Student Computer Science Self-efficacy, Interest, and Task Value, in Grades K-8

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Abstract: This research focused on documenting student computer science (CS) interest, value, and self-efficacy across K-8 grade levels. It also examined differences between various student subgroups. The research questions were:

1. Are there differences in K-8 students' ratings of CS interest, task value, and self-efficacy?
2. How does interest, task value, and self-efficacy change across grades K-8?
3. Are there differential effects depending on student gender, ethnicity, and locale (rural/urban)?

Results showed a continuing decline in the three student outcomes across grades, mirroring the larger body of STEM research. Students' perception of the value of computer science was significantly higher than their interest, which in turn was higher than their self-efficacy. This result suggests that student recognize the importance of CS and find it fun, but not easy. Moderation results showed no gender differences at the elementary level, but significantly higher middle school results for males on CS interest and self-efficacy. Ethnicity findings tended to favor majority (white) students, with the exception that grade 6 – 8 minority students had significantly higher interest ratings. Urban students had significantly higher results for all three outcomes at grades K-3 and 6 -8. The research extends research documenting the decrease of adolescent student STEM interest by focusing specifically on computer science and including results at the elementary level.

Introduction

Children and youth are quick to embrace digital technology, including mobile phones, computers, puzzles and games. This appeal offers the opportunity to introduce computational thinking as a logical way of thinking, with or without the assistance of computers, with solutions that are reusable in different contexts (Shute, 2017) and to promote students' interest to continue computer science (CS) learning. Since career development research suggests that children's career aspirations begin in childhood and transition to the adolescent years where they are targeting career paths (May, Wendt, Barthlow, 2022; Tran, 2018), it would seem that early exposure to CS is needed to create awareness and to cultivate positive attitudes. Experiencing CS in elementary and middle school grades places students on a path to develop needed knowledge, skills, and attitudes to position them as future CS students and ultimately for the 21st century workplace (Beyer, 2014).

Despite this proposed trajectory, there is considerable research documenting that adolescents *lose* interest in STEM, with fewer students enrolling in STEM subjects in high school and even fewer continuing to major in STEM fields

in college (Potvin & Hasin, 2014; Institute of Engineering and Technology, 2019). However, most of this research has been conducted with secondary school students and has not specifically included computer science. An exception is a nationwide study by Google and Gallup (2017) that showed that grade seven boys and girls have a similar level of interest in learning CS. However, girls' interest decreases between ages 12 and 14, while boys' increases. Both boys and girls then show an interest decrease between ages 15 to 18. A summer 2020 study conducted through CSTA reported that 21% of the 3700 K-12 CS teachers believed that student interest in computer science was a major challenge, and the proportion increased incrementally with grade level and at lower income schools (Koshy, *et al.,* 2021).

Gender differences have also been found for CS self-efficacy. Recent research examining gender differences for middle and upper elementary students' CS self-efficacy showed that males scored higher than females (Nugent, et al., 2019; Phillips & Brooks, 2017; Vandenberg, et al., 2021). The Vandenberg study also examined differences for race/ethnicity and found no significant difference.

This study extends these previous results by involving a large age group of students (K-8) and examining moderating effects for various student subgroups. The study is grounded in social cognitive career theory (SCCT; Lent, Brown, & Hackett, 1994) which delineates relationships among variables that form the basis of career development. Based on Bandura's (l986) social cognitive theory, self-efficacy is viewed as a predictor of career orientation within SCCT, with the argument that students are more likely to pursue careers where they are confident of their capabilities and less likely to be drawn to careers where they doubt their skills and performance. Youth interest , or 'liking for' (Lent, Lopez, Lopez, & Sheu, 2008) academic subjects, also influences career orientation. Research has shown that an early interest in STEM topics is a predictor for later learning and/or eventual career interests and choices (DeBacker & Nelson, 1999; Organisation for Economic Co-operation and Development, 2007).

Methodology

The research questions addressed in this study are:

1. Are there differences in K-8 students' ratings of CS interest, task value, and self-efficacy?
2. How does student computer science interest, task value, and self-efficacy change across grades K-8?
3. Are there differential effects depending on student gender, ethnicity, and locale (urban/rural)?

Participants were 494 students (127 in K-3; 131 in 4-5 and 236 in 6 – 8) from a Midwestern state with teachers involved in an NSF *CS for ALL* project. The teachers participated in computer science professional development and delivered grade-level appropriate CS curriculum during the following school year (Nugent, et al., 2022). There was an even split between male and female students. Sixty-five percent of students were white; 35% minority. Seventy percent were from rural/town locales; 30% from urban locations as categorized using U.S. Department of Education locale designations (https://nces.ed.gov/surveys/ruraled/definitions.asp).

