THE UNIVERSITY OF UTAH

UTAH EDUCATION POLICY CENTER

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Broadening Participation In Computing In Utah

An Evaluation of the Impact of the Computing Partnerships Grants Program

PREPARED BY THE UTAH EDUCATION POLICY CENTER ON BEHALF OF THE UTAH STEM ACTION CENTER

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PART ONE:

INTRODUCTION

This section sets the context for the evaluation by reviewing literature on computer science education in the United States. The review addresses topics including the importance of computing technologies for the United States' economy; job growth in computer science fields and the shortage of STEM professionals; the proliferation of computer science education in U.S. K-12 schools; disparities in student access to computer science education at the K-12 level; the impact of K-12 computer science education and teacher quality on student outcomes in STEM; and the role of computing partnerships in advancing K-12 computer science education. In Part One, the report also provides an overview of the Computing Partnerships Grants Program, the evaluation's methods, and the report's organization.

Setting the Context

The Importance of Computing Technologies for the United States' Economy

Novel advances in science have and continue to undergird the U.S. economy (U.S. Congress Joint Economic Committee, 2012). Many of these innovations, as research suggests, have been made possible by computing technologies (Barr & Stephenson, 2011; Berhane, Onuma, & Secules, 2017). To date, computing technologies have been key to generating solutions in medicine and healthcare (e.g., for detecting, preventing, and curing diseases), in the automotive industry (e.g., for facilitating autonomous driving capabilities among other vehicular advancements), and in the workplace and homes of many Americans (e.g., offering opportunities for efficiency, productivity, and even relaxation) (Jeffers, Safferman, & Safferman, 2004; U.S. Congress Joint Economic Committee, 2012). These breakthroughs and advancements that were made possible by computing technologies have undoubtedly aided the United States in attaining the position of global leader in the science, technology, engineering, and mathematics (STEM) arena. However, if the nation is to maintain this position in the coming decades, it is imperative that it accelerates its production of STEM degree recipients and, more generally, that individuals in the U.S. society possess, at the very least, a basic level of technological and digital competence (Blikstein; 2018; President's Council of Advisors on Science and Technology, 2012).

Job Growth in Computer Science Fields and the Shortage of Qualified Professionals

Given the nation's reliance on technology for economic growth, it comes as no surprise that STEM jobs appear ubiquitous and that job growth in STEM fields have consistently surpassed those in non-STEM fields (Berhane et al., 2017; Fayer, Lacey, & Watson, 2017). Most recent data from the U.S. Bureau of Labor Statistics (2020) estimates that STEM jobs in the United States will increase by 8.8% between 2018 and 2028, while job growth for non-STEM occupations will be significantly lower, at 5.0%. In Utah, the Department of Workforce Services (2018) projects that the state's job openings for software and applications developers, an occupation that requires a computing or mathematical background, will grow by 7.1% between 2016 and 2026. As these projections suggest, STEM jobs both in Utah, and the nation as a whole, are far from being in short supply. At the same time, however, evidence also continues to grow that the United States is not producing nearly enough qualified individuals to meet the demand (Sanzenbacher, 2013).

The Proliferation of Computer Science Education in U.S. K-12 Schools

The present shortage of STEM professionals has resulted in an urgent quest for ways to invigorate the nation's STEM pipeline. And justifiably, it continues to heighten the focus on STEM education at the K-12 level. The result is a consensus that the K-12 years are integral to advancing the nation's STEM labor force (Barr & Stephenson, 2011; Google Inc. & Gallup Inc., 2015). In 2006, the National Science Board described this need for additional focus on K-12 education, asserting that,

> we simply cannot wait until our students turn 18 years old to begin producing the intellectual capital necessary to ensure this future workforce; the time is now to get serious about this problem and better sharpen our efforts at all grade levels, in order to

dramatically accelerate progress, lest we find our Nation in severe workforce and economic distress (p. 2).

Answering the call from the National Science Board (2006), researchers, over the past decade, have increasingly investigated STEM education at the K-12 level. Many have focused particularly on access to computer science education (Joshi & Jain, 2018; Leyzberg & Moretti, 2017; Papini, DeLyser, Granor, & Wang, 2017). In recent years, scholars have acknowledged, repeatedly, the proliferation of computer science curricular and extracurricular opportunities in U.S. schools as well as the high value placed on such opportunities by parents, teachers, and administrators (Blikstein, 2018; Weintrop, Hansen, Harlow, & Franklin, 2018). As a study conducted by Google Inc. and Gallup Inc. (2015) found, schools across the United States are more than ever before offering dedicated computer science courses during the traditional school day, integrating computer science learning into other courses, and providing after-school groups and clubs that focus on computer science. Still other studies, such as that conducted by Sanzenbacher (2013), have found that access to computer science education at K-12 level has been expanded through the provision of job shadows, externships, and guest lectures by scientists, researchers, and engineers.

Fueling this increase in computer science opportunities are teachers, parents, and administrators who, as research has found, perceive that computer science is just as important, if not more important, than required courses such as math, science, history, and English (Google Inc. & Gallup Inc., 2016a). Interestingly, computer science education has found an even stauncher group of advocates among parents with no college education as well as Black and Hispanic parents. Findings from Google Inc. and Gallup Inc. (2016a) suggest that these group of parents are more likely than parents with more college education and White parents to indicate that computer science is more important than required or elective courses. However, systemic inequities persist that continue to undermine access to computer science opportunities for the nation's "underrepresented majority" students, which also includes girls (President's Council of Advisors on Science & Technology, 2012, p. i).

Disparities in Student Access to Computer Science Education at the K-12 Level

Indeed, the nation's goal to broaden participation in STEM fields, particularly among underrepresented students, is far from being achieved (Berhane, Secules, & Onuma, 2020). Black school-age students, according to recent research, are less likely than their White counterparts to have opportunities, such as access to dedicated computing courses, to learn computer science at school (Google Inc. & Gallup Inc., 2015; Qazi, Gray, Shannon, Russell, & Thomas, 2020). Moreover, this troubling disparity has been found to persist in spite of the socioeconomic background of Black students (Google Inc. & Gallup Inc., 2015; Qazi et al., 2020). Opportunities to enroll in advanced computer science courses also remain largely out of reach for students of color, with recent data indicating that Black and Hispanic students, together, account for less than 15% of AP Computer Science A test takers (Google Inc. & Gallup Inc., 2015; Qazi et al., 2020). Girls also experience similar impediments with access to computer science education with research suggesting that they are less likely than their male peers to be aware of computer science learning opportunities, to affirm that they have learned computer science, and to be told by a teacher or parent that they will be good at computer science (Google Inc. & Gallup Inc., 2016b). Also, in line with the experiences of the above underserved populations, students who live in small towns or rural areas and those from households below the poverty lines have been found to be well-represented in school districts where school boards do not place high priority on providing or expanding computer science learning opportunities (Google Inc. & Gallup Inc., 2015).

The Impact of K-12 Computer Science Education and Teacher Quality on Student Outcomes in STEM

The growing provision of computer science education at the K-12 level has also led to more research on student outcomes and the role that teachers play in facilitating these outcomes. There is a consensus among researchers that early exposure to computer science increases students' interest, curiosity, and engagement with computer science as well as their computational thinking and problem-solving skills (Freeman et al., 2014; Google Inc. & Gallup Inc., 2015; Papini et al., 2017). Scholars are also increasingly pointing to the deficiencies in computer science education that is brought on by the preponderance of unqualified teachers who oversee these learning experiences (Joshi & Jain, 2018; Leyzberg & Moretti, 2017; Pollock et al., 2017; Sanzenbacher, 2013). As recent data suggests, two-thirds of computer science teachers in U.S. K-12 schools do not hold a degree in computer science (Leyzberg & Moretti, 2017). And this lack of content knowledge in computer science significantly hampers their confidence and competence to teach these courses (Leyzberg & Moretti, 2017). As Joshi and Jain (2018) note, teachers' lack of subject matter knowledge in computer science poses a hindrance to students' deeper exploration of the subject in cases where students' knowledge surpasses that of their teachers. Relatedly, many computer science teachers, again because of the low barrier for entry into computer science teaching, are often uninformed about how to integrate inclusive pedagogical strategies that foster interest and engagement among underrepresented students. Sanzenbacher (2013) calls attention to another area of concern. That is, due to lack of content expertise, elementary teachers are often uncomfortable with employing pedagogical approaches that emphasize scientific inquiry. This can further exacerbate the engagement of students in computer science.

The Role of Computing Partnerships in Advancing K-12 Computer Science Education

In their quest to address the insufficient formal training of computer science teachers, schools are increasingly turning to an ad hoc, and effective, remedy. Precisely, K-12 schools are forming partnerships with higher education institutions and industry to increase the quality and rigor of the computer science opportunities they provide. Some schools, for instance, have been known to collaborate with postsecondary institutions to provide professional development to their STEM teachers (Sanzenbacher, 2013). Still other schools have found success in forging co-teaching partnerships between computer science professionals and educators, bringing these industry experts inside the classroom to facilitate learning alongside teachers (Papini et al., 2017).

The current report evaluates an effort, the STEM Action Center's *Computing Partnerships Grants Program*. This program was advanced in Utah to broaden student participation and success in computer science through computing partnerships and opportunities as those reviewed above. The next section in this introduction provides a broad overview of the STEM Action Center's *Computing Partnerships Grants Program* including how it is being implemented in school districts, educational consortia, and charter schools.

Overview of the Computing Partnerships Grants Program

In 2017, Senate Bill 190 (S.B. 190), passed in the Utah State Legislature, created the Computing Partnerships Grants Program. The grant program, as described in the bill text[1], is to fund "the design and implementation of comprehensive K-16 computing partnerships" (S.B. 190, lines 71-72). Computing partnerships that meet the criterion of comprehensiveness, as S.B. 190 further specifies, are those that intend to enhance outreach and engagement, course content and design, work-based learning opportunities, student retention, professional learning, access, diversity, and equity, and institutional, industry, and community collaborations. In funding these partnerships, the overarching goal of the grant program is to support students' acquisition of skills and knowledge necessary for success in computer science, information technology, and computer engineering courses and careers. S.B. 190 authorized the STEM Action Center to administer the grant program, in consultation with the Utah State Board of Education and Talent Ready Utah.

Program Implementation

As the principal administrator of the Computing Partnership Grants Program, the STEM Action Center establishes the grant application process, reviews grant applications, awards grants, and defines the outcome-based measures to be used in evaluating the impact of grant activities. According to the STEM Action Center, application for grant funding is open to public preK-12 school districts, schools, and educational consortia, and applicants may request funds for 1-3 years. To be consider eligible for funding, however, applicants are expected to propose innovative activities that align with two or more of the aforementioned areas of focus identified in S.B. 190. Additionally, school districts, educational consortia, and charter schools are encouraged to partner with industry, higher education, community/cultural organizations or other local education agencies (LEAs; i.e., school districts and schools). As it concerns appraising the impact of grant activities, the STEM Action Center proposes that grant activities be evaluated for their impact on the teacher and student outcomes outlined in Figure 1.

