computing as it investigates young women who showed an interest in computing in high school and followed-up with them in their college and careers.

Design/methodology/approach – The mixed-methods approach compares data from quantitative surveys and qualitative focus groups and interviews. The sample comes from database of 1,500 young women who expressed interest in computing by applying for an award for high schoolers. These women were surveyed in 2013 and then again in 2016, with 511 women identifying themselves as high schoolers in 2013 and then having graduated and pursued college or careers in the second survey. The authors also conducted qualitative interviews and focus groups with 90 women from the same sample.

Findings – The findings show that multiple factors influence women’s persistence in computing, but the best predictor of women’s persistence is access to early computing and programming opportunities. However, access and opportunities must be evaluated within broader social and contextual factors.

Research limitations/implications – The main limitation is that the authors measure women’s persistence in computing according to their chosen major or profession. This study does not measure the impact of computational thinking in women’s everyday lives.

Practical implications – Educators and policymakers should consider efforts to make Computer Science for All a reality.

Originality/value – Few longitudinal studies of a large sample of women exist that follow women interested in computing from high school into college and careers particularly from a critical educational equity perspective.

Keywords: Equity, STEM, Computing, Mixed-methods, Women, CS-for-All
ARTICLE ABSTRACTS & KEY WORDS


**Abstract**

A recent study explores what helps young women persist in computing despite the obstacles they encounter. Many individuals and organizations have worked tirelessly for years on the issues of how to recruit and retain more women and other historically underrepresented individuals in the field of computer science. Much has been learned in recent years about practices that could work to interest and retain these individuals. We know now, for example, that early exposure, access to rigorous computing classes, and having friends who also do computing are important for stimulating students’ interest in the field. What we know less about is what makes some women persist and others not in the face of field-wide obstacles, such as computer science not being a graduation requirement in high school, male-dominated classes at most high schools and colleges, unhelpful stereotypes and media images, and subtle and outright biases from teachers, counselors, and even fellow students. In the face of all of this, how do some women persist? It’s this question that we set out to answer in our study comparing National Center for Women and Information Technology (NCWIT) Aspirations in Computing (AiC) Award Awardees and women who had expressed interest in computing during high school, but then didn’t win the award or didn’t even apply.


**Abstract**

This paper reports preliminary findings from a multi-year study of young women who showed interest in applying for an award that recognizes high school females’ computing-related interests and achievements, the National Center for Women & Information Technology (NCWIT) Aspirations in Computing Award. The research sample includes two groups: Awardees and non-Awardees. This mixed-methods study consists of a social cognitive career theory (SCCT) survey instrument, as well as interviews and focus groups exploring themes of confidence, self-efficacy, a sense of belonging, and perceived supports and barriers to being involved in computing. This paper describes results from the first survey and select demographics from the two groups, Awardees (n=691) and Non-Awardees (n=760), along with preliminary analyses of the qualitative data gathered thus far.

*Keywords: Social and Behavioral Sciences, Social Issues, Computers and Society, Ethical/Societal Implications, Gender, Broadening Participation*

A B S T R A C T

As part of an ongoing three-year study, we surveyed women at two points in time: high school and college. 523 women answered survey questions based on Social Cognitive Career Theory (SCCT), a widely used vocational model which assesses the constructs of Interest in Computing, Confidence in Computing, and perceived Social Supports and Barriers. The second survey also asked about college major and post-graduate employment. Our analyses compared persisters in computer science and related technology fields to those who did not persist in these fields. We found significant differences between groups (with persisters having higher scores) on all three measures, and these differences widened over time. For both groups, computing interest decreased from high school to college, regardless of major, but tech majors’ interest decreased less than did non-majors and can be explained by their move into subspecialties. Not surprisingly, computing confidence increased for persisters but decreased for non-persisters. Perceived support for computing from family and friends for both groups remained stable between high school and college, regardless of major, although persisters perceived significantly more support for computing than did non-persisters. Another important finding was that high schoolers’ responses to a single survey item about intent to persist predicted later persistence moderately well. Seventy-two percent of those students who said in high school that they were interested in pursuing a CS or tech-related college major did so during college. Thus, we learned that for many girls, plans about future area of study remain relatively constant from high school to college. This finding has implications for improving how we evaluate interventions aimed at high school women when longitudinal tracking is impractical. The SCCT-related findings suggest which constructs are important to try to influence in students early on and timing interventions for the greatest impact on broadening participation in technology fields.

CCS Descriptors:
• Social and professional topics~K-12 education • Social and professional topics~Computing occupations

Keywords: Gender, Human factors, Persistence in computing, SCCT, Longitudinal research, Social science research