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Women in Computing & Engineering: Differences between Persisters and Non-persisters

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ABSTRACT

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 Concepts

• **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

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Much has been written about exposing girls to computing activities from an early age in order to pique their interest and offer them experiences necessary to persist in computing. Less is known about girls who show some interest in computing during high school and then consider pursuing a technology-related field in college. In the place of longitudinal data, researchers have often relied upon one-time measures meant to predict persistence with no follow-up evidence of how students' intentions actually played out. In our study we examined how survey responses by high school girls predicted persistence three years later defined as being tech and computer science majors [or minors] in college. We also examined other factors that may be influential in that choice of major.

A number of studies exploring field persistence from education to career have used the Social Cognitive Career Theory (SCCT) model which holds that personal, behavioral, and environmental factors play a role in career decision making.[1] The SCCT model posits that person-centered variables of domain-specific self-efficacy coupled with interests and realistic outcome expectations about the field propel individuals to pursue particular careers. Career choice is further influenced by a combination of supportive and inhibiting contextual factors. Supportive factors associated with pursuing computing include: early exposure, access to high quality learning experiences, supportive parents, and peer groups.[2, 3] Inhibiting factors include limited access, subtle and not-so-subtle racism and sexism, geographic location, and lower socio-economic status.[3, 4]

Importantly, SCCT incorporates gender and race/ethnicity explicitly in its model, which renders it appropriate for work with girls and young women.[5] Over the past 10 years, studies employing SCCT have found it to be a good fit for a wide range of populations underrepresented in STEM.[6-8] As such, SCCT emerges as a useful framework to help understand the ongoing underrepresentation of women and other racial/ethnic minorities in computing and to identify leverage points for addressing this ongoing problem.

In a review of research on women's persistence in computing published between 1994-2005, Singh and her colleagues found that women in the US tended to have less confidence in their computing abilities compared to men, regardless of how well they did in college course work and other objective indices.[9] The authors reported that stereotypes about who did computing and the chilly climate in computer science classrooms created further obstacles to women's persistence. These factors coupled with classroom practices that discourage collaboration, especially in first year computer science courses, negatively affected women's interest in computing and subsequently, their commitment to persist in the field.[9, 10] Particularly in the last decade, there have been myriad interventions focused on increasing women's interest and confidence in computing and on changing classroom practices and disrupting stereotypes. However, there is little longitudinal tracking of women's changing attitudes as they pursue (or don't pursue) computing from high school through college and into the workforce.

We designed and administered a version of the SCCT survey to high school girls during 2013 and followed up again in 2016 with the same students who, by then, were at the university. We wanted to know if the responses of students who persisted in Computer Science or a related information technology field differed from students who did not persist in these areas. We also wanted to know if responses to a survey in high school were reliable predictors of persistence in tech-related areas in college.

METHODS

Participants. Data collection was part of research and evaluation on the Aspirations in Computing high school award program established in 2007 by the National Center for Women & Information Technology (NCWIT) to recognize and encourage female high school students who have shown interest and achievement in computing (www.aspirations.org). National Aspirations Award winners receive prizes, cash, and a trip to Bank of America headquarters for the award celebration, as well as access to scholarships, internships, and a community of like-minded women. Regional awards are similar in nature but vary by region. One purpose of the Aspirations Award program is to encourage young women to pursue their interests in computing. As of this writing, more than 8,000 female high school students have received winner, runner-up, or honorable distinction through the program.

From the sample of 1,500 respondents to the first survey (S1) administered during spring 2013, 523 young women identified themselves as high school students and were in university or the workforce by the second survey (S2) in spring 2016. Of these respondents, 316 were awardees (winners or runners-up). The remaining 207 respondents were either non-awardees or non-applicants (the latter being individuals who registered on the website but did not go on to complete an award application). The key dependent variable of interest for this study was persistence.