Figure 1. Teacher and Student Outcomes in Computing Assessed by the Current Evaluation

Teachers	Students
• Computing competence	• Computing self-efficacy
• Computing confidence	• Computing interest
• Views about equity and access in computing	• Computing engagement
• Views about teaching that integrates computing	• Cognitive skills in computing
• Use of project-based and experiential pedagogy	• Technical skills in computing
• Teaching attitudes	• Intentions to pursue computing

[1] https://le.utah.gov/~2017/bills/static/SB0190.html

Purpose of the Evaluation

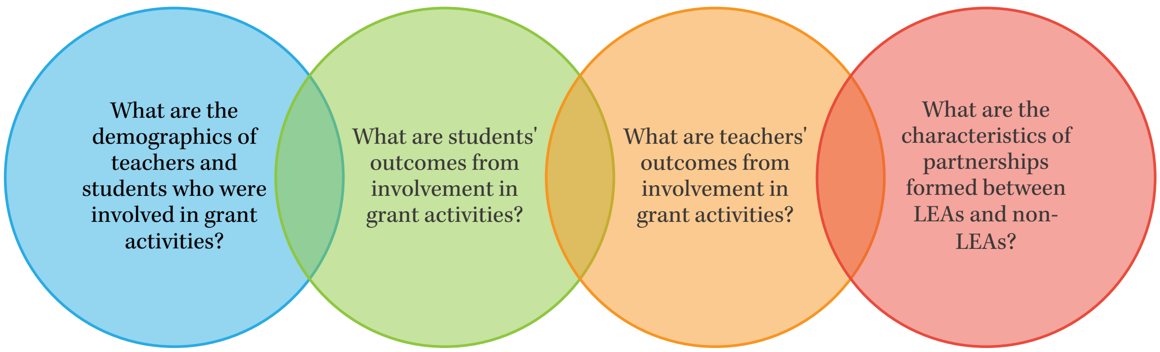
The current evaluation seeks to understand the outcomes of students and teachers involved in grant activities as well as the quality and effectiveness of computing partnerships forged between LEAs and post-secondary institutions, industry, and community organizations. This evaluation is being performed at the request of the STEM Action Center.

Methods

Evaluation Questions

Given the aforementioned evaluation objectives, four questions, as outlined in Figure 2, guided the inquiry.

Figure 2. Guiding Evaluation Questions



Data Source

To address the evaluation objectives and questions, the Utah Education Policy Center (UEPC) at the University of Utah designed a survey for teachers who partook in activities funded by the Computing Partnerships Grants Program.

Survey Foci

Although teachers were the survey participants, both teacher and student outcomes from participating in grant activities were assessed in the survey. The teacher and student outcomes evaluated in the survey were identified by the STEM Action Center and are itemized in Figure 1. Definitions for these outcomes are provided in the *Terminology and Definitions* section of this report. The survey also examined the demographics of teachers including the local education agencies to which they are affiliated, the grade levels they teach, and the grant activities in which they and their students were involved. Additionally, the survey investigated the characteristics—more specifically, the quality and effectiveness—of computing partnerships formed between LEAs and post-secondary, industry, and community organizations.

Survey Design

With regard to its design, the survey included both closed- and open-ended questions. The close-ended question format was the primary question format in the survey and was used to collect data that directly pertained to the evaluation objectives and questions. Open-ended questions, on the other hand, were included rather sparingly in the survey and used to collect data not directly related to the evaluation objectives and questions. The open-ended survey questions, more specifically, queried teachers about their general experiences with participating in grant activities. These questions provide important insight, for instance, into the challenges that teachers experienced with certain grant activities such as integrating computing in non-computing courses.

Survey Validity

To ensure the construct validity of the survey instrument, items pertaining to teacher and student outcomes in the survey were informed by well-recognized and validated scales related to computing, including, but not limited to, the Confidence with Technology Scale (TC; Pierce, Stacey, Barkatsas, 2007), Computer Confidence Scale (Galbraith & Haines, 2000), Computer Motivation Scale (Galbraith & Haines, 2000), Affective Engagement Scale (AE; Pierce et al., 2007), Behavioral Engagement Scale (BE; Pierce et al., 2007), Utility Value of ICT Scale (Vekiri, 2013), Intrinsic Value of ICT Scale (Vekiri, 2013), Teachers' Instructional Beliefs and Web 2.0 Scale (Jimoyiannis, Tsiotakis, Roussinos, & Siorenta, 2013) and Teachers' Beliefs of the Educational Potential of Web 2.0 Scale (Jimoyiannis et al., 2013).

Survey Administration

In spring 2020, the STEM Action Center provided the UEPC with information on the primary contact persons at LEAs that received funding from the Computing Partnerships Grants Program. Primary contacts were notified by the STEM Action Center about this information exchange and informed to expect an email from the UEPC with a link to the survey on a set date in April 2020. Primary contacts were also advised to share the link to the survey, upon receipt, with teachers who had participated in grant activities. On the day of the survey launch, the UEPC sent an email, embedded with a link to the survey, to the designated primary contact persons at LEAs that received grant funding. This email also included the request for distribution to participating teachers. Over the course of the survey participation period, additional reminders were provided to teachers to complete the survey. The UEPC provided participation updates to the STEM Action Center during the survey administration period. The survey was closed in May 2020 after being open for four weeks.

Survey Participation

With assistance from LEAs that received funding, the STEM Action Center confirmed that a total of 1,068 teachers were invited to participate in the survey. Of the 1,068 teachers who were invited to participate in the survey, 281 teachers (26%) provided responses.

Data Analysis

Data from close-ended questions were summarized using descriptive statistics (e.g., frequencies, averages, and percentages) and open-ended responses were analyzed using inductive coding, a process of aggregating responses using themes that emerge directly from the data (Merriam, 2009). In representing data from close-ended questions formatted as Likert scale items, bar graphs were utilized that organize data from positive to negative (e.g., strongly agree to strongly disagree). The inductive coding process for open-ended responses was undertaken by two researchers who each read the responses in their entirety and conferred with one another about the themes they gleaned from the data. This process of "investigator triangulation" was done to ensure the rigor and validity of the evaluation's qualitative analysis (Merriam, 2009, p. 216). Descriptive statistics from the close-ended responses provide the basis for addressing the evaluation objectives and questions. Themes and representative comments extracted from open-ended responses provide the basis for answering auxiliary questions about teachers' general experiences with participating in grant activities.

Report Organization

This introduction is the first of ten sections of this report. The second section of the report, *Terminology and Definitions*, provides definitions for the grant activities, student outcomes, and teacher outcomes discussed in the report. *Demographics,* the report's third section, provides information on the teachers and students involved in grant activities, with particular attention given to their school districts or schools, grade levels, and the specific grant activities in which they were involved. The fourth, fifth, sixth, seventh, eighth, and ninth sections of the report are each concerned with a specific grant activity—*Dedicated Computing Courses*, *Integration of Computing into Existing Courses*, *Outreach and Student Engagement Activities*, *Work-Based Learning Experiences*, *Professional Learning*, and *Post-Secondary Institutions, Industry, and Community Collaborations* respectively. Discussions on the first five grant activities focus on student and teacher outcomes and, where applicable, themes and excerpts about the experiences of teachers who partook in the activity. Discussion on the sixth grant activity primarily addresses its quality and effectiveness. Finally, the tenth section of the report, *Conclusions and Considerations,* provides a summary of the report's findings as well as considerations for the Computing Partnerships Grants Program.

PART TWO:

TERMINOLOGY & DEFINITIONS

This section provides definitions for terms used in this report to refer to the types of grant activities in which students and teachers were involved. It also reviews terms used in this report to refer to student and teacher outcomes in computing.

Grant Activities

Dedicated Computing Courses - Courses squarely focused on the study of computing principles and use of computers. These courses may cover topics in one or more of the following computing-related areas of study: computer science, information technology, information systems, computer and software engineering, cybersecurity, digital media, and gaming.

Integration of Computing into Existing Courses – The careful and intentional incorporation of computational thinking and education-related instructional technologies in courses not directly concerned with computing, such as, but not limited to, English, mathematics, and science.

Outreach and Student Engagement Activities – Out-of-classroom activities, chaperoned or supervised by teachers, that involve the application of computing principles and use of computers. These activities may occur before or after school or during the Summer months. Outreach and student engagement activities may draw on principles of computer science, information technology, information systems, computer and software engineering, cybersecurity, digital media, and gaming.

Work-Based Learning Experiences – Out-of-school activities designed to provide students with real-life work experience in a particular field while simultaneously engaging their knowledge and experience with digital technologies. Work-based learning experiences include such activities as internships, apprenticeships, and job shadows.

Professional Learning for Teachers and Staff – Activities intended to improve teachers' instructional practices that involve digital technologies. Professional learning activities, as research suggests, generally rely on active learning and collaboration among teachers in the same school or subject area and occur over a period of time to permit adequate testing, improvement, and mastery of teaching practices (Stewart, 2014).

Post-secondary, Industry, and Community Collaborations – Partnerships forged between LEAs and post-secondary institutions, industry, or community/cultural organizations for the purposes of designing computing-related activities, informing the content of said activities, and/or procuring equipment or other resources to facilitate their successful implementation.

Student Outcomes

Computing Self-Efficacy – A measure of a student's belief or confidence in their capabilities to use computers (Clarke-Midura, Sun, Pantic, Poole, & Allan, 2019; Kolar, Carberry, & Amresh, 2013; Zhang & Espinoza, 1998). Computing self-efficacy is also referred to in research as computer confidence (Galbraith & Haines, 2000), or confidence with technology (Pierce, Stacey & Barkatsas, 2007).

Computing Interest – A measure of a student's enjoyment or intrinsic value of computing (Clarke-Midura et al., 2019; Denner, 2011; Pierce et al., 2013; Vekiri, 2013). Computing interest is also described in research as affective engagement in computing (Pierce et al., 2007).

Computing Engagement – A measure of a student's participative or behavioral engagement in computing (Jain, 2013; Pierce et al., 2007).

Cognitive Skills in Computing – A measure of a student's understanding or comprehension of elements of computer or informatics systems and the principles they are based on (Kollee et al., 2009).

Technical Skills in Computing – A measure of a student's ability to utilize computers in a variety of ways, construct an informatics system, or perform reverse engineering on it (Kollee et al., 2009).

Intentions to Pursue Computing – A measure of a student's interest in careers in computer science and related fields (Clarke-Midura et al., 2019), or their perception of the usefulness, or utility value, of computing in relation to their future plans (Vekiri, 2013).

Teacher Outcomes

Computing Competence – A measure of the diversity and depth of skills sets possessed by a teacher with relation to technology integration (Guzman & Nussbaum, 2009; Tondeur et al., 2017).

Computing Confidence – A measure of a teacher's belief in the ability to use technology and effectively integrate it in their instruction (Rovai & Childress, 2002; Russell & Bradley, 1997). Computing confidence is also described in research as computer confidence or computer self-efficacy (Rovai & Childress, 2002).

Views about Equity and Access in Computing – A measure of a teacher's cultural responsiveness and equity orientation in relation to computing (Christie, 2005; Fields, Kafai, Nakajima, Goode, & Margolis, 2018; Gürer & Camp, 2005).

