Girls' Interest in Computing: Types and Persistence

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Abstract: This paper examines interest development through a longitudinal study of young women who had extensive middle school computer science experience. A repeated measures survey was conducted at the end of high school and results compared from the end of middle school to the end of high school. For girls who had developed an interest in a computing career by the end of middle school, interest in computing increased. Aspirational expressions of interest, defined as stating an interest in computing, were highly correlated while embodied expressions of interest, defined as engaging in computing activities such as classes, clubs, or hobbies were generally not correlated. Participants appeared more definite in their attitudes towards computing by the end of high school, particularly interest in computing as a career and college major, than they had at the end of middle school.

Introduction

It is well-documented that women are underrepresented in computing, as early as middle school through the workforce (NCWIT, 2016). Economists and computer scientists have long made a case that in an increasingly-technological world, there is an increased need for well-prepared high-tech workers; women could fill these jobs. Further, diverse teams create higher quality products (Ashcraft & Breitzman, 2012), speaking to not only a social justice motivation for increasing diversity but also an economic one.

Speculation on the role of early experience in developing students' interest in computing, particularly engaging underrepresented populations such as women, is rampant. On the one hand, it is widely perceived that early experience is important, and so clubs, camps, and programs to introduce children, especially girls, to computing proliferate (e.g. Adams, 2010; Ericson & McKlin, 2012). At the same time, little work has been done to understand the long-term effects of these early experiences. While some programs do engage in high quality program evaluation, longitudinal follow-ups are challenging for informal programs who may have no meaningful way to track students after the program ends. Further, while engaging workshops and camps certainly can stimulate situational interest described in the Four-Phase Model of Interest Development (Hidi & Renninger, 2006), a short experience may not be enough to sustain the transition to individual interest, though it may inspire a student to seek out learning opportunities (Barron, 2006). School environments may be better suited to support interest development due to the opportunity for repeated re-engagement with the topic required in a course.

At a time when the "CSForAll" movement is gaining traction in providing computer science courses in schools across the U.S. it is crucial to understand the implications for interest development. On the one hand, providing computer science classes in all schools can provide access and opportunities for students to discover a new passion(Ainley & Ainley, 2011). On the other hand, one lesson of "school science" is that class experiences disconnected from the inspirational features of "real science" may diminish students' interest (Osborne, Simon, & Collins, 2003). It is critical to understand the long-term implications of compulsory school-based computer science courses on students' long-term interest.

This paper reports on a longitudinal study of girls who attended a middle school where computer science courses were mandatory. Students were initially surveyed at the end of eighth grade, then re-surveyed at the end of high school/beginning of college. This paper is descriptive, examining the changes in students' attitudes about computing, as well as differences in their experiences. It examines the long-term effects of early experience and career interest on engagement and continued interest.

Context

This study took place in Silicon Valley, among girls who had attended an all-girls school. Silicon Valley, home to Apple, Google, and myriad other tech companies, celebrates computing and technology. Further, this study took place as interest in computing took off, with record enrollment at the college level and increased funding for tech startups regularly making the news. While the stereotype of computing as nerdy and unrewarding persists, the temporal and geographical context of this study, in which computing was seen as financially and socially rewarding, make it unique.

The participants in the study were recruited from a girls' middle school (grades 6-8) where computer science was mandatory for all students in all years. The potential stigma of engagement in traditionally masculine disciplines is removed in a single-sex environment, as everyone doing math, science, and computer science is a girl. Many of the confounding factors described in other research, such as boys taking over the keyboard or boys dominating class discussions to the detriment of girls are not issues in single-sex environments. Research has demonstrated that the positive effects of single-sex education persist after women return to coeducational settings, as they take on more leadership roles and have higher confidence than their peers who have attended only coeducational schools (Sax, Riggers, & Eagan, 2013).

The school provided female role models, as all computer science teachers during this study were women. One was a young, blonde engineer; one a pierced & tattooed young computer scientist; and one an older MIT graduate whose own daughter had previously attended the school. Further, the computer science curriculum was designed to be engaging. It was a breadth-based approach, including robotics, web design, programming with Python and Scratch, database design, animation, as well as deeply conceptual topics such as ethics, information flow, object-oriented design, etc. The school had a one-to-one laptop program, and thus technology use was spread across all classes, with students using word processing in all classes, Excel and other programs for science data collection and analysis, and various math applications to examine algebraic functions and other topics.

The setting should be ideal for sparking girls' interest in computing – project-based hands-on curriculum, positive stereotype-busting message about computing, female teachers to act as role models, extensive experience and message of competence and mastery, and the larger setting of Silicon Valley where technology careers are celebrated.