Research Design and Data Analysis: This study used a cross-sectional design, and data were collected after the students completed their computer science course at each grade level. Descriptive statistics were calculated for each of the three student outcomes. To provide information on moderating differences between grade levels, the students were divided into three age groups: K-3, 4-5, and 6-8 basically reflecting lower elementary, upper elementary, and middle school. Student outcome means at each of these grade levels were then compared using one-way ANOVA statistics with post hoc Tukey tests. Moderation analyses for gender, ethnicity and locale by grade band were analyzed using two-way ANOVAs.

Instrumentation: Most student instruments measuring CS interest, task value, and self-efficacy have been developed for college or high school audiences. A comprehensive review of CS instrumentation (Decker & McGill, 2019) showed that only 18% of instruments targeted students in K-8, with only 6% at K-5. A project review of instruments was conducted to identify those measuring our target outcomes and appropriate for K-8 to provide guidance for instrument development (Ericson & McKlin, 2012; Grover, Pea, & Cooper, 2016 ; Outlier Research & Evaluation, 2017, Vandenberg, et al., 2021).

Final items used a four-point Likert scale of *strongly agree*, *agree*, *disagree*, and *strongly disagree*. The interest questions focused on student's perception of CS as *fun*; task value on CS *importance*. Self-efficacy questions included items such as "I can figure out problems in computer science class." Experienced CS teacher leaders reviewed the items to assure their appropriateness and relevance for the target audience and curriculum. Basic demographic information of gender and ethnicity (majority/minority) was also collected, although ethnicity information could not be obtained for K-3. In addition, because of the lack of reading fluency of K-3 students, a subset of the grade 4-8 questions was presented online with voice-over narration and smiley faces pictorial prompts. The overall Cronbach Alpha measure for instrument reliability was .93; separate alphas were interest, .87; task value, .89, and self-efficacy, .88.

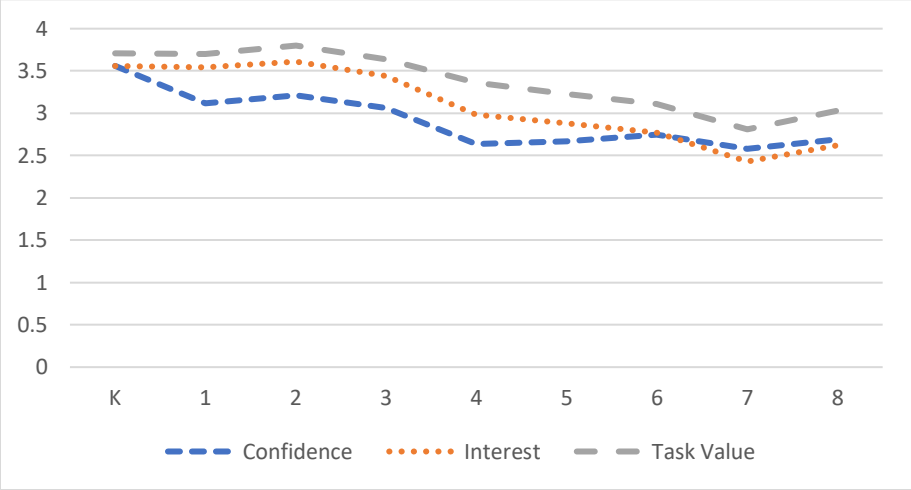
Results

Results are organized by research question:

1. Are there differences in student ratings of interest, task value, and self-efficacy?

Figure 1 shows a graph for all three student outcomes by grade level. Students consistently rated the value of CS highest, followed by interest and self-efficacy. Statistical comparisons confirmed that task value was significantly higher than interest ($p < .001$), and interest was significantly higher than self-efficacy ($p < .001$).

Figure 1. Student outcomes across grade levels



2. How does student computer science interest, task value, and self-efficacy change across grades K-8?

Figure 1 shows gradual decreases in all outcomes across grade levels, with the exception of slight increases at grades 7 – 8, where computer science was an elective course for this sample of students. More specific comparisons for each of the CS constructs across grade bands (K-3, 4-5, and 6-8) showed that K-3 self-efficacy, interest and task value ratings were significantly higher than grades 4 -5 and 6–8 ($p < .001$). Grades 4–5 interest and task value were significantly higher than grades 6–8 ($p < .001$), but not for self-efficacy.