In the first survey when the majority of respondents were still in high school, we asked students about their intent to persist. In the second survey, we sought to determine actual persistence based on respondents' answers about their major and minor at university, and if respondents worked at a computer or IT-related job. We coded the responses to major/minor and job as "persisting" or "not persisting," using two different dependent variables in our analysis. One was *Tech-persister* (coded persister/non-persister) using the criteria: 1) majoring or minoring in computer science, information science, or any engineering field (or completing these majors) and/or 2) as working in a technical position in the workforce (based upon job title and company). We created this broad category because the program and its funders care about female persistence in a wide variety of computing-related fields; however, we know many stakeholders in our research are exclusively interested in broadening participation in computer science (CS), so we created a second variable. The second dependent variable we tested was called *CS-persister* (also coded persister/non-persister). *CS-persister* was defined more narrowly than *Tech-persister* and included only women who were pursuing, or had graduated with a Computer Science or Computer Engineering degree. All others were coded as *CS non-persister*.

The race/ethnicity of all respondents in our study is shown below by persister group.

Table 1 Race/Ethnicity by persisting group.

Race/ethnicity	***Total***	***Tech-persister (n=325)***	***Tech Non-persister (n=198)***	***CS-persister* (n=185)**	***CS Non-persister (n=336)***
Asian	25%	28%	21%	33%	20%
African-American	8%	7%	10%	7%	9%
Hispanic	11%	11%	11%	8%	12%
Native-American	<1%	1%	1%	1%	1%
White	47%	48%	51%	44%	52%
Multiracial	6%	4%	2%	4%	3%
Other	<1%	<1%	<1%	1%	0%
Not reported	3%	<1%	4%	2%	3%

Note: 2 missing cases from CS-persister variable.

Measures. We administered surveys online to awardees and non-awardees/non-applicants using Survey Monkey for both administrations. The survey was developed by researchers at NCWIT and is based upon the SCCT model which posits five constructs represented by 34 items: *Interest (9 items), Confidence (7 items), Intent to Persist (5 items), Perceived Social Supports/Barriers (7 items),* and *Outcome Expectations (6 items)*. The current comparison focuses on the constructs: *Interest, Confidence* and *Perceived Social Support/Barriers*. We also examined how one item, "How much do you want to get a computer science or technology-related college degree?" predicted actual persistence in computing in college or the workforce.

Survey items were organized in blocks and were scaled 1-5 with possible responses keyed to item prompts. The *Interest* and *Confidence* constructs include items about designing computer games, trying new computer software, solving software problems, fixing or building computers or other technologies out of parts, programming computers, thinking of or creating new technology inventions, and finding technological solutions to world problems. The *Social Supports* construct contained items measuring perceived peer and family support such as "I believe people like me can do well learning computing" and "My family likes me to learn about computing." As noted above, the intent to persist question in the first survey read: "How much do you want to get a computer science or technology-related college degree?" The response options "Very much" and "quite a bit" responses were coded as "Yes"; "Not at all" and "Only a little" were coded as "no."

Analysis: We used the average ratings across item blocks in our analysis. We used t-tests of independent groups to assess differences among persister groups at survey 1 (high school) and survey 2 (college), and paired samples t-tests to assess gain over time within groups. We also tested gain/loss from high school to college and differences in the amount of gain/loss between groups with Repeated Measures ANOVA. We set the significance level at $\alpha < .05$; however, most comparisons met the stricter standard of $\alpha < .01$. [All statistical results are included in the appendix.]

RESULTS

Differences Between Persisters and Non-persisters. We compared *Tech-persisters* and *Tech non-persisters* and *CS-persisters* and *CS non-persisters* on three composite variables from our SCCT survey. Table 2 summarizes results about *Tech-persisters* and *Tech non-persisters*. Table 3 shows results for *CS-persisters* and *CS non-persisters*.

Table 2. Comparison of Tech-persister and Tech non-persister groups, average scores on SCCT composite variables.

