Journal of Research in Technical Careers
May 2022, Vol. 6, No. 1

Why Computing? Motivations and Mathematics to Pursue Postsecondary CIS Education

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Computing and information sciences (CIS) careers in the United States are expected to grow faster than the average occupation between 2019 and 2029 and educational requirements for these positions span subbaccalaureate and baccalaureate degrees. Despite secondary curricular interventions, the population of people who pursue CIS pathways are not diverse by race, ethnicity, socioeconomic status, or gender. This study applies situated expectancy-value theory to investigate the motivational factors which influence the decision to pursue postsecondary CIS degree programs for students in the High School Longitudinal Study of 2009 (n = 18,730). Prior CIS experiences are associated with increased odds of declaring subbaccalaureate and baccalaureate CIS within three years of high school, but several math-related factors are associated only with pursuing baccalaureate CIS. These results have implications for designing interventions that encourage more students to pursue computing careers and understanding why students choose between two postsecondary educational paths.

Keywords: postsecondary, motivation, computer and information systems, situated expectancy-value theory

Introduction

Computing and Information Systems (CIS) occupations are among the fastest growing and highest paying occupations across the United States. CIS jobs requiring an associate's degree have a median salary over $50,000 and are expected to grow 8% between 2019 and 2029 (Bureau of Labor Statistics, U.S. Department of Labor, 2020); CIS jobs requiring a bachelor's degree like software developer have a median pay over $100,000 and are expected to grow 22% in the same time period (Bureau of Labor Statistics, 2021). Postsecondary CIS education at the subbaccalaureate and baccalaureate levels are filling a critical labor market need and preparing individuals for high paying occupations in the fast-growing CIS sector. Between 2010 and 2020, the number of CIS associate's degrees awarded each year dropped by 1% (National Center for Education Statistics, 2021a) though the number of CIS bachelor's degrees more the doubled

https://doi.org/10.9741/2578-2118.1112

(National Center for Education Statistics, 2021b). Given the high demand and pay in occupations aligned with both educational pathways, why has the number of young people choosing baccalaureate pathways grown dramatically but not in the subbaccalaureate pathway?

High school curricular offerings have responded to increased labor market demand for computing skills. In 2010-2011, 33% of high school students in California had access to at least one computer science course and, by 2018-2019, 79% did (Bruno & Lewis, 2021). While some of these courses have workforce development aims, others are designed for broader goals such as computing for equity and justice, developing literacy, and student engagement with schools (Jacob et al., 2022; Vogel et al., 2017). Some curricular reforms have explicitly responded to evidence suggesting that schools in low income communities and with high proportions of Black and Hispanic students have not had access to high quality STEM (Oakes, 1990) and computing (Margolis, 2008) education. Two examples of this type of reform include Advanced Placement Computer Science Principles (APCSP; Arpaci-Dusseau et al., 2013) and school-wide career academies themed around information technology career clusters (Orr et al., 2003). The College Board and local school districts explicitly designed reforms to prepare more students for postsecondary CIS pathways, especially populations currently underrepresented in computing professions by race, ethnicity, gender, and family socioeconomic status (SES).

These efforts at the secondary level have not yet improved the diversity of who enrolls in postsecondary CIS educational pathways. People who identify as Black and Hispanic are underrepresented among subbaccalaureate CIS associate's degree and certificate seekers (Hudson, 2018) and overrepresented in the community and technical college student population (Ma & Baum, 2016). Subbaccalaureate CIS students are also more likely to come from families in the top 25% of family income compared to their institutional peers (Hudson, 2018). Between 2008 and 2018, the share of Black computer science bachelor's degrees decreased from 11% to 8%, and the share for Hispanic or Latino students increased from 8% to 11% (National Center for Science and Engineering Statistics, 2021). In 2008, 18% of computer science bachelor's degrees were awarded to women and 20% by 2018 despite more than doubling the total number of degree awardees (National Center for Science and Engineering Statistics, 2021). The number of students in high school computing classes and pursuing postsecondary CIS degrees has increased but the sociodemographic profile of students who choose these pathways remains largely unchanged.