3. Are there differential effects depending on student gender, ethnicity, locale?

Gender: There was a significant gender by grade level interaction for interest ($F(2,214) = 4.67$ $p < .05$), and self-efficacy approached significance ($F(2,517) = 2.91$, $p = .05$). Follow-up tests for the separate grade bands showed that there were no significant K-3 and 4-5 differences between males and females for all three outcome variables. However, grade 6 – 8 males' scores were significantly higher than females for interest ($t(236) = 2.33$, $p < .05$) and self-efficacy ($t(236) = 3.04$, $p < .01$). There was no gender difference at grades 6-8 for task value.

Ethnicity: The overall interaction effect for grade by ethnicity (majority/minority) was significant for interest ($F(1,385) = 10.654$, $p < .001$) and task value ($F(1,385) = 6.99$, $p < .01$), but not self-efficacy. The grade 4-5 majority group scored significantly higher than minority for interest ($t(145) = 2.77$, $p < .01$) and task value ($t(145) = 2.32$, $p < .05$), and the difference for self-efficacy approached significance at $p = .06$. Grades 6–8 minority students scored significantly higher on interest ($t(240) = 2.09$, $p < .05$), but there was no significant difference between groups for self-efficacy and task value.

Locale: The interaction for grade level by locale (urban/rural) was significant for all three outcomes: interest: ($F(2,522) = 4.85$, $p < .01$), task value ($F(2,522) = 5.79$, $p < .01$), self-efficacy: ($F(2,522) = 3.74$, $p < .05$.) Follow-up tests for K-3 showed significantly higher urban ratings on one outcome: task value ($t(136) = 2.32$, $p < .05$). There were no significant effects for grades 4–5. However, in grades 6–8 urban students scored higher for all outcomes: interest: $t(240) = 4.61$, $p < .001$, task value: $t(240) = 3.93$, $p <.001$, and self-efficacy: $t(240) = 4.84$, $p < .001$.

Discussion and Summary

STEM research examining the relationship between self-efficacy and interest within a SCCT perspective for middle school students has pointed to the need for investigating these relationships at various ages, suggesting that the relationships may well manifest themselves differently at a younger age (Nugent, et al., 2019). This research tracks the presence of these CS constructs across K-8, showing a continuing decline of CS interest, task value, and self-efficacy across grades, and mirroring the larger body of STEM research. However, student outcome ratings were consistently above the 2.5 scale midpoint, indicating positive CS attitudes and confidence. The overall higher ratings for task value suggest that students recognize the value of computer science to a greater extent than they have a personal interest in CS. Similarly, students' confidence in their CS abilities was lower than their interest and task value perception, particularly in the elementary grades. This result suggests that students recognize the importance of CS and find it fun, but not easy.

Although this research shows differential effects at the various grade bands, the steady downward trends suggest that these variables follow a consistent pattern in impacting career orientation. Follow-up analyses confirmed this positive relationship with correlations between self-efficacy and task value .52 ($p < .001$), self-efficacy and interest = .65 ($p = .001$) and task value and interest = .66 ($p < .001$). The decrease in interest may be influenced by students' decline in CS confidence as the difficulty of CS increases. Recent research with sixth graders has suggested that perceived difficulty may have a distinctive role in motivation (Nuutila, et al., 2021), with high perceived difficulty negatively influencing perception of task value and interest.

Moderation results showed that there was no difference in male and female interest, task value, and self-efficacy for the elementary students (K-5). At middle school males and females had similar perception of the value of CS, but consistent with previous research, males scored significantly higher on CS interest and self-efficacy. This result underscores the need to infuse gender appropriate pedagogical practices to insure that females develop the needed self-confidence.

The ethnicity results for grades 4–5 favored the majority (white) students on all three outcomes. In contrast, the 6–8 self-efficacy results showed a significant difference only for interest. These results differ from the Google/Gallup study which found that Black students were more likely than white students to feel they were skilled in the different topic areas and were more likely to be very confident they could learn CS (68% vs. 56%). However, our results are similar to the Google/Gallup study in that minority students had higher interest in learning CS – a result which holds promise for recruitment and retention of minority students.

The locale results tended to favor urban students, with significantly higher urban results at grades K-3 and 6–8. Findings could reflect urban students' greater access to computer resources outside of school and within the community. However, the lack of significant effects at grades 4–5 suggests a more nuanced effect at upper elementary.

Limitations

A limitation of this study is the cross-sectional design, conducted at a single point in time and which did not follow individuals across time. As such it provides preliminary descriptive evidence which can guide further studies, but it cannot establish causal relationships. Another limitation is that the first year of the study was impacted by COVID-related school closures, preventing data collection at certain time points. This reduced the sample size, and translated into limited power for the moderating results, where overall sample sizes had to be further divided into female/male, rural/urban, and minority/majority. Nevertheless, the specific research focus on K-8, where quantitative research is limited and where K-3 study is virtually non-existent, provides results that highlight areas for further investigation.

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