This document accompanies the Building An Operating System For Computer Science Education report developed by CEMSE and UEI at the University of Chicago by providing a summary of relevant research literature focusing on student attitudes about computer science (CS) education. This summary focuses on the processes by which students make course selections, their rationales for and against choosing CS coursework, and overall attitudes towards CS.

In compiling these resources, we searched databases including Web of Knowledge, ERIC, Google Scholar, and ACM Digital Library for key terms: ‘computer science’ and ‘high school,’ ‘computer science’ and ‘student attitudes,’ ‘computer science’ and ‘student perceptions,’ ‘computing’ and ‘attitudes,’ ‘high school’ and ‘course choices,’ ‘computer science’ and ‘course choices,’ and other related terms and combinations. The literature on student attitudes towards CS showed a heavy focus on gender differences—as this was not the focus of the current document, only a sample of this literature was included in the report. Little research is available on what motivates students to enroll in elective CS or technology-based classes, especially at the high school level, and much of what was found comes from outside the United States. Because of these limitations, the search was expanded to include studies of students’ course choices relating to elective mathematics and science courses. This is not intended to be a comprehensive review of the literature on students’ course-taking and course choices; rather, the focus here is on student perceptions of and attitudes towards CS, and students’ course choices as they relate to elective or advanced CS, math, and science courses.

A few caveats are certainly in order:

- The overall research base is thin.
- While it’s likely that there are similarities between high school and undergraduate attitudes about CS, equating the two likely isn’t appropriate.
- Similarly, while it’s safe to assume for now that CS operates like mathematics or science in terms of attitudes and motivation, it’s not entirely clear that it will.
- Contexts matter and these are general ideas, not specifics.
- As in any emerging or young field of study, contradictions are expected.
Implications for policy and for the field are not clear-cut, largely due to the incompleteness of the research base. Some of the references include recommendations about next steps to take, including the following:

- Schulte and Knobelsdorf (2007) suggest that supporting self-confidence in CS, classes is not enough — conceptual change is necessary so that all students see themselves as insiders.
- Yardi and Bruckman (2007) offer the following suggestions for computing courses: (a) The curriculum should be personally relevant to the student; (b) Students should be able to recognize a specific purpose for working on an assignment; (c) Students should perceive a real-world implication or relevant social application for an assignment.
- Barker, McDowell, and Kalahar (2009) advise that faculty focus on providing opportunities for student-student interactions within and outside of their classrooms (pair programming, group problem solving, group discussions and shared assignments are recommended).
- Biggers, Brauer, and Yilmaz (2008) identify ways to strengthen the student experience and increase student retention: (a) Implement an early and on-going way to present CS as more than coding; (b) Contextualize assignments and use real world issues; (c) Develop a community within the CS program that promotes social interaction for students and faculty; (d) Identify students’ needs before the program begins; develop a program that addresses these needs.
- Bøe (2012), on the topic of improving participation in mathematics, advocates for promoting higher future expectations and setting higher levels of parent involvement, both of which are equally applicable to CS education.

Ultimately, the safest conclusion here is that more research is needed. Current research about course-taking patterns in high school — particularly in the STEM disciplines — is limited.

**HOW DO STUDENTS CHOOSE COURSES?**

**▼ Student interests, attitudes, and achievement play a major role.**

- In a survey of 788 undergraduate students, interest in the subject was the most influential factor in students’ choice of college major (Malgwi, Howe, and Burnaby, 2005).
- Interest-enjoyment, self-realization, and fit to personal beliefs were important factors in Norwegian high school students’ course choices (Bøe, 2012).
- An analysis of data from the Longitudinal Study of American Youth showed that prior mathematics achievement and prior attitude showed the strongest effect on participation in advanced mathematics (Ma, 2001).
- Students who did not choose to study science exhibited a narrow and stereotypical view of science, science careers, and scientists (Cleaves, 2005).

**▼ Parents’ education, plans for students, and expectations may influence students’ course choices.**

- In students’ choice to study at technical high schools in Iran, parental education showed the most influence of family-related factors (Zara-ee and Shekarey, 2010).
• Ma’s (2001) analysis of data from the Longitudinal Study of American Youth found that parents’ college plans for children and parent expectations had a moderate effect on students’ participation in advanced mathematics.
• Undergraduates did not rate parent influence highly as a factor in their choice of college major (Malgwi, Howe, and Burnaby, 2005).
• In a study of recent high school graduates, over half of students surveyed (58%) report relying on their family for guidance in identifying and achieving their goals after graduation. 71% of students whose parents both graduated from college reported that they relied on family as their primary source for guidance, while the same is true for only just under half (48%) of students whose parents both did not graduate from college (The College Board, 2011).