Both educational pathways prepare students with high demand skills for high paying occupations in fast growing fields. The subbaccalaureate pathway is also a transfer pathway given that 18% of STEM bachelor's degree holders have an associate's degree (National Science Board, 2019). Today, computer science education in K-12 has a unique position among technical education subjects because it is framed as a high status academic subject like math and science (Rafalow & Puckett, 2022). However, computer science education in K-12 began as a Career and Technical Education (CTE) subject and subbaccalaureate pathways in computer are still governed by CTE. Technical education pathways through secondary and postsecondary CTE have historically been conceived as separate and lower status tracks of education. There are efforts to elevate the status of CTE, similar to computer science, arguing that it prepares students for high pay, high growth occupational opportunities, but it is unclear how the sentiment persists among students, schools, communities.

This paper focuses on which factors influence young people to choose postsecondary CIS educational pathways after high school and how those factors differ for students who select associate's degree, certificate, or non-degree programs (subbaccalaureate) and four-year degree programs (baccalaureate) within three years of high school graduation. This evidence is important to understand how to identify and scale high school curricular interventions to develop and support postsecondary CIS interest and attainment for all students. This paper is organized around two research questions:

1. Which factors influence high school students' choice to enroll in postsecondary CIS education within three years of high school graduation?
2. How do these factors differ between students who choose subbaccalaureate and baccalaureate degree programs?

The primary data in this study come from the High School Longitudinal Study of 2009 (HSLS:09). This nationally representative dataset follows a cohort of high school freshmen in 2009 over time and links high school experiences and future aspirations with postsecondary education enrollment outcomes in 2016. Students in the cohort can be identified as declaring a baccalaureate or subbaccalaureate CIS program of study. The data are analyzed in a multinomial logistic regression model using situated expectancy-value theory to identify the motivational factors associated with increased odds of choosing either pathway. The results indicate that having family members in CIS occupations, increased math aptitude, and interest in CIS occupations are associated with increased odds of postsecondary CIS concentration for all students. Subbaccalaureate concentrators are more likely to come from lower income backgrounds and not taken upper-level mathematics in high school. Baccalaureate concentrators are more likely to have taken upper-level mathematics in high school and two affective constructs (expectancy of success and attainment value) are associated with odds of concentration. These results indicate differences in math preparation for both groups and suggest that experiences with high school mathematics are particularly influential on determining postsecondary choices for students interested in CIS. The paper concludes by suggesting future work to interrogate how mathematics experiences might be limiting factors to pursue postsecondary CIS pathways and how to leverage longitudinal datasets to examine how students transition from high school to postsecondary education.

Literature Review

The literature review draws from the prior investigations of the motivational factors which influence students to choose postsecondary CIS concentrations. This study explores the association between high school measures and postsecondary enrollment—two bodies of evidence that have not been previously explored together. Nearly all the extant literature identifies motivational factors from retrospective studies of students who already chose postsecondary CIS education. Literature from secondary computing education research uses surrogate variables like task interest or future career aspirations to identify motivational factors for students who expect to continue in computing college and career pathways. This study brings together these perspectives to conduct a longitudinal analysis of students who select postsecondary CIS educational pathways.

A recent report concluded that personally and professionally authentic computing tasks are an important strategy to increase CIS-related task engagement and intrinsic value in K-12 students (National Academies of Sciences, Engineering, and Medicine, 2021). The report claims that identity-reaffirming experiences with computing in K-12 education will develop subject interest and increase the likelihood of future task engagement like pursuing postsecondary education in CIS. Personal authenticity is related to a student's identity, while professional authenticity is more closely associated with career aspirations. Constructs like career aspiration, subject matter interest, domain identity, and perceived course utility in high school influence whether students choose to continue engaging in CIS after high school and are included as part of this study.