Research questions

This work was guided by the following research questions:

- How does computing interest vary over time between girls who were open to computing careers at the end of middle school and those who were not?
- Are there differences between the expressions of interest as career interest, interest in computing generally, level of engagement in computing experiences, and plans to engage in future computing experiences between the two groups?

Method

Setting and participants

This paper reports on the findings from 40 young women who took surveys on computing attitudes and experiences at the end of middle school and again at the end of high school. Participants had attended a private girls' school in Silicon Valley, California, USA, where computer science is a required course for all students all years. This provided a baseline of unusually high computing experience.

Following middle school, the students dispersed to a variety of high schools. Most attended high school at area public (n=26) or private (n=10) schools. While the effects of high school configurations and offerings were of interest, the population was determined to be too small to make any claims, and this line of inquiry is left to future work.

For this longitudinal follow-up, participants from the first study were asked to participate in a follow-up survey approximately 3.5 to 5 years after the first data collection, during either participants' senior year of high school or freshman year of college. This paper reports on data from the 40 participants who completed surveys at both time points.

Procedure and instrument

The survey was based on an existing survey on interest, access, and experience with technology (Barron, 2004; Friend, 2015). The survey distributed in eighth grade is lengthy and covers not only topics related to computing but to technology broadly. The middle school survey was distributed by paper in school during the students' final days of eighth grade. For the longitudinal follow-up, a shortened version was distributed through a web form. Most of the questions are repeated measures and were identical in both surveys. In a few cases, questions were included or updated to reflect participants' life position (e.g. middle school or high school) as described below.

Measures

Measures were repeated between the two surveys, updated as necessary to reflect participants' changed context. In other words, while the middle school survey asked about high school plans, the high school survey asked about college plans. The following is a brief description of each survey construct analyzed below.

Career interest

One question asked students if they could see themselves becoming "a computer programmer or engineer of some sort" and was used to measure interest in a computing career. This question was used to group the students into a "CS Career" group who were open to a computing career and a "No CS Career" group who were not. The groups were created following the middle school survey: those who indicated they "definitely" or "probably" could not see themselves as a programmer or engineer of some sort were put in the "No CS Career" group and those who indicated they "maybe", "probably", or "definitely" could see themselves as a programmer or engineer were in the "CS Career" group. Once assigned to a group, based on the middle school survey, group membership was maintained independent of a participant's response to the question in the high school survey.

Computing interest

Four questions measured each student's express statement of interest in computing: "I would like to learn more about computers", "Computers are interesting to me", "Learning about what computers can do is fun", and "I like the idea of taking computer classes." Responses were averaged for a single measure of computing interest.

Future plans

Two measures were developed to investigate participants' future plans to engage in computing: interest in majoring in computer science, and interest in future learning about computing. To determine interest in a CS **major**, the survey asked to what extent participants could see themselves majoring in computer science in college. Interest in **future learning** was measured through several questions about to what extent participants could see themselves participating in a variety of experiences around computing. These included taking more classes about computers, taking a class on programming or web design in the next step of their academic career, enrolling in a computer summer program, or "learning about" programming, hardware, simulations, or robotics.

Experiences

Participants were asked how much they had engaged in various computational experiences. In the middle school survey, the question asked how many times they had *ever* done the activities; in the high school survey, the question asked how many times they had done the activities in high school, in order to distinguish continued participation after middle school.

Classes: Students were asked how many computer science classes they had taken at school.

Clubs: Students were asked how many technology-based clubs such as First robotics they had participated in.

Hobbies: Participants were asked how much they had done each of thirteen computational activities. Examples of activities included making a robot, designing a 2-D or 3-D model, or making a web site. In the eighth grade survey, one of the activities was "created your own newsgroup, blog, or discussion site on the internet." In the high school survey, this question as replaced with "used a makerspace at school or elsewhere" because of the increased prevalence of Maker Spaces in the area, and extent to which creating a newsgroup or blog is no longer a computational activity. "Hobbies" represented the number of activities a participant indicated she had engaged in six or more times. To have engaged in a single activity so many times would be more than required by a class, and therefore represents an act of volition such as joining a club or engaging in the activity in their free time, therefore it is considered a computational hobby.

Analysis

Following the middle school survey, participants were grouped for analysis based on their response to the question about seeing themselves as a programmer or engineer. The "CS Career" group responded they definitely, probably, or maybe could see themselves as a programmer or engineer in the future. The "No CS Career" group responded that they could probably or definitely *not* see themselves as a programmer or engineer. For the purposes of this paper, participants were kept in the same group. Thus, the "CS Career" grouping represents whether participants had CS career interest *following middle school.*

Repeated measures analysis was used to compare outcomes between the two groups (O'Brien & Kaiser, 1985).