		Survey-1 (HS)	*Survey-2 (College)*	*SD*	*Gain*	*Difference in Gain*
Interest	*Tech non-persister*	2.77	2.33	0.63	-0.44	0.20
	Tech-persister	3.16	2.92	0.49	-0.24	
Confidence	*Tech non-persister*	2.13	1.92	0.59	-0.21	0.30
	Tech-persister	2.33	2.42	0.6	0.09	
Social Support	*Tech non-persister*	3.33	3.18	0.52	-0.15	0.18
	Tech-persister	3.50	3.53	0.44	0.03	

Note: Tech-persister n = 325, Tech non-persister n = 198

Note: All between group, group by survey time (1-2) and differences in gain comparisons were significant at $\alpha = .01$ level except *Social Supports* gain from S1 – S2 for *Tech-persister* group.

We found all comparisons between groups (*Tech-persisters* v. *Tech non-persisters*) within the first survey administration (S1) when the respondents were in high school statistically significant at the $\alpha = .01$ level with those who ended up not pursuing tech degrees to be significantly lower than *Tech-persisters* on all measures. Likewise, all between-group comparisons for the three variables for the second survey were statistically significant between *Tech-persister* and *Tech non-persister* groups when the respondents were in college or the workforce, also favoring the *Tech-persister* group. (Values for t-scores can be found in the appendix.)

We also found that all comparisons of gain within *Tech-persister* groups were also statistically significant over time (from high school to college), except for gain for *Tech-persisters* on the *Social Supports* measure. While the *Social Supports* measure varied only slightly from high school to college for *Tech-persisters*, it declined significantly for *Tech non-persisters*.

The test of the interaction between gain and group was also significant for all three measures. *Tech non-persisters* decreased their ratings more in the *Interest*, *Confidence* and *Social Support* measures than *Tech-persisters*, who either gained slightly in their ratings or decreased less than *Tech non-persisters*.

Next we compared the *CS-persister* and *CS non-persister* groups across our composite variables and across time.

Table 3. Comparison of CS-persister and CS non-persister groups on SCCT composite variables.

		Survey-1 (HS)	***Survey-2 (College)***	***SD***	***Gain***	***Difference in Gain***
Interest	*CS non-persister*	2.88	2.51	0.64	-0.37	0.17
	CS-persister	3.25	3.05	0.47	-0.20	
Confidence	*CS non-persister*	2.18	2.05	0.60	-0.13	0.28
	CS-persister	2.4	2.55	0.58	0.15	
Social Support	*CS non-persister*	3.31	3.31	0.52	0	0.03
	CS-persister	3.52	3.55	0.56	0.03	

Note: CS-persister n = 185, CS non-persister n = 336, 2 cases missing.

Note: All between group, group by survey time (1-2) significant at $\alpha = .01$ level except Social Supports "gain" from S1 – S2. Difference in gain between groups was non-significant for Social Supports, indicating both groups gained or lost at roughly the same rate.

As with the *Tech-persister*s, we found all between group comparisons of *CS-persisters* and *CS non-persisters* statistically significant at S1 and at S2. On average, *CS-persisters* rated all items higher than did *CS non-persisters*.

All comparisons of gain (or loss) within the *CS-persister* and the *CS non-persister* groups from survey 1 to survey 2 were significant, with the exception of the *Social Supports* variable for both groups which remained virtually unchanged. (Values for t-scores can be found in the appendix.)

The magnitude of gain/loss differed for *CS-persisters* and *CS non-persisters* on the variables *Interest* and *Confidence*, with *CS-persisters* gaining and *CS non-persisters* decreasing in *Confidence*, and *CS non-persisters* decreasing at greater rates than *CS-persisters* in *Interest.* The interaction effects between gain over time and group status were assessed with the Repeated-Measures ANOVA; all interaction effects for *Interest* and *Confidence* were statistically significant at $\alpha = .01$ and *Social Supports* at $\alpha = .05$.