There is little extant literature on the motivations to pursue subbaccalaureate CIS degrees. One study of California community college students reported that women were more likely to have another degree and work experience in the field and men were more likely to declare their intent to transfer to a four-year university after degree completion (Werner et al., 2012). A follow-up study with the same population found that interest in CIS postsecondary pathways was developed outside of formal school settings and that intrinsic value in programming was associated with intent to continue from a two-year to four-year degree program (Denner et al., 2015). While CIS concentrators at two-year colleges tend to come from higher income families than relative to other students at their colleges (Hudson, 2018), their family SES is still less than CIS majors who first enter a four-year college (Blaney, 2020) suggesting this is a key variable to investigate. At the baccalaureate level, the motivational factors to pursue computer science degrees include intrinsic and utility values in the coursework (Säde et al., 2019). These retroactive studies of students who already chose postsecondary CIS pathways reaffirm the logic of the National Academies report (2021) that students need opportunities to identify and develop personal value in computing professions during high school in order to persist in computing educational pathways. Furthermore, students who pursue two-year and four-year degree pathways have different motivations and that, at least among subbaccalaureate concentrators, men and women ascribe different motivations to their choice.

> Out-of-school opportunities with CIS also influence degree intentions. In related technical fields, these opportunities are associated with the presence of local industry (Bell et al., 2019) so students who live in communities with high concentrations of CIS professionals should be more likely to pursue postsecondary CIS education. However, an analysis of high-school coursetaking patterns indicates that, "there is a significant negative relationship between local IT employment and [secondary CIS] concentrations" (Sublett & Griffith, 2019, p. 21). These results suggest a theoretical link between geography (urbanicity and census region) and students to pursue postsecondary CIS education, but the

secondary education results are contradictory and important to include in this study. As critical socializers, parents employed in STEM fields increase the odds of STEM high school coursetaking (Plasman et al., 2021) and selecting college STEM majors (Moakler & Kim, 2014) so the same is expected for both postsecondary CIS pathways justifying their inclusion in this study.

Given the growth of high school computing course offerings, it is important to consider how they influence postsecondary CIS education choices. A recent investigation of AP CS coursetaking indicates that taking AP CS A is positively associated with intent to major in CS (Sax et al., 2022). However, a qualitative study of high school students observed that students chose AP CS coursework because they see computing skills relevant to other occupational interests like law or art (Jones & Hite, 2020). Students develop interest in computing through high school coursetaking, but they may see it as a complimentary skill and not choose postsecondary CIS concentrations. These observations resonate with a growing trend that computing is ubiquitous in our personal and professional lives. Computing skills are often embedded in other disciplinary courses like science (Weintrop et al., 2016) indicating that CIS degree programs are not the only way to develop skills and pursue computing occupations. However, prior longitudinal studies indicate that disciplinary interests may be more influential than high school coursetaking in STEM-related major selection (Maltese & Tai, 2011). This study includes students' interest in CIS-specific college and career pathways as well as high school CIS coursetaking as independent variables.

High school mathematics also plays an important role in student selection of postsecondary CIS pathways. Computing fields of study grew from mathematics and nearly all postsecondary degree programs require at least calculus and probability/statistics coursework (Baldwin et al., 2013). However, a survey of recent computing graduates employed in the profession indicates that calculus was among the least important skills taught in college (Exter et al., 2018). Degree programs could reconsider the role of mathematics because these courses can be a barrier to degree attainment. For example, subbaccalaureate students who place into developmental math (trigonometry or lower) are less likely to complete STEM courses, to complete degree programs, or transfer to baccalaureate programs (Park & Ngo, 2021). This evidence suggests that even at community and technical colleges, informed students with less math preparation may struggle in CIS pathways and could be less likely to choose them.