Views about Teaching that Integrates Computing – A measure of teacher's belief about the educational potential or usefulness of technology in instruction (Jimoyiannis, Tsiotakis, Roussinos, & Siorenta, 2013).

Use of Project-Based and Experiential Pedagogy – A measure of teacher's incorporation or use of technology-based activities in their instruction (Jimoyiannis et al., 2013)

Teaching Attitudes – A measure of a teacher's interest, enjoyment, and satisfaction with teaching.

PART THREE:

DEMOGRAPHICS

A total of 281 teachers participated in the evaluation that informed this report. Discussed in this section are key demographic information about these teachers, and by extension, their students.

Key Findings on Participant Demographics

Teachers from a Variety of Local Education Agencies Were Involved in Computing Partnership Grant Activities

Teachers who participated in grant activities were asked in the survey to identify the school districts or schools to which they belong. As shown in Table 1, teachers were affiliated with a wide range of local education agencies including 16 school districts, 1 tri-district consortium (Juab-North Sanpete-South Sanpete Districts), and 5 charter schools.

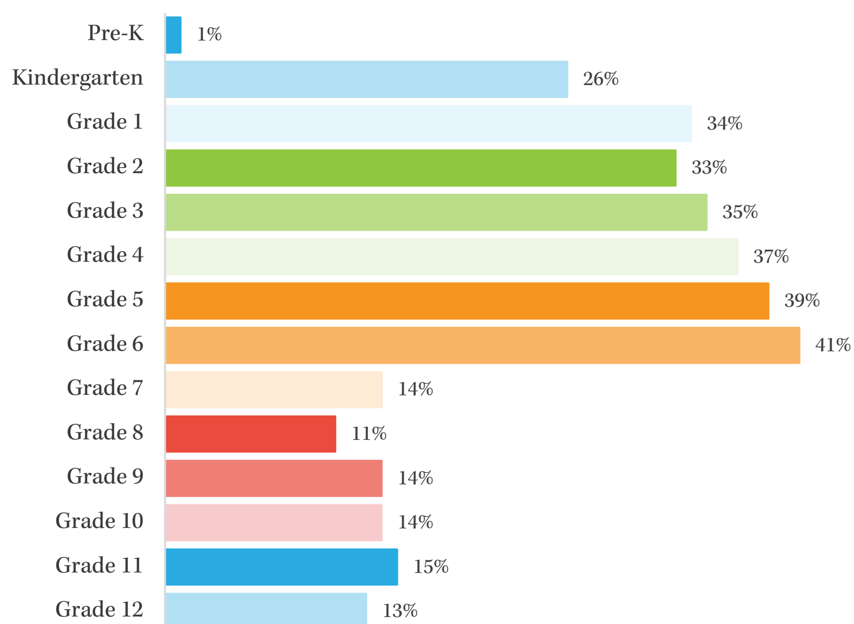
Table 1. Local Education Agencies and Number of Participants

School Districts and Educational Consortia		Charter Schools	
Alpine District	(26)	Nebo After School Programs	(8)
Beaver District	(6)	Entheos Academy	(16)
Cache District	(13)	InTech Collegiate High School	(3)
Davis District	(25)	Itineris Early College High School	(4)
Duchesne District	(4)	Pinnacle Canyon Academy	(27)
Emery District	(1)		
Garfield District	(5)		
Granite District	(5)		
Iron District	(20)		
Juab District	(11)		
Juab, North Sanpete, South Sanpete Districts	(35)		
Kane District	(15)		
Ogden District	(6)		
Provo District	(28)		
Salt Lake District	(2)		
San Juan District	(14)		
Washington District	(7)		
TOTAL			(281)

Teachers Who Were Involved in Computing Partnership Grant Activities Taught or Supervised Students at Different Grade Levels

Teachers were asked in the survey to select all the grade levels that they teach or supervise. As Figure 3 suggests, teachers who were involved in grant activities taught or supervised a variety of grade levels, spanning pre-kindergarten to grade 12. Additionally, many teachers taught or supervised more than one grade level as indicated by the percentages in the figure that add up to more than 100%. As it concerns the grade levels most reported by teachers, teachers most often indicated that they taught or supervised students in grades 4 (37%), 5 (39%), and 6 (41%). Relatedly, they were least likely to indicate teaching or supervising students in pre-kindergarten (1%), grade 8 (11%), and grade 12 (13%).

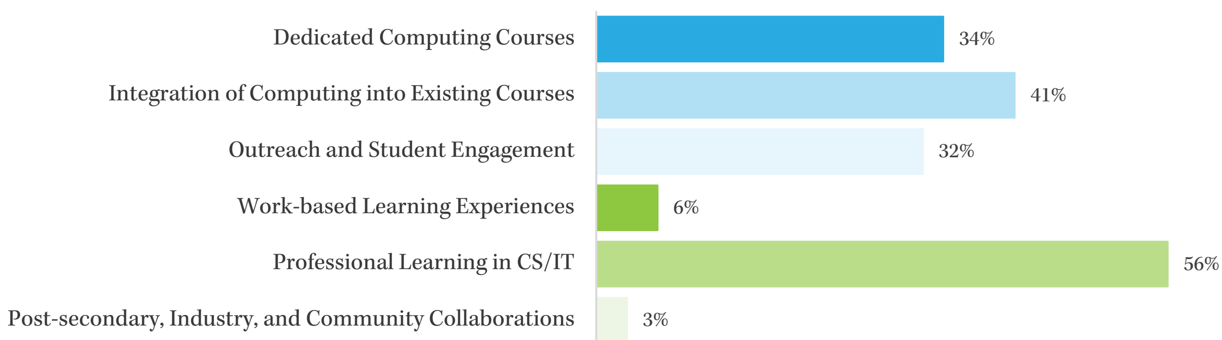
Figure 3. Grade Levels Taught by Teachers



Teachers Were Mostly Involved in Four of Six Computing Partnership Grant Activities

Teachers were prompted in the survey to select as many grant activities as they were involved in from the six options provided—*Dedicated Computing Courses*, *Integration of Computing into Existing Courses, Outreach and Student Engagement*, *Work-Based Learning Experiences*, *Professional Learning in Computer Science/Information Technology*, and *Post-Secondary, Industry, and Community Collaborations*. As Figure 4 suggests, all six grant activities received some participation from teachers. However, participation rates varied from a high of 56% in Professional Learning in CS/IT to a low of 3% in *Post-Secondary, Industry, and Community Collaborations*. Also, besides *Professional Learning in CS/IT*, three other activities—*Integration of Computing into Existing Courses* (41%), *Dedicated Computing Courses* (34%), and *Outreach and Student Engagement* (32%)—received notable participation from teachers.

Figure 4. Teachers' Grant Activities



PART FOUR:

DEDICATED COMPUTING COURSES

Teachers who taught dedicated computing courses were queried about the impact that these courses had on key student outcomes in computing. The student outcomes of interest are those identified in **Figure 1 - Teacher and Student Outcomes in Computing Assessed by the Current Evaluation** and include computing self-efficacy, computing interest, computing engagement, cognitive skills in computing, technical skills in computing, and intentions to pursue computing. Teachers were also asked to evaluate their own outcomes from teaching these courses. More specifically, they were asked to specify the extent to which they agree that teaching dedicated computing courses impacted their computing competence, views about equity and access in computing, views about teaching that integrates computing, use of project-based and experiential pedagogy, and teaching attitudes. This section reviews key findings pertaining to these survey items.

Key Findings on Student Outcomes

The Five Most Offered Dedicated Computing Courses Are Not Equally Effective at Improving Student Outcomes in Computing

Five dedicated computing courses garnered the most responses from teachers who responded to the survey. These courses include *Elementary Computing Specialty*, *Creative Coding, Computer Science Discoveries*, *Introduction to Python*, and *Exploring Computer Science 1*.

As Figures 5-9 illustrate, notable differences exist in teachers' perceptions about the effectiveness of these courses in bringing about the desired student outcomes in computing. Figure 5, for instance, suggests that *Elementary Computing Specialty* may be the most effective of the five courses in improving students' computing self-efficacy, with 50% of teachers who taught the course noting that they observed an increase in students' computing efficacy towards the end of their enrollment in the course. *Introduction to Python*, on the other hand, appears to be the least effective in this regard with only a quarter of teachers who taught the course noting that they observed an increase in students' self-efficacy by the end of their enrollment in the course.

With regard to students' computing interest, Figure 6 indicates that *Creative Coding* and *Exploring Computer Science 1* are the two most effective of the five courses in improving this student outcome. Sixty percent and 54% of teachers who taught *Creative Coding* and *Exploring Computer Science 1,* respectively, indicated that they observed an increase in students' computing interest by the end of the courses.

Most teachers of the top dedicated computing courses, with the exception of those who taught *Introduction to Python*, observed an increase in students' computing engagement (Figure 7) and students' computing skills (Figure 8) by the end of the courses. Only a third of teachers who taught *Introduction to Python* observed an increase in students' computing engagement and about a quarter of them observed an increased in students' computing skills. Teachers who taught *Elementary Computing Specialty*, however, were the most likely to indicate that they observed improvement in both student outcomes. Fifty-eight and 75% of these teachers noted that they observed improvement in students' computing engagement and computing skills respectively by the end of the course.

Teachers of the most offered dedicated computing courses did not respond nearly as favorably about students' intentions to pursue computing as compared to other student outcomes. Among these group of teachers, those who taught *Creative Coding* were the most likely, at 30%, to indicate an improvement in this outcome.