▼Findings on peer and other influences are mixed.
• Friends’ influences mattered most, in the area of personal factors, in a study of Iranian high school students (Zara-ee and Shekarey, 2010).
• Students show a preference for courses that other students have rated high on learning value and lecturer’s style, and those that are rated as easy or moderately difficult (Babad and Tayeb, 2003).
• In an analysis of the National Longitudinal Study of Adolescent Health (Add Health) and the Adolescent Health and Achievement study (AHAA), opposite-sex friends showed no effect on students’ likelihood to take advanced classes (Riegle-Crumb, Farkas and Muller, 2006).
• Neither peer influence nor teacher expectation showed a significant effect on students’ participation in advanced mathematics (Ma, 2001).
• The influences of guidance counselors and high school teachers did not receive high ratings in Malgwi, Howe, and Burnaby’s (2005) study of students’ choice of college major.
• Thirty-five percent of recent high school graduates say that they relied on teachers for guidance in identifying and achieving their post-high school goals, and 30% report relying on friends (The College Board, 2011).

▼College preparedness and career prospects affect choices of study.
• Students rated potential for career advancement, the major’s potential job opportunities, aptitude, level of pay in the field, and the college’s reputation in the field as influential in their choice (Malgwi, Howe, and Burnaby, 2005).
• Utility value for university admission was rated as an important factor by Norwegian students studying science (Bøe, 2012).
• Of recent high school graduates surveyed, 44% report that they wish they had taken different courses during high school. Among those students, 37% wish they had taken more classes that prepared them for a specific job, 40% wish they had taken more math, and 33% wish they had taken more science courses. Students also wished that they had taken courses with more writing skills and research emphasis. (The College Board, 2011.)

▼Gender makes a difference.
• Utility value for university admission was more important to girls than to boys in course selection (Bøe, 2012).
• Analysis of the National Longitudinal Study of Adolescent Health (Add Health) and the Adolescent Health and Achievement study (AHAA) showed that there is a positive effect of same-gender friends’ grades on a girl’s likelihood to take advanced classes, but this effect was not found for boys. Boys who reported high levels of involvement with male friends were less likely to take AP or Honors English (Riegle-Crumb, Farkas and Muller, 2006).
• Girls were more likely to take college-preparatory math and science courses (Dunham and Frome, 2003).
• Women were more likely to be influenced by their aptitude in a subject, while men gave higher ratings to the influence of level of pay in the field, potential for career advancement, and potential job opportunities (Malgwi, Howe, and Burnaby, 2005).

WHY DO STUDENTS CHOOSE CS?

▼ Teachers have a positive influence on students’ decision to study CS.
• Undergraduate CS majors cited teacher influence as one of the reasons for their initial decision to study CS (Biggers, Brauer, and Yilmaz, 2008).
• Perceived levels of support from teachers at school showed a significant positive relationship with students’ interest in future computer-related courses or careers (Denner, 2011).

▼ Students are interested in and curious about computers.
• Curiosity about computers and the extent to which students saw computing as relevant were associated with students’ intentions to study computer science in the future (Denner, 2011).
• Men who expected to major in CS most often attributed the choice to their interest in computer games (Carter, 2006).
• Interest in computers and a perception of information and communications technology (ICT) as interesting were identified as factors influencing girls to take ICT subjects (Anderson et al., 2006).
• CS majors report liking to solve problems as a reason for their decision to study the subject (Biggers, Brauer, and Yilmaz, 2008).

▼ Male students may be more intrinsically motivated to study CS.
• Women who expected to major in CS cited their desire to use computers in another field as the main reason for their choice (Carter, 2006).
• Girls’ motivation to study CS is related to better employment prospects rather than interest in computer CS, while boys’ motivation is seen to be both extrinsic and intrinsic (Papastergiou, 2008).
WHY DON’T STUDENTS CHOOSE CS?

▼ Students don’t think that CS is interesting.

- Students reported finding the subjects boring and a lack of interest in computers as reasons for not enrolling in ICT classes (Anderson et al., 2006).
- Students who started college as computer science majors and left the field reported a loss of interest as a major factor in their decision to leave (Briggers, Brauer, and Yilmaz, 2008).
- While students are excited about and engaged in online environments, they report a lack of interest in computer science as a field of study or career path (Yardi and Bruckman, 2007).
- Anderson et al. (2006) suggest that the two most important factors in girls’ decision not to take advanced-level ICT courses are an aversion to computers and a perception of the subject as boring.
- One of the top reasons students gave for not choosing CS as a major was not wanting to sit in front of a computer all day, which reflects a common misconception (Carter, 2006).