Findings

Career interest

Responses to the question about whether a participant could see herself becoming a programmer or engineer formed the main grouping variable for analysis, as described above. A chi squared test of independence was highly significant ($X^2 = 13.7$, $p < .001$), demonstrating that group membership in middle school was strongly associated with group membership in high school. Seven participants had high school responses that would have resulted in a different career group, as summarized in Table 1. The five participants who had been open to a CS career in middle school and could no longer see themselves as a programmer or engineer had all responded "Maybe" on the original study, so not a large change in attitude. Of the two participants who became open to a computing career, one moved from "probably not" to "maybe" while the other showed substantial increase in interest from "probably not" to "definitely yes."

Table 1: Interest in a programmer/engineering job by time

		Middle School		
		CS Career	No CS Career	**Total**
High School	CS Career	8	2	**10 (25%)**
	No CS Career	5	25	**30 (75%)**
	Total	**13 (33%)**	**27 (67%)**	

The distribution of responses on the five-point Likert scale are shown in Figure 1. Participants appear more decisive in their feelings about a computing career by the end of high school – the majority who had been neutral to mildly negative had moved into rejecting the idea more completely, while those who were open to a computing career had become more positive about it.

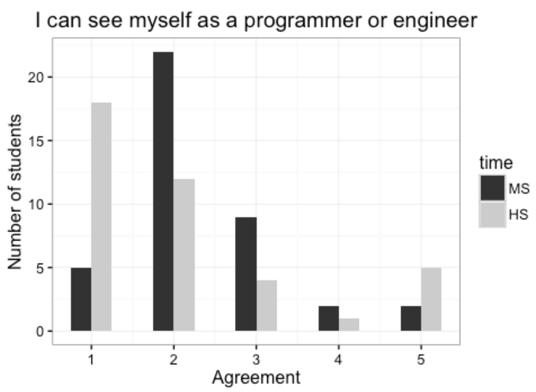

Figure 1. Programmer Career Interest.

Computing interest

As described above, while the participants were grouped by their openness to a computing career, interest in computing more broadly was also interrogated. "Interest" measures each participant's response to explicit questions about her interest in computing, such as "learning what computers can do is fun."

As shown in Figure 2, there is a significant difference in interest between the two groups. A paired t-test on the CS Career group shows an increase in interest between middle and high school ($t(12) = 2.16, p = .05$) while the No CS Career group does not ($t(26) = .70$, $p = .49$). To further investigate, a repeated measures ANOVA was run, which shows a main effect of group ($F(1, 38) = 15.59$, $p < .001$) and a main effect of time ($F(1, 38) = 4.24$, $p=.046$), but no interaction ($F(1, 38) = 1.52$, $p = .225$). This suggests that girls who were already interested in computing increased interest during high school, but for girls who were not open to a computing career, their interest in computing is relatively unchanged.

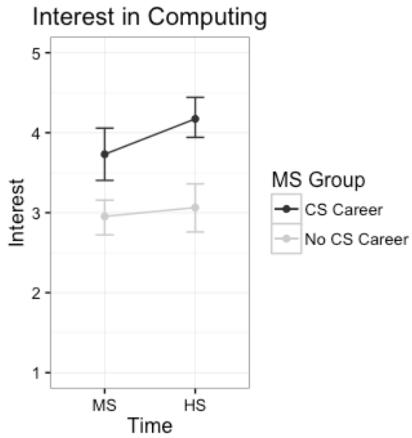

Figure 2. Change in interest by group.

Future plans

Beyond asking directly how interested participants are in computing, the survey also indirectly measured interest through asking about participants' future plans to engage in computing. Future plans were measured both by asking to what extent participants could see themselves majoring in computer science, and also their plans to participate in computing in less formal ways, such as taking classes and learning independently.

Participants in the CS Career group were more interested in majoring in CS (HS M=2.85, SD = 1.46) than participants in the No CS Career group (HS M=1.56, SD=.89), a trend that did not change over time: repeated measures ANOVA shows a main effect of group ($F(1, 38) = 34.88$, $p < .001$) but no effect of time or interaction between time and group. There was high variance in the responses, particularly in the CS Career group. Figure 4 disaggregates the CS Career group responses and suggests that individuals are becoming more decisive in their consideration of a CS major, whether positive or negative.