Figure 5. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Self-Efficacy

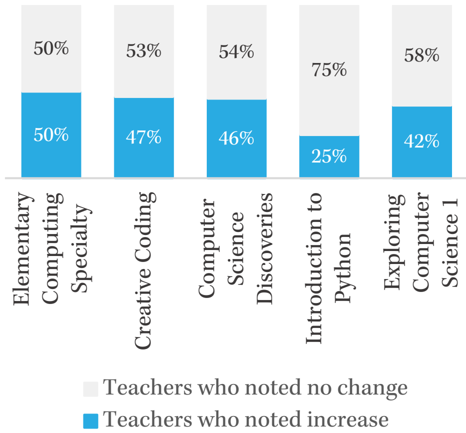


Figure 6. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Interest

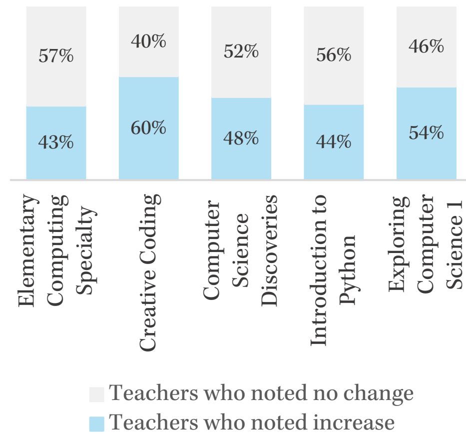


Figure 7. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Engagement

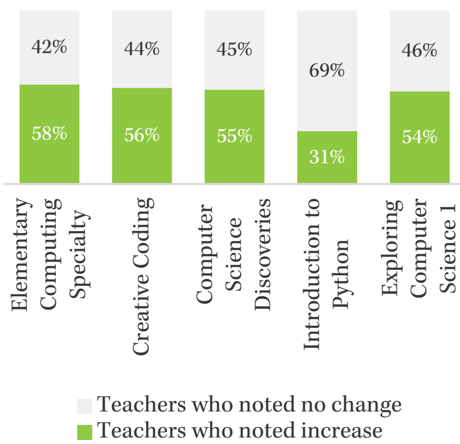


Figure 8. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Skills

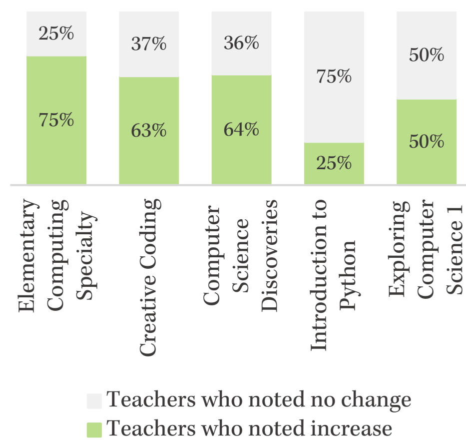
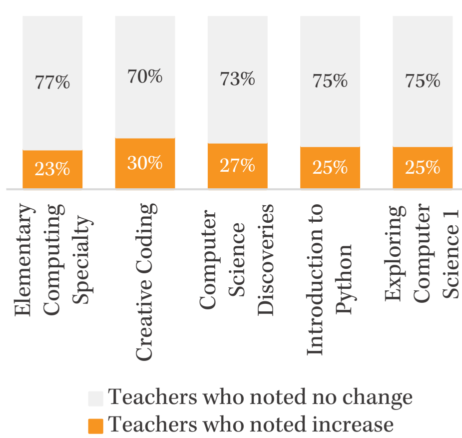


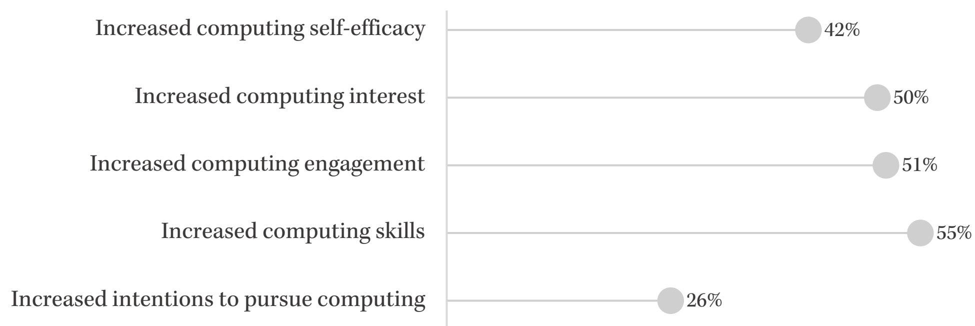
Figure 9. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Intentions to Pursue Computing



The Five Most Offered Dedicated Computing Courses Are Generally More Effective at Improving Certain Student Outcomes in Computing than Others

While important differences exist in teachers' assessment of the effectiveness of the top five courses in improving each student outcome in computing, there appears to be a trend nonetheless in the student outcomes that are most impacted by these courses. As illustrated in Figure 10, when consolidated, the top five dedicated computing courses generally appear to be most effective at increasing students' computing skills, followed by their computing engagement, computing interest, computing self-efficacy, and lastly intentions to pursue computing. Fifty-five percent of teachers of the top five dedicated computing courses observed an increase in students' computing skills at the end of their enrollment in these courses compared to 26% of these teachers who noted improvement in students' intentions to pursue computing during the same time frame.

Figure 10. Average Percent of Teachers Who Observed an Increase in Students' Outcomes in Computing Across Top 5 Dedicated Computing Courses



Most Teachers of Dedicated Computing Courses Strongly Agree or Agree That Their Students Achieved the Desired Outcomes in Computing Towards the End of Enrollment in the Courses

Figures 5-10 discussed earlier are only concerned with the five most offered dedicated computing courses and thus, do *not* capture the perspectives of all teachers of dedicated computing courses concerning the effectiveness of these courses more broadly in bringing about the desired student outcomes in computing. In addition to the top five courses, other dedicated computing courses were offered including *A+ Maintenance Repair*, *Animation*, *Boot Up*, *Computer Programming 1*, *Computer Science Prep*, *Computer Science Principles*, *Game Design*, *JavaScript*, *Learning to Code*, *Micro Bit*, and *Scratch Jr.* to name a few. Figures 11-16, unlike the earlier figures, reflect the responses of all teachers who indicated that they taught dedicated computing courses.

As Figures 11-16 illustrate, teachers of dedicated computing courses were presented with various indicators of each of the student outcomes in computing and asked to specify the extent to which they agree that their students possessed the attributes described at the beginning and also at the end of the courses. As these same figures also show, teachers of dedicated computing courses were much more likely to strongly agree or agree that their students had the attributes described by the end of the courses rather than at their beginning.

Despite this overarching similarity in their responses, important differences are present nonetheless in teachers' perceptions about the outcomes that students possessed at the two points of observation. Concerning students' attributes at the onset of enrollment in dedicated computing courses, teachers were generally less likely to agree that student possessed indicators of cognitive skills in computing (Figure 14) and technical skills in computing (Figure 15). Only 7% of teachers, for example, strongly agreed or agreed that their students could "explain the behavior of informatics and computer systems in their own words" (an indicator of cognitive skills in computing) at the beginning of the course. Similarly, only 9% of teachers noted that they strongly agreed or agreed that their students could "analyze software problems" (an indicator of technical skills in computing) at the beginning of the course.

With regards to student outcomes at the end of enrollment in dedicated computing courses, teachers were similarly less likely to strongly agree or agree that students possessed the indicators of cognitive skills in computing and technical skills in computing. Between 59% and 80% of teachers, depending on the indicator, strongly agreed or agreed that their students possessed cognitive skills in computing at the end of the course. Additionally, between 68% and 90% of teachers, again varying by indicator, strongly agreed or agreed that their students possessed technical skills in computing. These percentages pale in comparison to those for other student outcomes such as computing interest (Figure 12) where 93% to 97% of teachers, contingent upon the indicator, strongly agreed or agreed that students possessed the attribute at the end of the course, and computing self-efficacy (Figure 11) where the percentage was 95% to 100% of teachers.

Figure 11. Teachers' Perceptions of Students' Computing Self-Efficacy at the Start and End of Enrollment

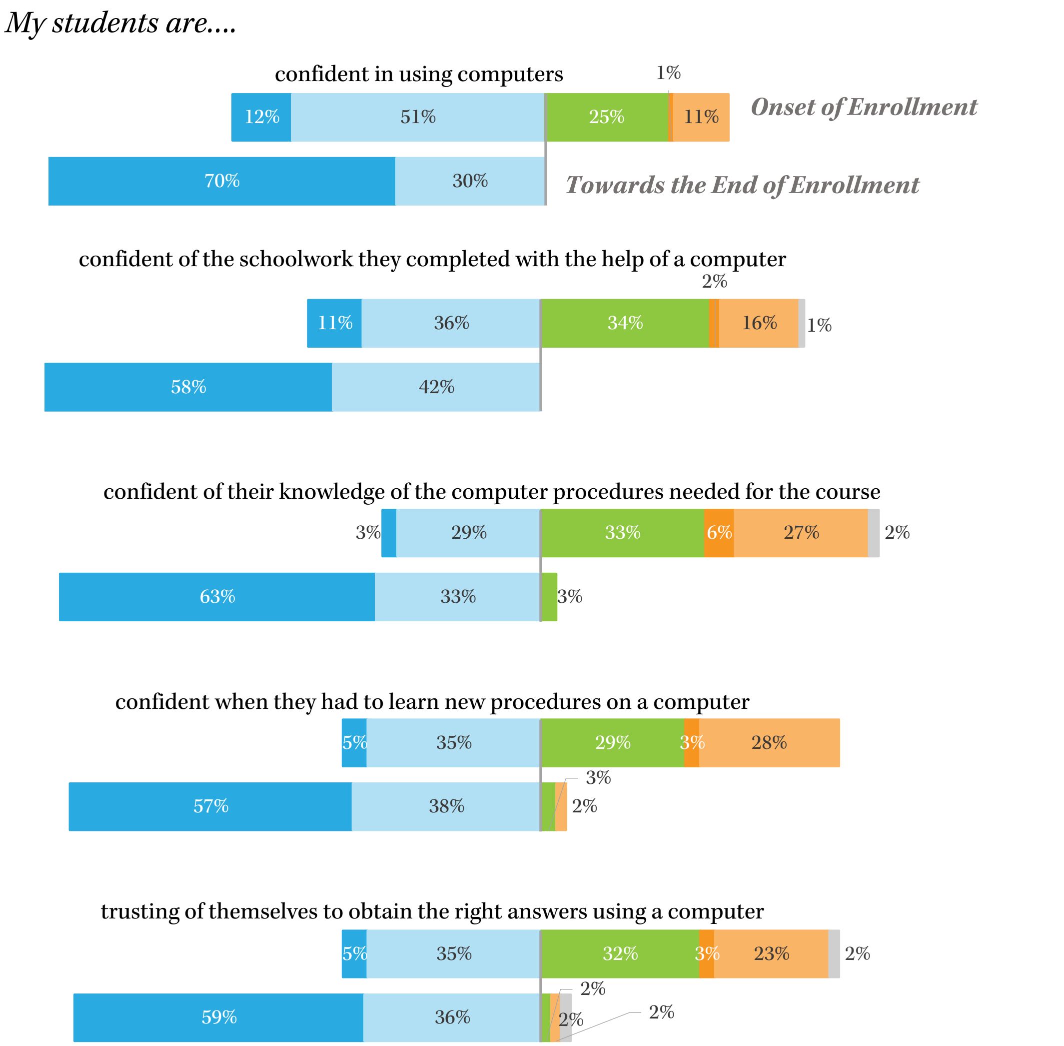


Figure 12. Teachers' Perceptions of Students' Computing Interest at the Start and End of Enrollment

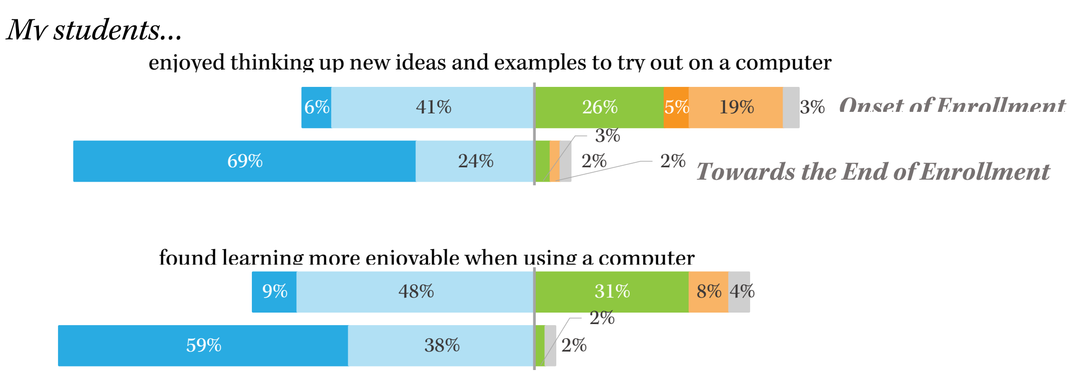


Figure 13. Teachers' Perceptions of Students' Computing Engagement at the Start and End of Enrollment