There has been less attention paid to the relationship between the affective experience in math class and postsecondary CIS choice, but closely related STEM field offer some clues. A study of motivations to pursue STEM college and career pathways found, "[h]igher values of mathematics attainment value increased the odds of a student planning for a STEM career at the bachelor's level, and no significant impact on STEM careers that do not require a bachelor's degree" (Gottlieb, 2018, p. 21). These results indicate that math attainment value, similar to math identity, may be associated with baccalaureate CIS intentions but not subbaccalaureate. Thus, including math-specific constructs in this study which measures students' experiences in math class may point to differences between students who selected subbaccalaureate and baccalaureate CIS pathways.

Theoretical Framework

Situated expectancy-value theory (SEVT) models how student persistence and performance in achievement-related tasks are associated two constructs: expectancy of success and subjective task value (Eccles & Wigfield, 2020). Expectancy of success describes the degree to which an individual believes they have a chance for success in a particular task (Wigfield & Eccles, 2000). The more one believes they have a chance for success, they more likely they are to pursue that task (Wang & Degol, 2013). Expectancy of success is informed by one’s social and cultural context as well as how the individual interprets prior experiences with the task (Wigfield & Eccles, 2000). For example, individuals who interpret task failure as lack of ability have low expectancy for future success but those who interpret past failures as opportunities for learning see failures as contributing to positive expectancy of success. Expectancy of success is similar to Bandura’s (1977) concept of self-efficacy (Wigfield, 1994).

Subjective task value is comprised of four constructs: attainment value, intrinsic value, utility value, and cost. Attainment value is defined as, “the importance of doing well on a task” (Wigfield & Eccles, 1992, p. 16) and closely associated with domain self-concept and identity (Wang & Degol, 2013; Wigfield & Eccles, 2000). Intrinsic value is developed through prior task engagement in the same domain. For example, analysis of a large-scale career interest survey showed that students who participated in computing competitions in high school were significantly more likely be interested in computer science careers at the end of high school compared to students who participate in STEM-related competitions in other subjects (Miller et al., 2018). Utility value is derived from the specific facts relating to the task to individual goals and rewards. The utility value of educational pathways in computing careers (alignment with high paying and high status careers) is often communicated to students as a key motivational factor for enrollment. Cost accounts for negative value associated with engaging in a task (Wigfield & Eccles, 2000). In an academic context, degree program choices are often zero sum, so students cost accounts for the other degree or certificate pathways they exclude. Furthermore, pursuing certain educational pathways can represent a significant emotional or effort costs to some students. For example, African American students who pursue STEM degrees can be subject to racial microaggressions and stereotype threat which, for some students, comes at a significant cost due to the emotional energy and time needed to deal with these issues (McGee, 2016).

SEVT is often applied to investigate why students choose or avoid STEM-related achievement-related tasks. HSLS:09 survey items, for example, apply this framework to investigate STEM persistence and attainment (Ingels et al., 2015). In the domain of computing, SEVT has been applied to examine high school CS coursetaking choices (Jones & Hite, 2020) and retroactive studies investigate the motivational factors of students who chose to persist into CIS postsecondary education (Dickhäuser & Stiensmeier-Pelster, 2003; Zarrett & Malanchuk, 2005). These prior studies indicate that including the SEVT constructs, especially in the context of mathematics, should be associated with increased odds of selecting postsecondary CIS pathways.

Data and Methods

The data for this study come from the restricted-use HSLS:09 dataset (Ingels et al., 2015) which follows a nationally representative sample of over 20,000 US students who were in the 9th grade in 2009. The study was designed to "…allow researchers …to examine motivation, achievement, and persistence in STEM course taking and careers" (Ingels et al., 2011, p. 10). The dataset contains responses from student and parent surveys administered in 2009, 2013, and 2016. The data are also linked with high school transcripts collected in 2013. At each stage of data collection, missing data on the included variables is not ignorable, ranging from 0.2% to 32.7%, so multiple imputations in Stata 16 (StataCorp, 2019) was used to retain some of the statistical power in this analysis.