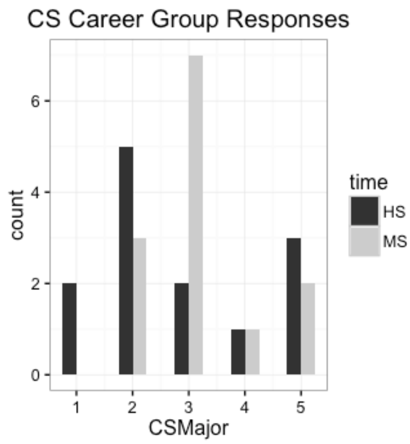

Figure 3. Openness to a CS Major for CS Career group.

In contrast to participants' inclination to *major* in computer science, their plans to continue learning more about computing and computer science continues to be high. Repeated measures ANOVA shows a main effect of group ($F(1, 37) = 24.86$, $p < .001$) but no interaction nor main effect of time. In other words, participants in the CS Career group have more intention to continue learning about computing than their No CS Career peers both in middle school and in high school, and neither group changes intention over time.

Experiences

While stating that one is interested in a topic, even interested in pursuing it in the future, is one measure of interest, another important factor in interest development is the enactment of that interest through engaging in activities related to the interest. The high school survey inquired into whether students had taken CS classes or joined clubs relating to computing. The middle school survey had not asked about these topics because all students were required to take computer science classes all years and few clubs were offered due to the small size. Both surveys inquired into the depth of participants experience with a variety of computational activities such as creating web sites, digital art, and programming.

Two participants in each group had taken three or more CS classes in high school. While most participants in the CS Career group *had* taken a CS class (n=8, 62%), most participants in the No CS Career group had *not* taken CS in high school (n=19, 70%). However, a t-test comparing the groups was not significant ($t(20)$=1.5, p=.14).

The results were similar in terms of joining computing clubs. The vast majority of participants in the No CS Career group had not joined any computing clubs in high school (n=24, 89%), while a smaller majority of the CS Career group had not joined computing clubs (n=7, 54%). As before, a t-test indicated no significant difference between the groups' on joining computing clubs ($t(15.9)$= 1.79, p=.09).

Participants were asked about how often they had engaged in each of thirteen activities, and the number of activities where they indicated they had re-engaged more than six times were counted and considered a digital hobby. For example, a student who had created more than six web sites, more than six pieces of digital art, and more than six robots would have three digital hobbies.

There was incredible variation in the number of participants' digital hobbies, with few trends. Repeated measures ANOVA showed no main effect of time or group and no interaction. A histogram of the responses is shown in Figure 4. In both groups, many participants have fewer hobbies in high school than they did in middle school. Although on average the number of hobbies demonstrated by participants in the CS Career group decreases from middle school to high school, the number of participants reporting *no* hobbies decreases, from four to one. It would be expected that participants who were interested in a computing career would have computational hobbies. By contrast, it would be expected that participants who were uninterested in a computing career may not have computational hobbies. Thus, it is notable that a substantial number of participants did have digital hobbies. Of particular notice is the number of people who had four or more hobbies in middle school – including the participant who had seven hobbies.

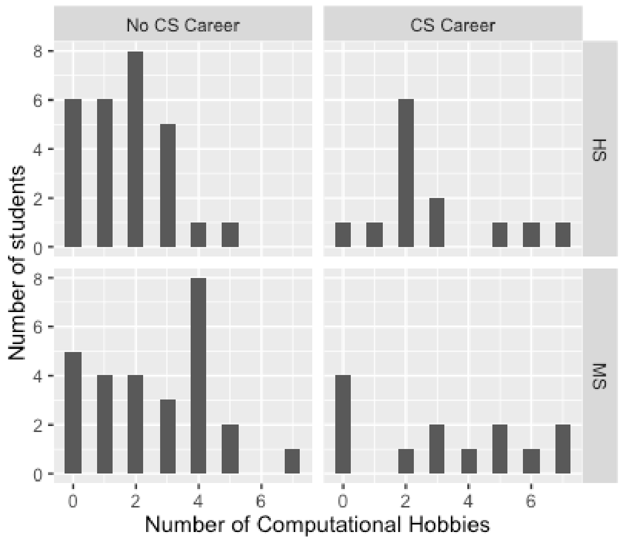

Figure 4. Number of computational hobbies by group and time.

Relationships between expressions of interest

In order to understand the relationships between the different expressions of interest, not just through the lens of career interest, but across all expressions described above, correlations were calculated, as shown in Table 2. These are correlations of the results from the high school survey.