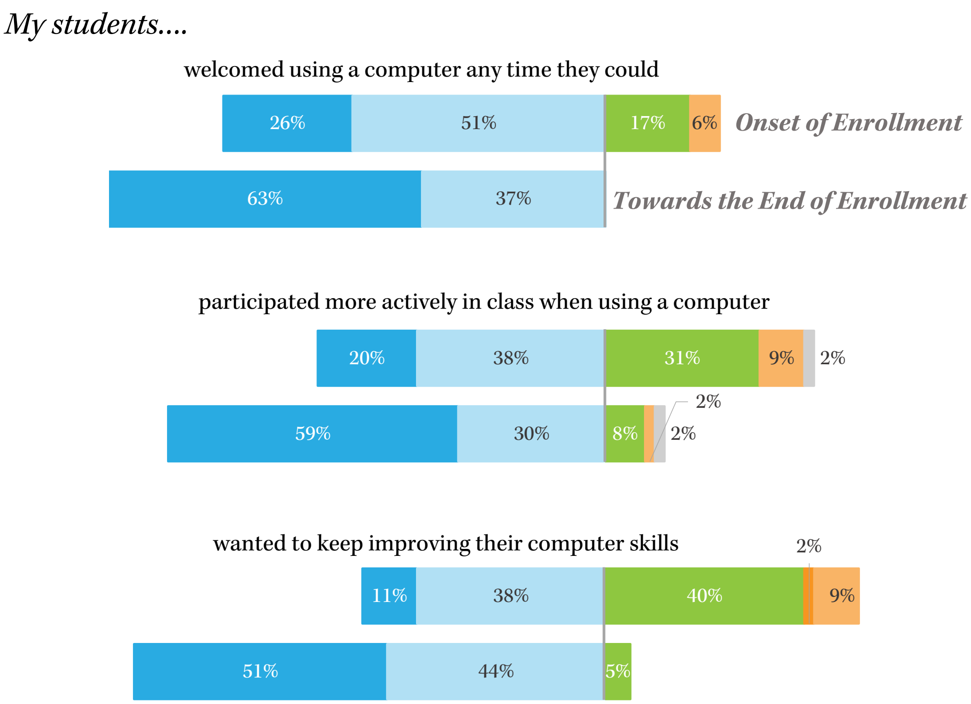


Figure 14. Teachers' Perceptions of Students' Cognitive Skills in Computing at the Start and End of Enrollment

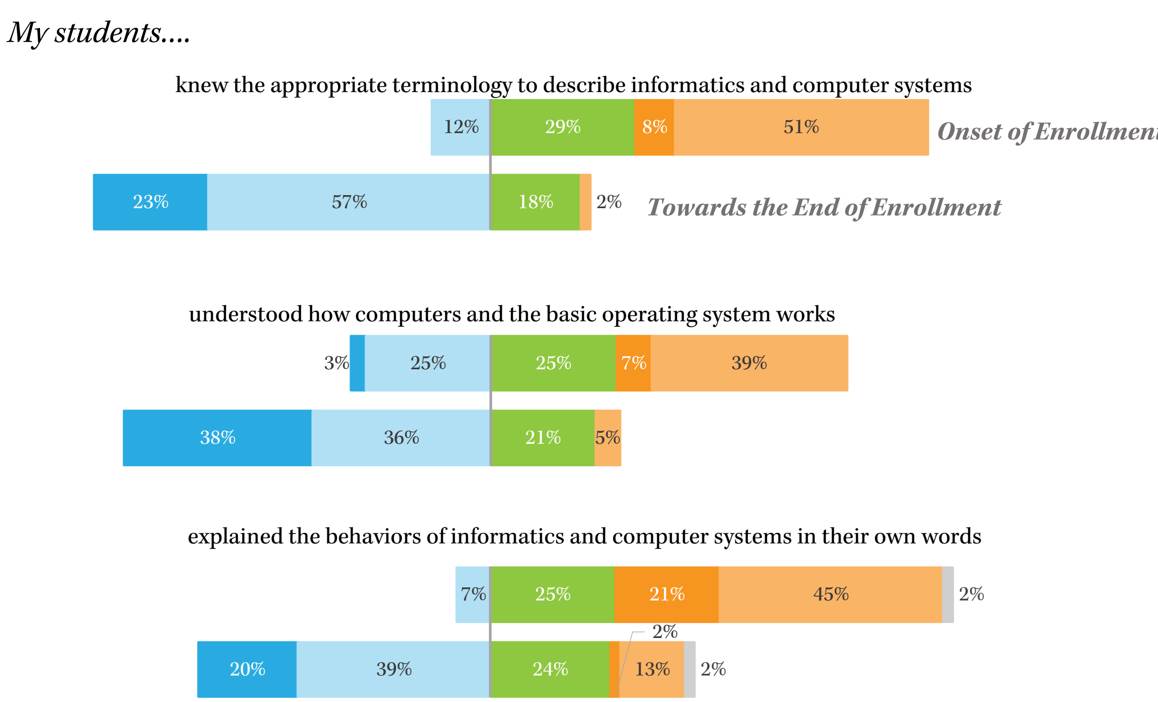


Figure 15. Teachers' Perceptions of Students' Technical Skills in Computing at the Start and End of Enrollment

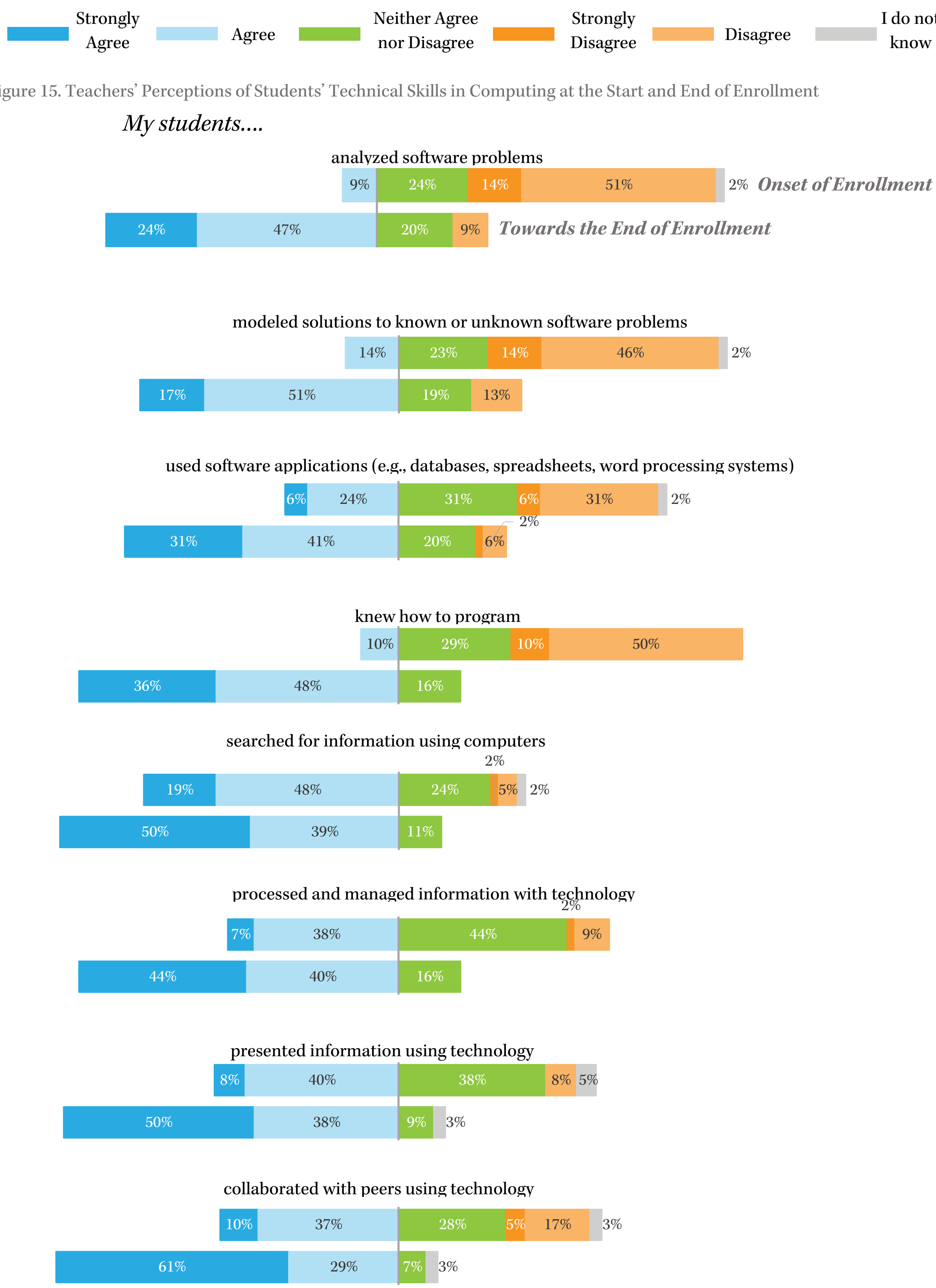
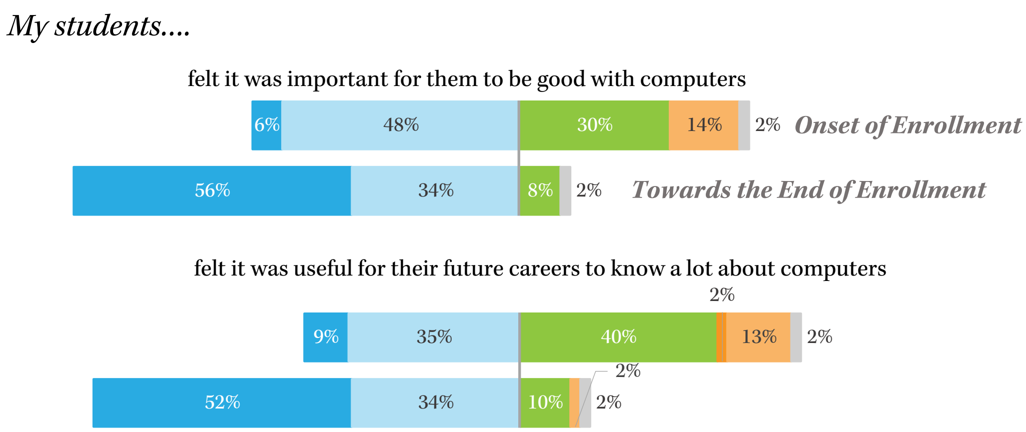


Figure 16. Teachers' Perceptions of Students' Intentions to Pursue Computing at the Start and End of Enrollment



Key Findings on Teacher Outcomes

An Overwhelming Majority of Teachers Strongly Agree or Agree that Teaching a Dedicated Computing Course Improved Their Outcomes in Computing

Teachers were provided with various indicators of each teacher outcome in computing and were asked to specify the extent to which they agree that teaching a dedicated computing course helped them cultivate these attributes. As Figures 17-21 illustrate, an overwhelming majority of teachers strongly agreed or agreed that teaching a dedicated computing course helped them nurture the various attributes associated with each outcome. For example, between 77% and 100% of teachers, depending on the indicator, strongly agreed or agreed that teaching a dedicated computing course helped improve their views about teaching that integrates computing (Figure 19). Eighty-five to 97% of teachers strongly agreed or agreed that teaching a dedicated computing course helped them cultivate more culturally responsive and equity-focused views about participation in computing (Figure 18). Between 65% and 95% of teachers strongly agreed or agreed that they developed key computing competencies through teaching a dedicated computing course (Figure 17). Concerning their teaching attitudes, 81% to 84% of teachers strongly agreed or agreed that teaching a dedicated computing course helped improve this outcome (Figure 21). And 80% to 84% of teachers strongly agreed or agreed that teaching a dedicated computing course helped encourage their use of project-based and experiential teaching strategies (Figure 20).