We also examined if gain or loss from high school to college for the composite variables was influenced disproportionately by larger gains or losses in one or more of the items related to each variable. We did see a pattern of losses for items related to gaming and game design, with much larger losses of *Interest* and *Confidence* between high school and college in these areas compared to items related to solving software problems or fixing or building computers. In some cases, gain or loss between high school and college on individual items was uneven between persister groups. For instance, ratings of interest in creating new software fell much more for *CS Non-persisters* than for the *Tech-persisters* who were involved in computer science or IT-related degrees or jobs.

Intent to Persist. We wanted to know if students who said they would persist in high school did in fact study computer science or a related IT field in college. As noted above, we transformed responses to the S1 item, *"How much do you want to get a computer science or technology degree?"* into a dichotomous variable ("*quite a bit"* and "*very much"* were coded as "yes," and "*not at all*" and "*only a little*" were coded as "no"). We compared responses to this intent to persist question from the high school administration to reports of actual persistence (as measured by college major or occupation) in the second survey. Table 4 shows the overall response patterns to the survey question from the high school administration grouped by reports of actual persistence in college for *Tech-persisters* and *Tech non-persisters*.

Table 4 Prediction of tech persistence in college from high school survey responses.

		Tech–persister		
		College report of major		
		Tech Non-persister	Tech-persister	Total
Student survey response in high school	*Tech not likely*	75 (73%)	28 (27%)	103
	Tech likely	119 (28%)	295 (72%)	414

Note: n = 517, 6 cases missing matched responses.

In our sample, 72% of the students persisted in college after indicating they would do so in high school. Conversely, 73% of students who said they did not want to pursue CS or a tech-related major did not do so later. As a correlation coefficient, the overall relationship (predicting both persistence and non-persistence) can be expressed as r = .46, which is considered a moderately robust predictive correlation.

DISCUSSION

Comparisons between *Tech-persisters* and *CS-persisters* on the three SCCT constructs—*Interest*, *Confidence*, *Social Supports*—show a mixed pattern of group differences and gain between high school and college.

The much higher ratings for the *Interest* variable for *Tech-persisters* and *CS-persisters* during high school suggests that students who eventually enter CS- and IT-related majors already have an active interest in these areas when in high school. For both *Tech*- and *CS-persister* groups, computing interest decreased from high school to college, but tech majors' interest decreased less than did non-tech majors. It is somewhat counterintuitive to see lower ratings in *Interes*t for both groups when they reach college. This is most likely a reflection of loss of interest in the individual items that make up the composite such as gaming or game design or hardware, for instance. This interest shift coupled with the specialization that takes place in CS or IT majors may account for the overall decreased interest we observed. It makes sense that students who choose a specialized major focused on programming, for instance, may in fact then have less interest in building hardware, once in college or the workforce.

The difference in gain in *Confidence*, with small gains from high school to college for both *Tech-persisters* and *CS-persisters*, and losses for non-persisters, are congruent with students gaining computing self-efficacy as they move into CS-related fields. The finding suggests that even when faced with difficult classwork or a potentially negative environment as they move through their degree programs, female students who pursue CS or IT majors maintain confidence in their skills and capacities. That said, the overall lower ratings in this area compared to the other constructs (i.e., a mean of 2.4 for *Confidence* v. 3.25 for *Interest*) could reflect that students may be interested in specific areas such as programming, but lack confidence doing tasks in that area of interest. In addition, previous research has shown that women tend to rate themselves lower than men on confidence scales even when they have exhibited high skills and achievements.[9] Overall confidence ratings of this all-female sample could, perhaps, be explained by this phenomenon.

We saw small but statistically significant differences between persisters and non-persisters in high school in the area of *Social Supports with CS- and Tech-persisters* showing higher levels of perceived support than their non-persisting colleagues. Ratings for the *Social Supports* variable remained the same from high school to college for all groups except the *Tech non-persisters* suggesting that these contextual influences remain constant over time, at least for those women who continue to pursue tech-related fields. The consistently higher ratings for *Social Supports* (compared to the other constructs) for both persister groups (Tech and CS) suggests that social expectations from family and friends may play a larger part in the lives of high school students who pursue computing or IT degrees. That said, the social supports that were measured in our study were fairly narrowly defined, being limited to family and friends/peers and specifically in the context of pursuing technology. Thus it is unsurprising that the *Tech non-persister* group reported less perceived support when in college for pursuing tech.