Table 2: Relationship between variables

	Career	Interest	Major	Learning	Classes	Clubs
Comp. Interest	.58***					
CS Major	.76***	.59***				
Future Learning	.73***	.79***	.78***			

HS CS Classes	.36*	.06	.09	.00		
Clubs	.50**	.27	.30	.41**	.29	
Hobbies	.36*	.14	.18	.14	.47**	.2

* $p < .05$, ** $p < .01$, *** $p < .001$

Aspirational expressions of interest – defined as being open to a computing career, expressing interest in computing, being open to a CS major, and being interested in learning more about computing in the future - were all very highly correlated. Embodied expressions of interest – defined as engaging in activities that would demonstrate that interest: taking classes, joining clubs, or having computational hobbies - were generally not strongly correlated with aspirational expressions of interest. One exception is computing career interest, which was moderately correlated with the embodied outcomes.

Discussion

To the extent that "computing interest" can be broadly conceptualized, the prediction would be that students who express interest in computing would display that interest broadly, that they would not only agree with statements such as "I am interested in computing" but would also engage in computing activities and would be open to future opportunities. The results discussed here present a more complex picture of interest, in which aspirational expressions of interest – stating that one is interested or would be willing to engage in the future – are markedly different than embodied expressions of interest – actually engaging in the activity, whether by taking courses, joining clubs, or engaging in computing as a hobby.

Within the aspirational expressions of interest, one notable result is the change in computing interest expressed by the CS Career group, as shown in Figure 2. Not only did members of the group have a higher interest in computing generally at the end of middle school, but their interest continues to grow in high school – independent of whether they engaged in computing activities. It appears that once girls are "hooked" on computing, their interest may continue to increase even if they do not continue to engage in extensive computing activities. This could be seen as an expression of individual interest, and that once participants had developed individual interest their interest deepened from emerging to a more well-developed individual interest during high school. Further investigation is warranted, both through investigating how participants understand and conceptualize their interest in computing, but also whether this is an operationalization of individual interest, such as identifying the relationship between participants' identity with computing and expressions of interest.

In terms of attitudes, participants appeared to become more decisive about their future plans during high school. While a substantial number of participants were "maybe" or "probably not" open to a computing career at the end of middle school, by the end of high school a much larger number were definite in their response (see Figure 1). A similar trend occurred with participants' response to majoring in computer science (see Figure 3). This is not entirely surprising, as younger students may be open to more possible futures than adolescents who are close to having to choose a path (Eccles, 2007). The finding that participants who were more positive about computing careers at the end of middle school are more positive about majoring in CS at both times echoes Tai, Qi Liu, Maltese & Fan (Tai, Qi Liu, Maltese, & Fan, 2006) and suggests that despite their mixed engagement in computing experiences in high school they may go on to major in computing areas in college and even continue to computing careers.

The mixed results in terms of participants' high school experiences warrants further investigation. One open question relates to the participants in the No CS Career group with high experience. The participants who took many courses, had many hobbies, and joined computing clubs yet reject a future in computing are of interest, to understand their choices. It is notable that this study took place in Silicon Valley, where computing is prevalent and privileged. Further their middle school computer science experience included messages about the utility of computing; these participants may have seen computing experiences as a vehicle to other goals. Follow-up study is required to understand the meaning of this finding.

Perhaps the greatest area for future research is not explanatory, but one of generalizability. The sample in this study is not only small but also quite unique, both in the general setting of Silicon Valley and also in the particulars of graduates of a girls' school with a mandatory computer science curriculum. Future research would not only expand to schools in other settings outside of Silicon Valley but also other configurations of schools. As an increasing number of schools are offering and even requiring computer science courses, finding schools and students with high CS experience should become easier, allowing for comparison and generalization of the findings.

Conclusion

Implied in the introduction to this paper is the question of what will happen as school-based computing becomes more prevalent. Will it, as hoped, increase students' interest as they are exposed to a rich and engaging discipline? Or will "school computer science" become like "school science" which in its drive to meet standards and teach particular content may lose some of the excitement of discovery? This small study taking place in a single context can only hint at some possibilities, but they are hopeful.

For girls whose interest can be aroused, once they are captured, they seem to maintain and even increase their interest in computing. This is true even when they do not continue participating. One of the implications of the discrepancy between aspirational expressions of interest (i.e. stating one is interested) and embodied expressions of interested (i.e. doing the activity) is that it diminishes the importance of continued opportunities in high school. One concern as computing experiences become more prevalent, particularly in the form of camps and workshops for children, is that if children get excited about computing at a young age but then have no opportunities for continued engagement such as high school classes or clubs that their interest will diminish. The results of this study suggest that as long as the interest is more than marginal – if adolescents express even a marginally positive interest – that the interest can be maintained even without the support of school opportunities.

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