Despite teachers' overwhelming consent that teaching a dedicated computing course improved their outcomes in computing, a closer examination of the findings reveals that particular indicators of some outcomes garnered noticeably less affirmative responses from teachers than others. For example, only 77% of teachers strongly agreed or agreed that teaching a dedicated computing course convinced them that teaching that integrates computing "is more effective" (an indicator of views about teaching that integrates computing; Figure 19). Additionally, only 65% of teachers strongly agreed or agreed that teaching a dedicated computing course helped them gain "mastery of different technologies that I can use in my instruction" (an indicator of computing competence; Figure 17).

Figure 17. Teachers' Perceptions of the Impact of Dedicated Computing Courses on their Computing Competence

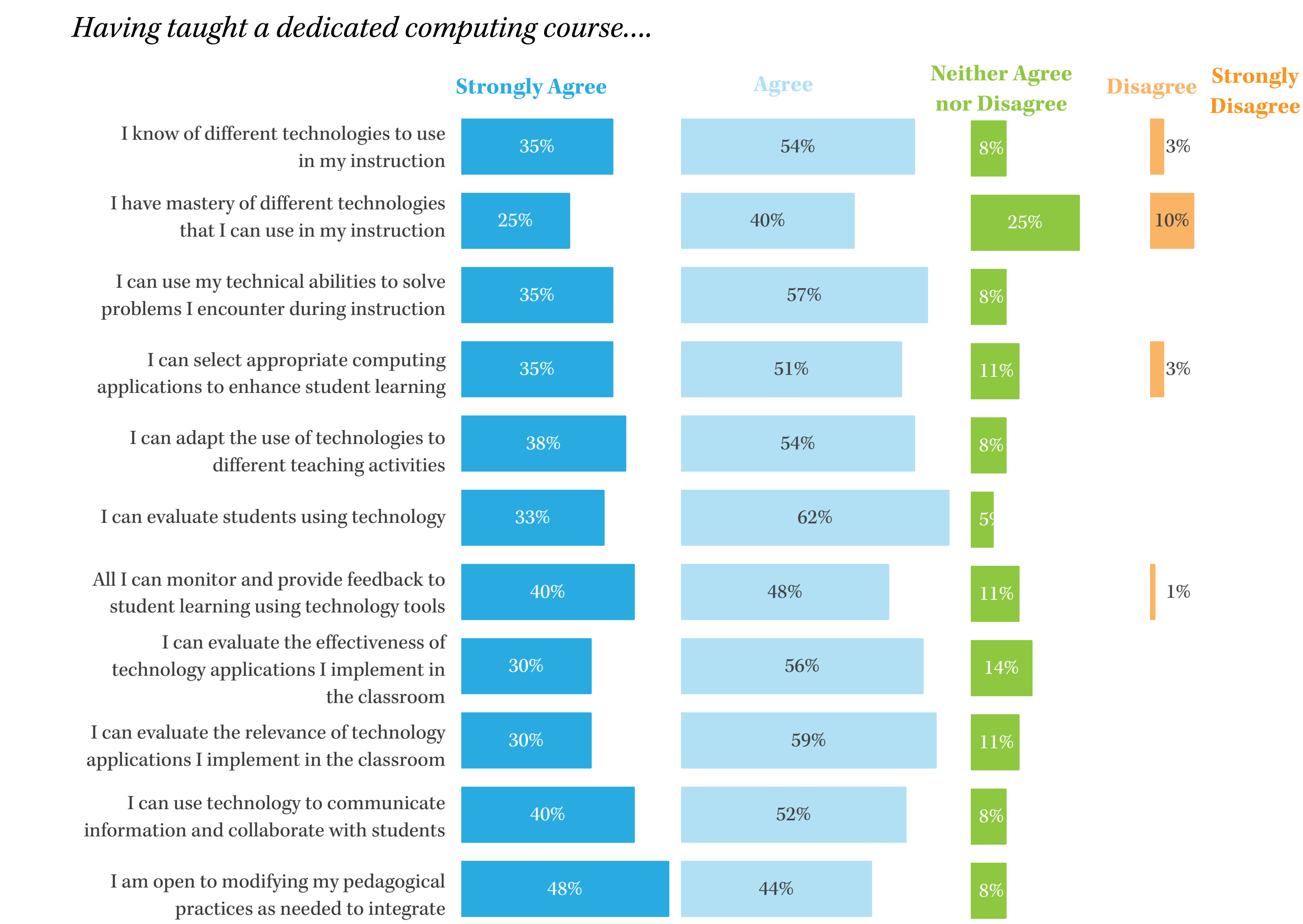


Figure 18. Teachers' Perceptions of the Impact of Dedicated Computing Courses on their Views about Equity and Access in Computing

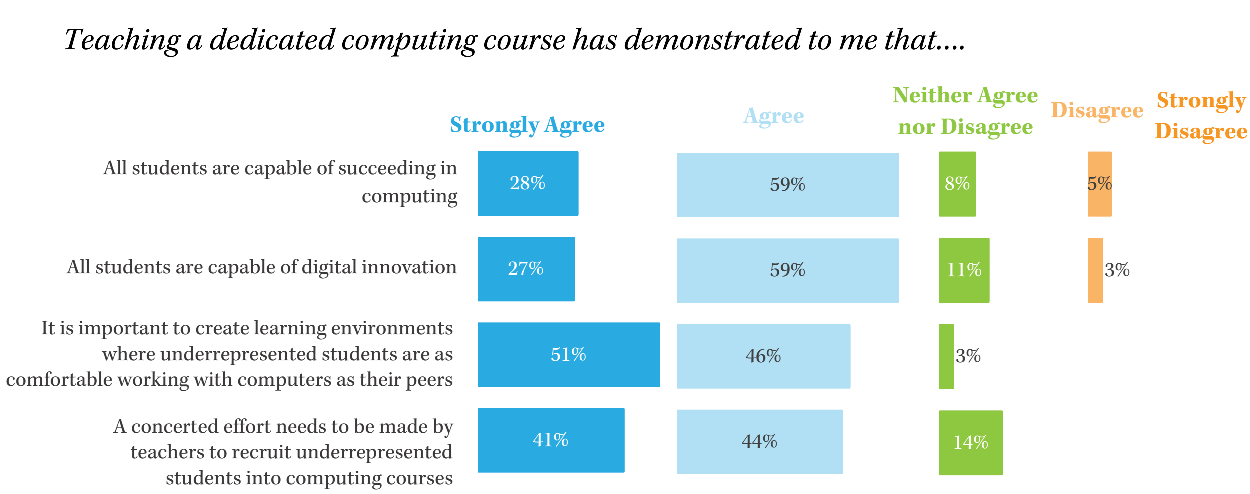


Figure 19. Teachers' Perceptions of the Impact of Dedicated Computing Courses on their Views About Teaching That Integrates Computing

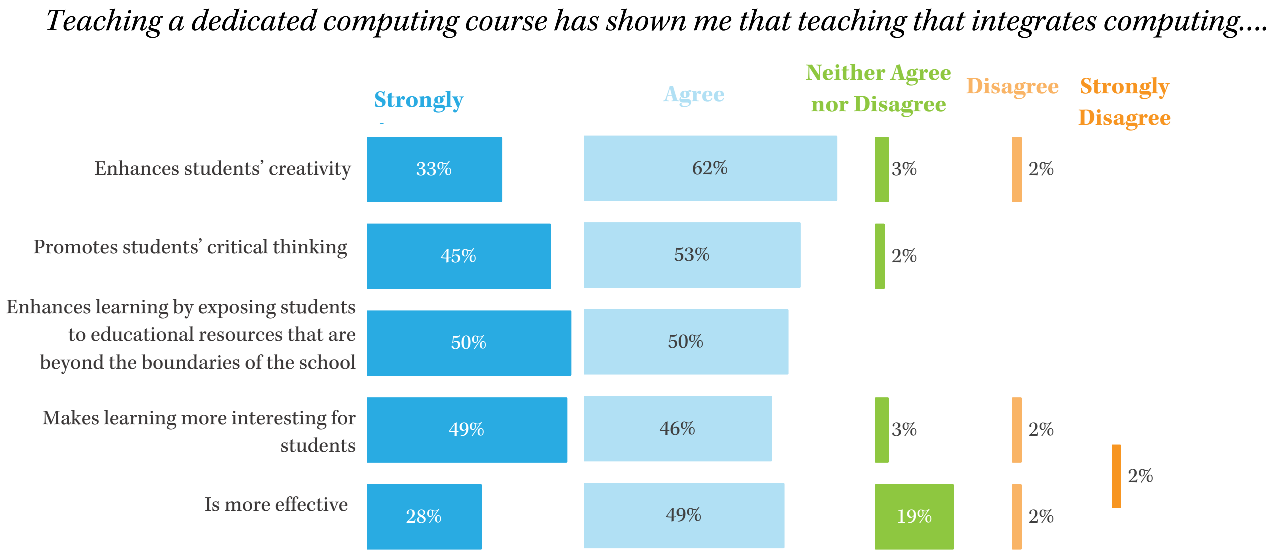


Figure 20. Teachers' Perceptions of the Impact of Dedicated Computing Courses on their Use of Project-Based and Experiential Pedagogy