Dependent Variable. The dependent variable is whether the student declared their primary degree or certificate in CIS at either the subbaccalaureate (certificate or AA) or baccalaureate level as reported on the 2016 student follow-up survey. The outcome variable is measured three years after the population completed their fourth year of high school. Students who did not directly enroll in postsecondary education, changed their major, did not complete their intended degree program, or transferred from a two-year to four-year program are not captured in this analysis.

Independent Variables. The factors included for analysis as independent variables are included in Table 1 and selected based on the evidence presented in the literature review section. Personal factors in the model include gender, race/ethnicity, urbanicity, census region, family SES, and whether the student has at least one parent in a STEM occupation as reported in the first survey wave in 2009. Math aptitude was measured in a test administered as part of the grade nine student survey and whether the student aspired to a CIS occupation at grade 30. Gender, race/ethnicity, urbanicity, interest in CIS, and parents in CIS occupations were comparable between groups, the baccalaureate concentrators come from higher income families, have higher math aptitude scores. The high school transcript collected in 2013-2014 was used to create a binary variable indicating if the student's highest math course was at least trigonometry indicating that they were prepared for college-level math. About half of the subbaccalaureate concentrators took trigonometry or higher and more than 90% of the baccalaureate concentrators did.

The SEVT constructs are measured in the domain of ninth grade math class given the importance of mathematics preparation for higher education in CIS fields. The expectancy of success, attainment value, intrinsic value, and utility value scales were comprised of four-point Likert-type items created and validated by the HSLS:09 administrators and normed to have a mean of 0 and standard deviation of 1 (Ingels et al., 2011). The cost scale was constructed and normed from three items in accordance with prior research applying SEVT to analyze the HSLS:09 dataset (Andersen & Ward, 2014; Gottlieb, 2018). Both groups report above average means on the SEVT constructs relative to the full sample though baccalaureate concentrators measure higher.

Table 1

Descriptive Statistics of CIS-Declared Students

	Subbaccalaureate CIS (n = 210)		Baccalaureate CIS (n = 290)	
	mean	SD	mean	SD
Female	0.145		0.199	
Race and Ethnicity				
Asian	0.143		0.229	
Black or African-American	0.079		0.089	
Hispanic	0.177		0.089	
White, Non-Hispanic	0.488		0.539	
SES	-0.095	0.67	0.436	0.73
Math Aptitude (grade 9)	51.97	8.9	59.7	9.46
Parent in CIS	0.053		0.115	
IT Concentrator in HS	0.157		0.262	
Expect CIS Occupation at 30	0.119		0.143	
Highest Math at least Trig	0.525		0.906	
STEM Cost	0.144	1.05	-0.129	0.896
Math Attainment Value	0.171	0.94	0.654	0.926
Math Intrinsic Value	0.1	1.1	0.402	0.927
Math Utility Value	0.151	1	0.224	0.802
Math Expectancy of Success	0.222	1.03	0.4	0.966
Urbanicity				
City	0.271		0.329	
Suburb	0.401		0.413	
Town	0.097		0.091	
Rural	0.232		0.168	
Census Region				
Northeast	0.164		0.206	
Midwest	0.256		0.315	
South	0.401		0.325	
West	0.179		0.154	

Research question 1 is addressed using a multinomial logistic regression (n=18,730) comparing the two outcomes, subbaccalaureate CIS and baccalaureate CIS declaration, to the base level of not declaring a postsecondary CIS concentration. The model was built hierarchically first including only the sociodemographic variables, then including the math/computing variables, and then the SEVT factors. To investigate research question 2, the statistically significant odds ratios (OR) in the logistic regression model across the two educational pathways indicate differences in factors associated with pathways selection.

Results

The odds ratio for gender in both categories was less than one indicating females had decreased likelihood of declaring a CIS concentration. Having a parent in a CIS occupation (OR = 2.04, $p<.01$ for subbaccalaureate and OR = 2.21, $p<.001$ for baccalaureate), concentrating in CIS during high school (OR = 3.30, $p<.001$ for subbaccalaureate and OR = 6.65, $p<.001$ for baccalaureate level), aspiring to a CIS occupation by age 30 (OR = 4.95, $p<.001$ for subbaccalaureate level and OR = 4.44, $p<.001$ for the baccalaureate level), and math aptitude in grade nine (for subbaccalaureate OR = 1.03, $p<.001$, and at the baccalaureate level OR = 1.06, $p<.001$) were all associated with increased odds of choosing either postsecondary CIS pathway after high school.