▼ Students lack awareness of CS.

- Graduate students studying Human-Computer Interaction (HCI) or Human-Centered Computing (HCC) reported a lack of awareness about even the existence of the field until just before applying to their program (Yardi and Bruckman, 2007).

▼ Students don’t see themselves as computer scientists.

- Students perceive their own skills as insufficient for learning CS, and also see CS as a field, which can’t be learned in the same way as other subjects (Schulte and Knobelsdorf, 2007).
- Former CS majors report leaving the field because they felt as if they did not belong (Briggers, Brauer, and Yilmaz, 2008).
- Students indicated that the subject would not be helpful to them in their chosen career path, and that this was a factor in their decision not to enroll in ICT courses (Anderson et al., 2006).
- Men who left a CS major indicated that they would be more fulfilled in a non-CS career. (Briggers, Brauer, and Yilmaz, 2008).
- Non-CS students with computing experience showed perceptions of themselves as outsiders and passive users of computers, and viewed CS classes as covering information that will be useful to future professionals, but not to them (Shulte and Knobelsdorf, 2007).

WHAT DO STUDENTS THINK ABOUT CS?

▼ Students lack an understanding of what CS is.

- Most high school students have little experience with computing, even less in a formal classroom setting, and have no concept of what CS majors learn or do (Carter, 2006).
• Students have a narrow understanding of CS, and emphasize the link between CS and programming, thereby overlooking other aspects of the field (Galpin and Sanders, 2007).
• Students who left CS majors demonstrated a narrow understanding of computing and careers in the field (Biggers, Brauer, and Yilmaz, 2008).
• Teenagers see CS as tedious and lacking room for creativity (Yardi and Bruckman, 2007).

▼Students do not see CS as relevant to the real world or to their lives.
• Teenagers reported seeing little connection between the real world and what they think of as the professional field of computing (Yardi and Bruckman, 2007).
• Computer science students who left the major reported that they did not see a relevant connection to the real world (Biggers, Brauer, and Yilmaz, 2008).

▼CS students see the field as engaging, creative, and relevant.
• CS students see computing as design and themselves as active learners (Schulte and Knobelsdorf, 2007).
• Graduate students in HCI and HCC see the field as interdisciplinary and as a place where they can combine their diverse interests in a single field of study (Yardi and Bruckman, 2007).
• Graduate students describe the fields of HCI and HCC as full of opportunity for innovation and creativity (Yardi and Bruckman, 2007).
• HCI and HCC graduate students stress the connection between their research and real-world problems (Yardi and Bruckman, 2007).

▼Again, gender may make a difference.
• Boys showed significantly more positive attitudes towards computers than girls (Brosnan, 1998).
• Female teenagers have a perception of CS as a male-dominated field (Yardi and Bruckman, 2007).
• Girls, more than boys, perceive computer science as difficult and programming-oriented (Papastergiou, 2008).
• Boys have more positive perceptions of the field, and consider it more interesting, creative, profitable, and prestigious than girls (Papastergiou, 2008).

▼Exposure to CS has shown mixed results.
• Moore, Wick, and Peden (1994) found an increase in enjoyment of the discipline as students progress through a University-level CS program.
• In a study of CS Unplugged (a non-computer curriculum designed to expose young people to central concepts in computer science), students’ views on the nature of CS improved partially from pre- to post-test, but students’ intention to study computer science declined (Taub, Armoni, and Ben-Ari, 2012).
• From the beginning to the end of a first-year undergraduate CS course, around 20% of the sample moved from a positive view of working with computers to a neutral one (Galpin and Sanders, 2007).
• Galpin and Sanders (2007) postulate that student opinions are, for the most part, fixed, and not influenced by taking CS courses.
• Students who left a major in CS reported a loss of interest in a computing career, and noted that the quality of human interaction and rigor and workload were better in their new fields of study (Biggers, Brauer, and Yilmaz, 2008).
• Galpin and Sanders (2007) postulate that student opinions are, for the most part, fixed, and not influenced by taking CS courses.
• Undergraduate students who had completed an introductory programming course rated both student-student and faculty-student interactions as “below favorable,” which is problematic, as belonging to the intellectual and social community is expected to increase retention (Barker, McDowell, and Kalahar, 2009).
References