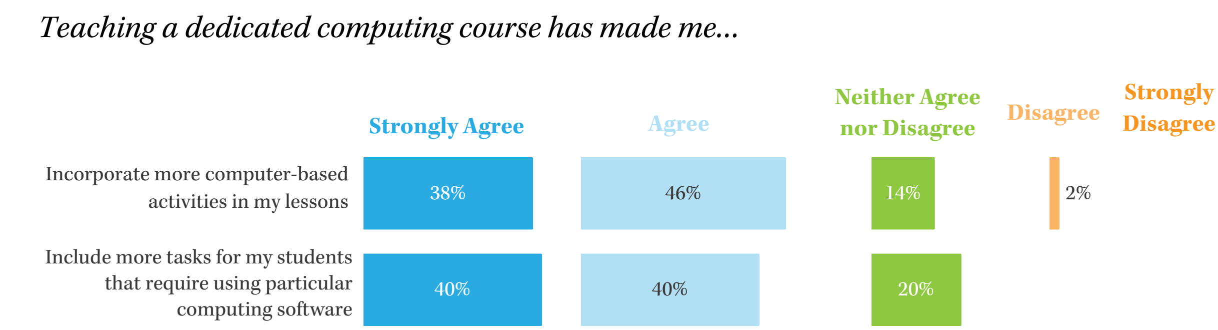
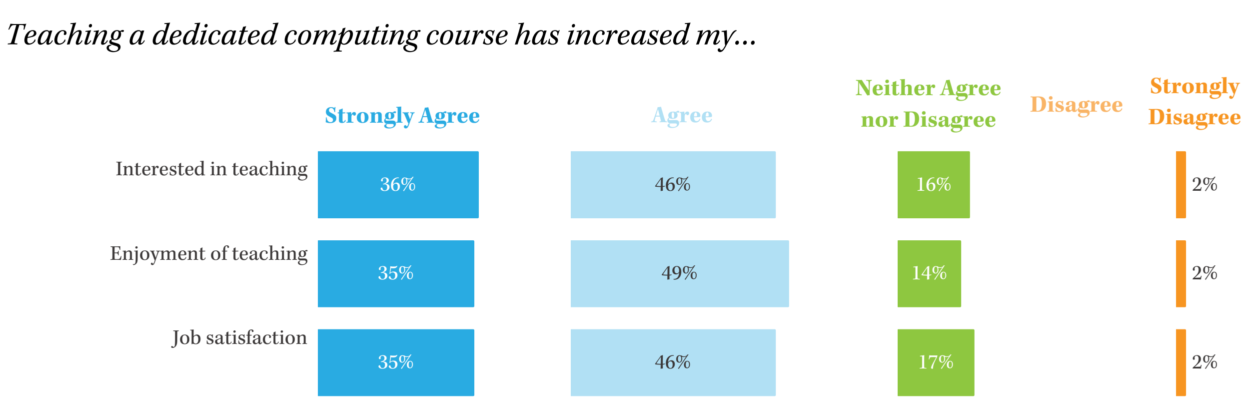


Figure 21. Teachers' Perceptions of the Impact of Dedicated Computing Courses on Their Teaching Attitudes



PART FIVE:

INTEGRATION OF COMPUTING INTO EXISITING COURSES

Teachers who integrated computing into their non-computing courses were questioned about the influence that their redesigned courses had on key student outcomes in computing. The student outcomes of interest are those identified in **Figure 1 - Teacher and Student Outcomes in Computing Assessed by the Current Evaluation** and include computing self-efficacy, computing interest, computing engagement, cognitive skills in computing, technical skills in computing, and intentions to pursue computing. Teachers were also asked to specify the extent to which teaching computing-enhanced courses impacted their computing competence, computing confidence, views about equity and access in computing, views about teaching that integrates computing, use of project-based and experiential pedagogy, and teaching attitudes. This section reviews key findings from these survey items.

Key Findings on Student Outcomes

Math and Science Courses that Integrate Computing Elements Are Not Equally Effective at Improving Student Outcomes in Computing

Teachers noted that they integrated computing elements in a wide variety of courses including, but not limited to, mathematics, science, U.S. history, art, elective language arts, and reading. Additionally, among teachers who noted that computing elements were incorporated in their mathematics and science courses, many, though not all, were specific about the grade levels in which these courses were taught, citing for example "Math 2," "Math 6," or "8th grade science." Given the sizeable number of responses received related to mathematics and science more generally, we highlight these two sets of courses here and compare their effectiveness at promoting the desired student outcomes in computing.

As Figures 22-26 suggest, math and science courses that integrate computing vary in their effectiveness at improving student outcomes in computing. Teachers who taught science courses were more likely than those who taught math courses to indicate that they observed an increase in students' computing self-efficacy (60% vs 53%; Figure 22), computing interest (67% vs 50%; Figure 23), computing engagement (60% vs 48%; Figure 24), and intentions to pursue computing (20% vs 18%, Figure 26) towards the end of the course. Contrastingly, teachers who taught math courses were slightly more likely than those who taught science courses (88% vs 87%; Figure 25) to note that the observed an increase in students' computing skills at the end of enrollment in course.

Figure 22. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Self-Efficacy

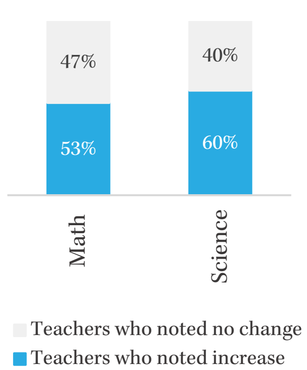


Figure 23. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Interest

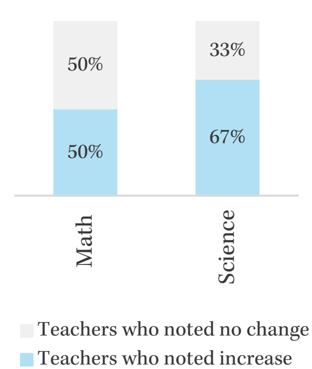


Figure 24. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Engagement

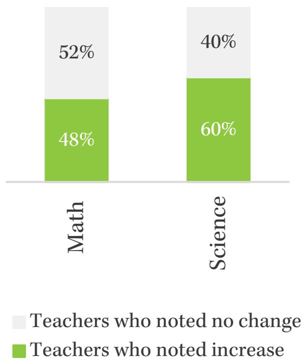


Figure 25. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Skills

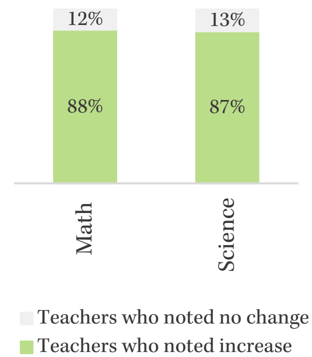
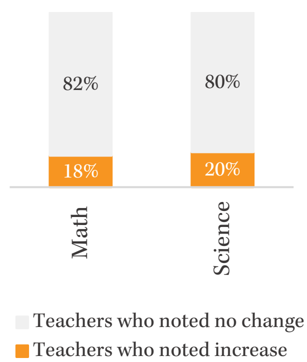


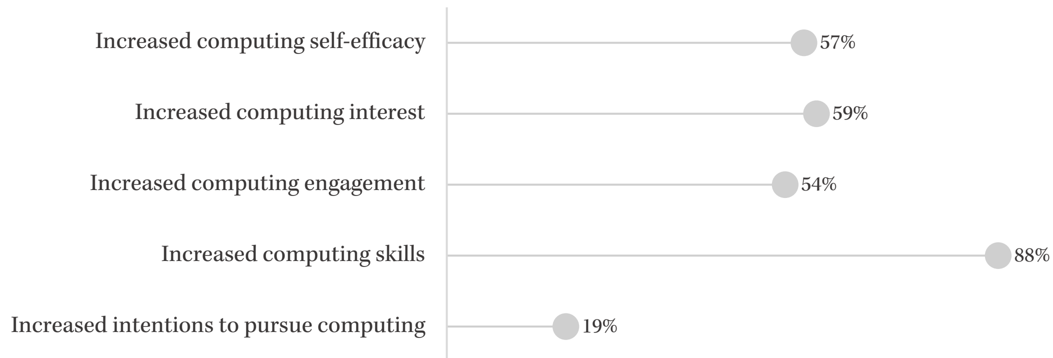
Figure 26. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Intentions to Pursue Computing



Math and Science Courses That Integrate Computing Elements Are Generally More Effective at Improving Certain Student Outcomes in Computing than Others

When math and science courses that integrate computing are combined, the trend in their effectiveness at improving the different student outcomes in computing is more easily observed. As Figure 27 illustrates, both courses, as gleaned from the percentages of teachers who noted that they observed an increase in each student outcome, are generally most effective at increasing students' computing skill, followed by their computing interest, computing self-efficacy, computing engagement, and lastly, intentions to pursue computing. Eighty-percent of math and science teachers that redesigned their courses to integrate computing, for example, indicated that they observed an increased in students' computing skills by the end of the courses. The proportion of teachers who noted an increase in students' intentions to pursue computing during the same time frame, however, is only 19%.

Figure 27. Average Percent of Teachers Who Observed an Increase in Students' Outcomes in Computing Across Computing-Enhanced Math and Science Courses



Most Teachers Who Integrated Computing Elements in Their Non-Computing Courses Strongly Agree or Agree That Their Students Achieved the Desired Outcomes in Computing Towards the End of Enrollment in the Courses

Figures 28-33, unlike Figures 22-27, reflect the responses of *all* teachers who indicated in the survey that they integrated computing in their non-computing courses. As Figures 28-33 show, teachers who redesigned their non-computing courses to incorporate computing elements were asked to specify the extent to which they agree that their students possessed the various indicators of each desired outcome at the start and also at the close of their courses. This group of teachers, as findings suggest, were generally more likely to strongly agree or agree that their students had the various attributes associated with each outcome towards the end of their enrollment in the courses, rather than at the start of their enrollment. Additionally, with the exception of one indicator of cognitive skills in computing (concerned with students' ability to "explain the behavior of informatics and computer systems in their own words;" Figure 31), over 50% of teachers strongly agreed or agreed that their students possessed all the attributes related to each student outcome by the end of the courses.

These generalities aside, important differences exist in teachers' perceptions about the outcomes that students possessed at both points of observation. As it concerns student outcomes at the start of enrollment in redesigned non-computing courses, teachers were, by far, least likely to strongly agree or agree that their students' had the requisite cognitive skills in computing. Only 2% to 15% of teachers, depending on the indicator, noted that they strongly agreed or agreed that students possessed cognitive skills in computing at the onset of their enrollment in non-computing courses that integrated computing (Figure 31). These percentages pale in comparison to the 56% to 73% of teachers, again contingent upon the indicator, who strongly agreed or agreed that students exhibited computing interest at the start of their courses (Figure 29) or the 54% to 60% of teachers who strongly agreed or agreed that students' demonstrated intentions to pursue computing at the beginning of their courses (Figure 32).

When considering student outcomes towards the end of enrollment in non-computing courses that integrated computing, differences in teachers' perceptions are also readily apparent. Teachers were, again, least likely to strongly agree or agree that students' possessed cognitive skills in computing compared to other student outcomes (Figure 31). To be precise, 47% to 74% of teachers, varying by the indicator, strongly agreed or agreed that students possessed cognitive skills in computing at the end of their courses. These percentages are much lower than the 89% to 97% of teachers who strongly agreed or agreed that students' exhibited intentions to pursue computing (Figure 32), the 93% to 97% of teachers who noted that students demonstrated computing engagement (Figure 30), and the 96% to 100% of teachers who strongly agreed or agreed that students were self-efficacious in computing (Figure 28) by the end of their courses.