Regarding research question 2, some of the factors were statistically significant for one outcome category but not the other. Having a higher SES decreased the likelihood of declaring a CIS major at the subbaccalaureate level (OR = .746, $p<.01$) but was not statistically significant at the baccalaureate level. Having a highest math class of at least trigonometry was also associated with decreased odds of subbaccalaureate CIS (OR =.722, $p<.05$). At the baccalaureate level, more factors were statistically significant include having the highest math class in high school at least trigonometry (OR = 3.11, $p<.001$), going to high school in the South compared to the Northeast (OR = .512, $p<.001$), math expectancy of success (OR =.784, $p<.05$), and math attainment value (OR = 1.30, $p<.05$).

Discussion

The data analysis identifies factors which influence whether a student chooses postsecondary CIS and how those factors differ for students who choose subbaccalaureate and baccalaureate pathways. The results are largely in agreement with prior literature investigating different students' motivations to pursue postsecondary CIS pathways. The longitudinal data sheds light on the link between high school and near-term postsecondary CIS choices. The comparison between baccalaureate and subbaccalaureate concentrators provides additional insight into how different experiences in high school influences students to select one pathway or the other. These results have theoretical implications for understanding how SEVT can be used with longitudinal data to model postsecondary degree choices. Finally, these results suggest that high schools must consider how students gain access to high quality mathematics instruction and the role of mathematics in postsecondary CIS degree programs to ensure computing career-interested students are choosing between these pathways rather than being limited by their prior experiences.

Motivational Factors for Postsecondary CIS. ***Regional Effects***. The null results for urbanicity indicate the postsecondary CIS coursetaking is more similar to patterns to secondary CIS course offerings which are not associated with local labor market (Sublett & Griffith, 2019) and contrasts with the way other STEM-related majors are influenced by local industry. Computing skills occupy a unique space in that they are relevant across many occupations and industries. High concentrations of IT-businesses, even for subbaccalaureate concentrators where more education-industry alignment is expected given the aims of postsecondary CTE, alone do not seem to factor into student postsecondary choices.

Family SES. The family SES results confirm general trends observed amongst CIS concentrators (Blaney, 2020; Hudson, 2018). Given the access to high paying, high demand occupations associated with subbaccalaureate CIS credentials, the observation that increased SES decreases odds of concentration means that students in these pathways may see them as levers for social mobility in a short time relative to other postsecondary education opportunities. More research is necessary to understand the student's perspective—especially because no association was observed for baccalaureate CIS concentrators. The P-TECH school model is among a number of school innovations designed for students from low SES backgrounds to take early college classes in a technical field by organizing the curriculum around the labor market needs (often in computing) of an industry partner like IBM (Litow & Kelley, 2021). These models were constructed from the logic of the Pathways to Prosperity report (Symonds et al., 2011) which argues that linking high school with subbaccalaureate certificates and degrees prepares students for jobs in high paying professions and they can continue educational and career advancement over time. Early program evaluation results show no effect on math achievement by year 3 in a New York City P-TECH school (Rosen et al., 2020) indicating that these efforts may be subtly limiting students to subbaccalaureate pathways given this findings about mathematics preparation presented in this analysis. However, it is too early to make conclusions on longer-term pathways outcomes of interest like postsecondary CIS degree enrollment, workforce attainment, or student social mobility the program was designed for.