Comparison between responses to the survey question *"How much do you want to get a computer science or technology degree*?" and actual persistence indicates that simply asking female high school students about their intentions to persist in computing and IT-related fields is a moderately effective way of determining who will actually end up pursuing a CS or other computing-related major. The item accurately predicts actual persistence about 73-4% of the time. However, we also found that some students who say they do not want to become involved in IT may change their minds later. Both of these findings are significant because it is cost-intensive and typically impractical to follow students from high school to career; yet there are many interventions aimed at high schoolers that encourage persistence in computing fields that would like to be able to predict student persistence after students leave their programs. In addition, the 27% of students who said in high school that they did not want to pursue tech, but then later did pursue a tech field shows that even those who are not leaning toward computing in high school may still be brought into the field later. Further study with other populations is needed to see how well this question predicts persistence in other groups.

CONCLUSION

Tech-persisters reported somewhat lower *Interest* and *Confidence* than *CS-persisters* and were nearly identical on *Social Supports*. This raises the question of whether or not distinguishing between CS and other computing-related majors is important. More research is needed on this topic, as it may have implications for efforts to broaden participation in computing and for defining who "counts" as persisting in the field.

The relationship between interest and confidence is entangled. We found these variables to be highly correlated. Because a lot of attention in the computing education research is paid to confidence, or self-efficacy, particularly in relation to women and other historically under-represented populations, it is important for researchers to understand how confidence and interest are interrelated, and if one drives the other. Further study is needed to understand the relationship between female students' computing interest and confidence.

Our item-level analyses of the SCCT variables suggest that *Interest* and *Confidence* in computing may be measured more effectively by asking college students about their particular focus rather than about computing in general. By contrast, asking high school students about a variety of aspects of computing (game design, programming, hardware, etc.) yields a relatively reliable indicator of interest in the field. Thus, survey instruments accurately measuring college or workforce interest and confidence in computing still need to be developed.

The consistent ratings of both persister groups on the *Social Supports* variable suggest that these influences may be more salient to women pursuing this male-dominated field because of the implicit barriers they may encounter in the field. However, since the variable was narrowly measured and did not explicitly identify important adult influencers like teachers and other mentors, it may not have been an accurate measure of the most important social supports influencing students' choices of education and career.

Our exploration of students' intent to persist is perhaps the most provocative finding. It is surprising that a high school student's intent to major in a certain field bears out three years later. In our sample, results suggest that an internally held goal (i.e., getting a computer science or technology degree) supplemented by perceived social supports may be important to persistence for women as they move from high school through college and into the workforce. By the time they reach college, there are many mitigating circumstances that can prevent people from achieving their stated goals while in high school (including financial constraints, life changes, chilly climate within academic departments, and countless other reasons).

Another significant result from this study for those interested in broadening participation in computing is our finding that more than a quarter of those who did not intend to major in technology did in fact end up doing so. This suggests that reaching out to graduating high school students and beginning college students may actually yield additional technology majors and minors from among those who were uninterested. This finding can provide hope for those discouraged by the body of research that explains why girls may turn away from computing by middle school.[2, 11] It is a cautionary tale, however, because our findings equally suggest that those who are interested in technology may later decide against a tech major. What remains to be identified is what factors actually play the most important roles in influencing young women's shift in interest relative to computing. This, too, is a question for future research, particularly as it may differ across racial/ethnic identities and regions.

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APPENDIX:
STATISTICAL TESTS FOR TECH-PERSISTER AND CS-PERSISTER GROUPS.