High School CIS Concentration. A similar, positive relationship between high school CIS concentration (earning at least two credits) and postsecondary CIS choices is also observed in engineering (Gottfried & Plasman, 2018). These courses are an important experience which develop interest and aptitude in the subject matter motivating students to select postsecondary CIS pathways. The magnitude of the odds ratio for baccalaureate concentrators, however, is nearly twice the magnitude for subbaccalaureate concentrators. This is a phenomenon for future research and could reveal important differences in how the course content and pedagogy are aligned with different computing postsecondary education options.

Parent Occupation. The influence of parents working in the occupation on their children's postsecondary education experience is seen in related technical fields (Plasman et al., 2021; Smit et al., 2020). The SEVT model demonstrates that parents, as primary socializers, should have a large influence on how students choose achievement-related tasks such as postsecondary institutions and degree programs. While prior research found that parent occupation had no impact on CIS career aspirations (Zarrett & Malanchuk, 2005), those data were collected ten years prior to HSLS:09 so the findings have limited transferability due to the rapid increase of computing technology and professions after that time. The results of this analysis support the claim the prior experiences with computing outside of the classroom are influential factors associated with students pursuing CIS educational pathways after high school.

High School Math Preparation. Given the importance of math preparation for postsecondary education attainment, the observed associations between selecting a CIS concentration and both math preparation variables is an important findings. Both groups had a small but positive association with ninth grade math aptitude meaning that students appropriately factor in their math skill associated with their postsecondary choice. The highest math class being at least trigonometry was associated with increased odds to pursue the baccalaureate pathway and decreased odds of subbaccalaureate pathways. Students who have the prerequisite coursework for the college-level statistics or calculus classes immediately after high school may be more inclined to select four-year degree pathways while the subbaccalaureate concentrators may be limited in their postsecondary institution choice by the prior mathematics course taking. The subbaccalaureate CIS concentration can be a space to improve math skills and a steppingstone to a four-year CIS degree in addition to an educational opportunity to prepare for different occupational opportunities. While math prerequisites are a limiting factor, odds of CIS concentration in either pathway were positively associated with aspiring to a CIS occupation at age thirty. How can the education system ensure that students with equal aspirations in grade nine have equal opportunities after grade twelve?

High School Math SEVT Constructs. None of the SEVT constructs were associated with odds of subbaccalaureate concentration though baccalaureate-level concentration was significantly associated with two. Higher math attainment value increased the likelihood of baccalaureate students to declare CIS while higher math expectancy of success decreased likelihood. The attainment value result is similar to what Gottlieb (2018) observed for STEM-related career pathway intentions sorted by educational requirement (two-year vs. four-year degree). Increased expectancy of success in math class was associated with decreased odds of baccalaureate CIS concentration. The high attainment value, low expectancy of success in math profile indicates the student takes on the identity of a "math person" but is not expecting success in math coursework. This is a complex interaction to explore further since SEVT suggests the two constructs should be positively associated with each other.

The lack of utility value significance can be explained by considering differences between math and CIS domains. High school students who take computer science courses describe its utility across multiple college and career pathways rather than specific computer science occupations (Jones & Hite, 2020). Students in this study live in a rapidly changing occupational landscape where computational literacy is critical for nearly all occupations. Sax et al. (2022) found that the programming-heavy AP Computer Science A course was a much better predictor of declaring a computing major than AP Computer Science Principles which was designed to introduce students to the breadth of computing. This evidence supports the choices other researchers have made to define programming as the key task associated with postsecondary CIS education. Instruments designed to measure SEVT constructs in the computing domain with programming-specific items find that all SEVT constructs are associated with increased odds of future CIS task engagement. However, given the importance of mathematics for future success in postsecondary CIS education, more research is needed to understand how math class can be better situated as having utility value for CIS-aspiring students.

SEVT and STEM-Related Pathways. Prior research using SEVT to investigate STEM-related career pathways operationalizes task engagement with surrogate measures like career aspirations (Gottlieb, 2018) or coursetaking intentions (Smit et al., 2020) measured at the same time as the SEVT constructs. As a result, the dependent variable has less validity compared to this study which measured student outcomes three years after high school graduation. However, a limitation of the study presented here is that the constructs included in this study were too far apart in time from the task choice used as the outcome variable which limited that predictive validity of SEVT. This effect may account for the lack of observed association between the SEVT variables and selecting CIS pathways. These constructs are dynamic throughout adolescence (Hsieh & Simpkins, 2022) and future research should consider how to design research which balances between construct validity of the dependent variable and time-variance of the SEVT constructs.

Another interpretation of these results is that measuring SEVT constructs in the context of high school mathematics courses does not adequately capture the subjective task value students ascribe to postsecondary CIS pathways. Prior research has argued that the HSLS:09 survey items are insufficient to capture the applied nature of STEM courses (Andersen & Ward, 2014). Furthermore When STEM education is defined more broadly than high school math and science experiences to prepare for four-year mathematics, science, and engineering degrees, the HSLS:09 SEVT items have diminished explanatory power (Gottlieb, 2018). While some definitions of STEM education now include computing (e.g., Committee on STEM Education, 2018), these findings are additional evidence that a narrow focus on the classroom experience in secondary math and science is necessary but insufficient to fully identify factors which influence students to pursue postsecondary CIS education.

Mathematics as a Limiting Factor into Postsecondary CIS. Subbaccalaureate and baccalaureate CIS degrees prepare students for high paying, high demand occupations. This research demonstrates that high school coursetaking and associated experiences in computing and mathematics are key determinants of which computing education pathway students might pursue after high school. This project raises important theoretical considerations about how to appropriately measure SEVT constructs to investigate postsecondary CIS coursetaking. Furthermore, it raises critical questions about how to design educational systems which support students access to high quality mathematics and computing learning experiences during high school so they can develop and pursue interests in computing occupations later in life.

The K-12 education system must respond to a key finding that future career aspirations observed in grade nine is associated with increased odds of both postsecondary CIS pathways. This finding supports the calls of other scholars (e.g., Godbey & Gordon, 2019) to develop middle school interventions for students in order to increase the diversity of CIS postsecondary concentrators. High school math course taking, and affective experiences in those courses which influence the SEVT constructs, play a significant role in aspiring to CIS degrees and selecting between the subbaccalaureate or baccalaureate levels. Schools must create systems to students match appropriate coursework and academic supports with their educational and career aspirations to ensure postsecondary choices are not limited by high school coursetaking. Secondary school curriculum which explicitly integrate computer science and computational thinking into other disciplines (Weintrop et al., 2016) are promising approaches to create positive computing experiences and connect the utility value of other domains with their interests in computing occupations.

Secondary school systems can also directly address family poverty levels which have historically been a determinant of access to differential computing pathways in high school (Oakes, 1990). Early college STEM high schools have been tightly coupled with subbaccalaureate educational pathways directly after high school though offered primarily in communities with a high percentage of students of color and low income students rather than as a pathway for all students (Morales-Doyle & Gutstein, 2019). Data from California indicate that while 8% of low income schools offer the most rigorous AP computing course, Computer Science A, 32% of high income schools do (Scott et al., 2019) further demonstrating this disparity in access to the factors which are differentially associated with subbaccalaureate and baccalaureate CIS education. While access to high school computing coursework is increasing, high school students may have access to different courses and some of these courses may be more aligned with either subbaccalaureate or baccalaureate educational pathways. Future research should investigate between- and within-school mechanisms which sorts students into different postsecondary CIS pathways early in high school regardless of student career aspiration.

Finally, these results prompt postsecondary institutions to consider the role of mathematics in their CIS curriculum and admissions practices. Early career professionals cite that calculus is among the least valuable technical skills they learned in college (Exter et al., 2018) so this course may be an unnecessary burden for many students. Ongoing efforts in higher education are aiming to disrupt the traditionally valued the algebra-to-calculus math pathway in high school which limits access to meaningful mathematics education and educational pathways (Barnett et al., 2022). This important line of work can influence broader systems changes and enable broader access to postsecondary CIS education.

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