Table 5 (Appendix). t-tests for independent groups, t, df and p for within group comparisons for Tech-persister.

	t	***Df***	***Sig. (2-tailed)***
Interest (S1)	-7.78	335.54	<.001
Interest (S2)	-10.82	361.06	<.001
Confidence (S1)	-4.12	397.45	<.001
Confidence (S2)	-9.69	415.89	<.001
Social Support (S1)	-4.04	368.36	<.001
Social Support (S2)	-7.90	338.81	<.001

Note: t-test degrees of freedom adjusted for equal variances not assumed.

Table 6 (Appendix) Paired t-tests for Survey-1 to Survey-2 gain, Tech-persister group.

	t	***df***	***Sig. (2-tailed)***
Tech-persister			
Interest (S1) - (S2)	7.23	315	< .001
Confidence (S1) - (S2)	-2.38	314	0.018
Social Support (S1) - (S2)	-1.11	319	0.264
Non-persister			
Interest (S1) - (S2)	8.55	190	< .001
Confidence (S1) - (S2)	4.25	187	< .001
Social Support (S1) - (S2)	3.83	185	< .001

Table 7 (appendix). Repeated measures ANOVA for *Interest*, *Confidence*, *Social Support*. Survey-1 to Survey-2 by Tech-persister group.

Measure*: Interest*

	Type III Sum of Squares	Df	Mean Square	F	Sig.
Gain	27.023	1	27.023	136.595	.000
Gain * Tech-persister	2.533	1	2.533	12.805	.000
Error	99.906	505	.198		

Measure: *Confidence*

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Gain	.973	1	.973	7.049	.008
Gain * Tech-persister	2.145	1	2.145	15.540	.000
Error	69.581	504	.138		

Measure: *Social Support*

	Type III Sum of Squares	df	Mean Square	F	Sig.
Gain	.973	1	.973	7.05	.008
Gain * Tech-persister	2.145	1	2.145	15.54	.000
Error	69.581	504	.138		

Table 8 (Appendix). T-tests for independent groups, t, df and p for within group comparisons for CS-persister.

	t	*df*	*Sig. (2-tailed)*
Interest (S1)	-8.39	484.10	<.001
Interest (S2)	-10.65	458.96	<.001
Confidence (S1)	-4.47	377.43	<.001
Confidence (S2)	-9.58	396.12	<.001
Social Support (S1)	-3.57	461.32	<.001
Social Support (S2)	-5.64	440.43	<.001

Note: t-test degrees of freedom adjusted for equal variances not assumed.

Table 9 (Appendix) Paired t-tests for Survey-1 to Survey-2 gain, CS-persister group.

	T	*Df*	*Sig. (2-tailed)*
CS-persister			
Interest (S1) - (S2)	5.32	178	<.001
Confidence (S1) - (S2)	-3.08	179	0.002
Social Support (S1) - (S2)	-0.78	182	0.432
Non-persister (CS)			
Interest (S1) - (S2)	9.77	325	<.001
Confidence (S1) - (S2)	3.212	320	0.001
Social Support (S1) - (S2)	2.425	320	0.016

Table 10 (appendix). Repeated measures ANOVA for *Interest, Confidence, Social Support*. Survey-1 to Survey-2 by CS-persister group.

Measure: *Interest*

	Type III Sum of Squares	Df	Mean Square	F	Sig.
Interest (S1 – S2)	18.853	1	18.853	94.812	.000
Interest * CS –persister	1.936	1	1.936	9.735	.002
Error	100.018	503	.199		

Measure: *Confidence*

	Type III Sum of Squares	Df	Mean Square	F	Sig.
Confidence (S1 – S2)	.046	1	.046	.243	.622
Confidence * CS –persister	3.593	1	3.593	19.115	.000
Error	93.806	499	.188		

Measure: *Social Support*

	Type III Sum of Squares	Df	Mean Square	F	Sig.
Social Support (S1 – S2)	.130	1	.130	.922	.337
Social Support * CS –persister	.623	1	.623	4.423	.036
Error	70.752	502	.141		