Figure 28. Teachers' Perceptions of Students' Computing Self-Efficacy at the Start and End of Enrollment

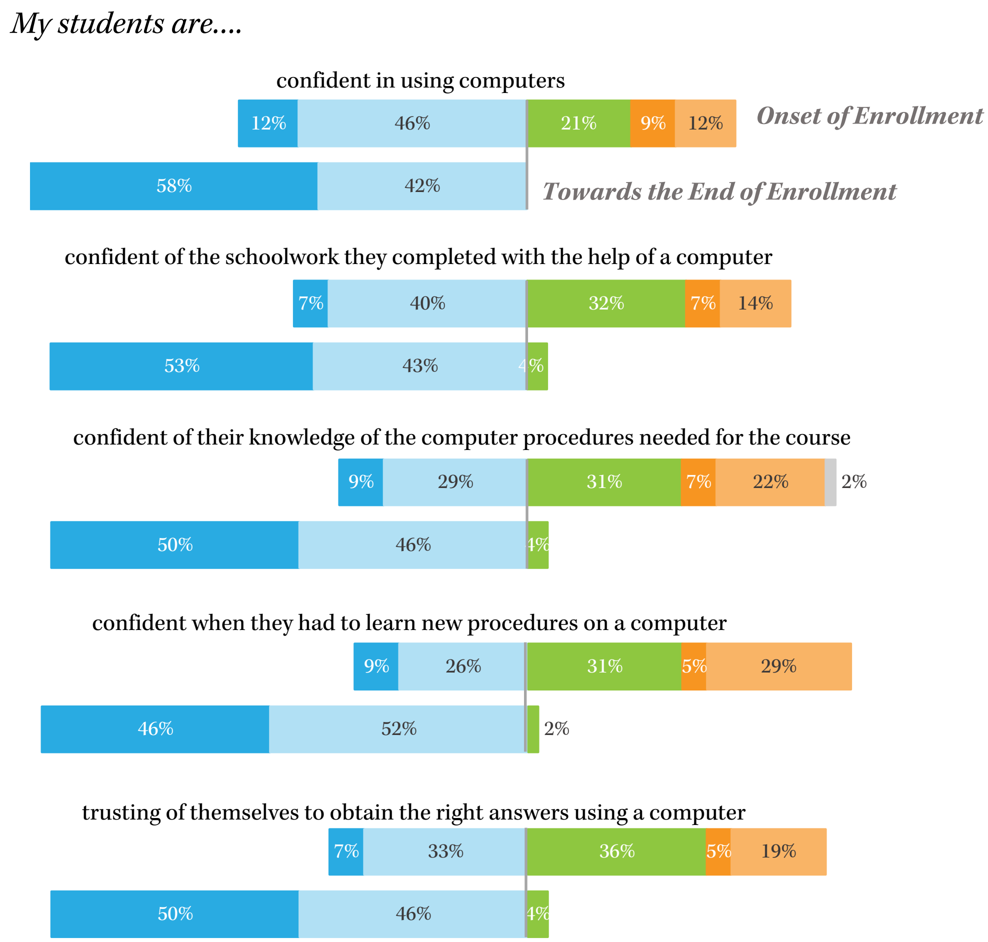


Figure 29. Teachers' Perceptions of Students' Computing Interest at the Start and End of Enrollment

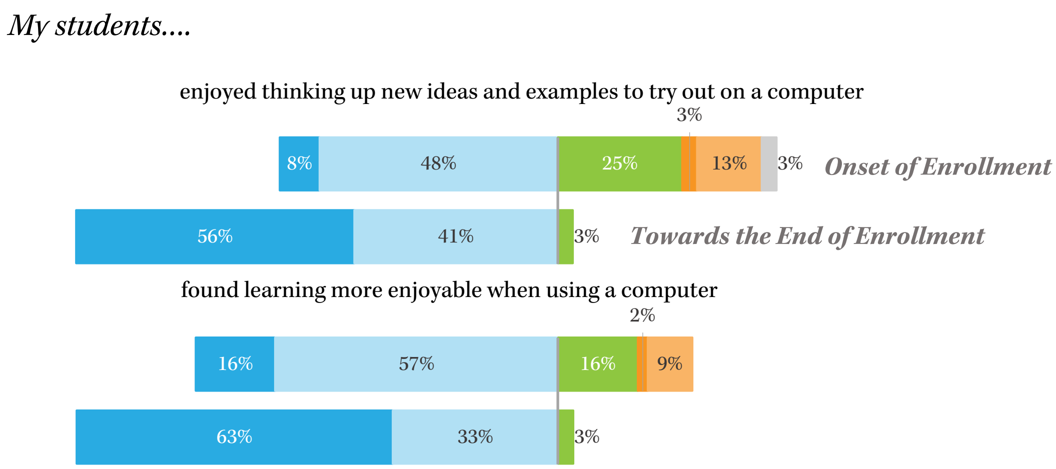


Figure 30. Teachers' Perceptions of Students' Computing Engagement at the Start and End of Enrollment

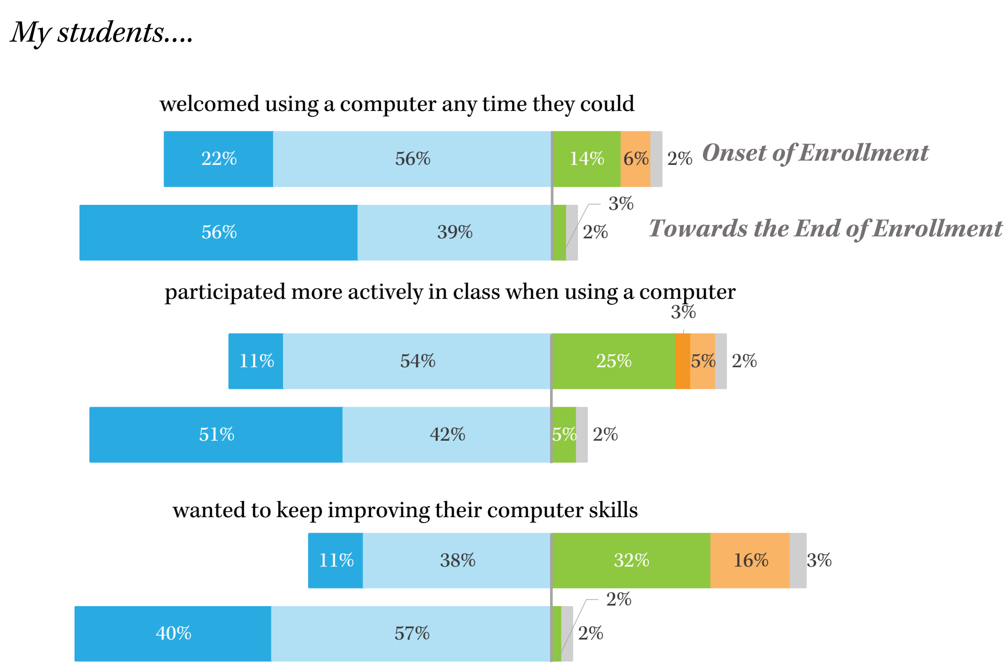


Figure 31. Teachers' Perceptions of Students' Cognitive Skills in Computing at the Start and End of Enrollment

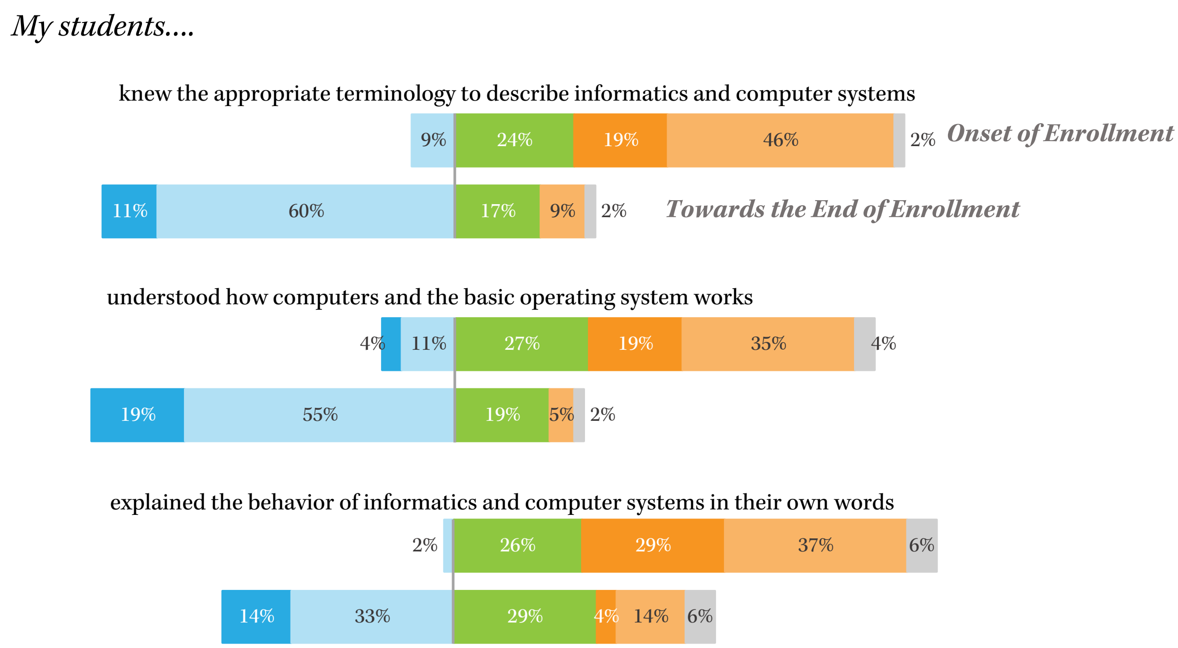


Figure 32. Teachers' Perceptions of Students' Intentions to Pursue Computing at the Start and End of Enrollment

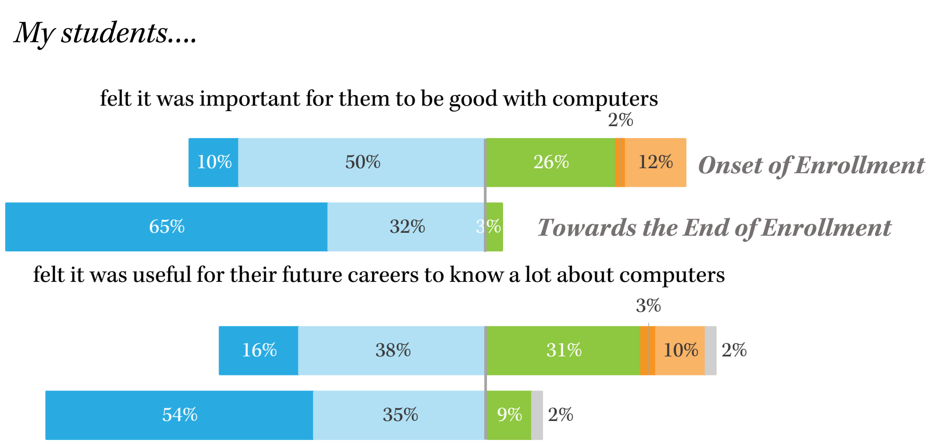
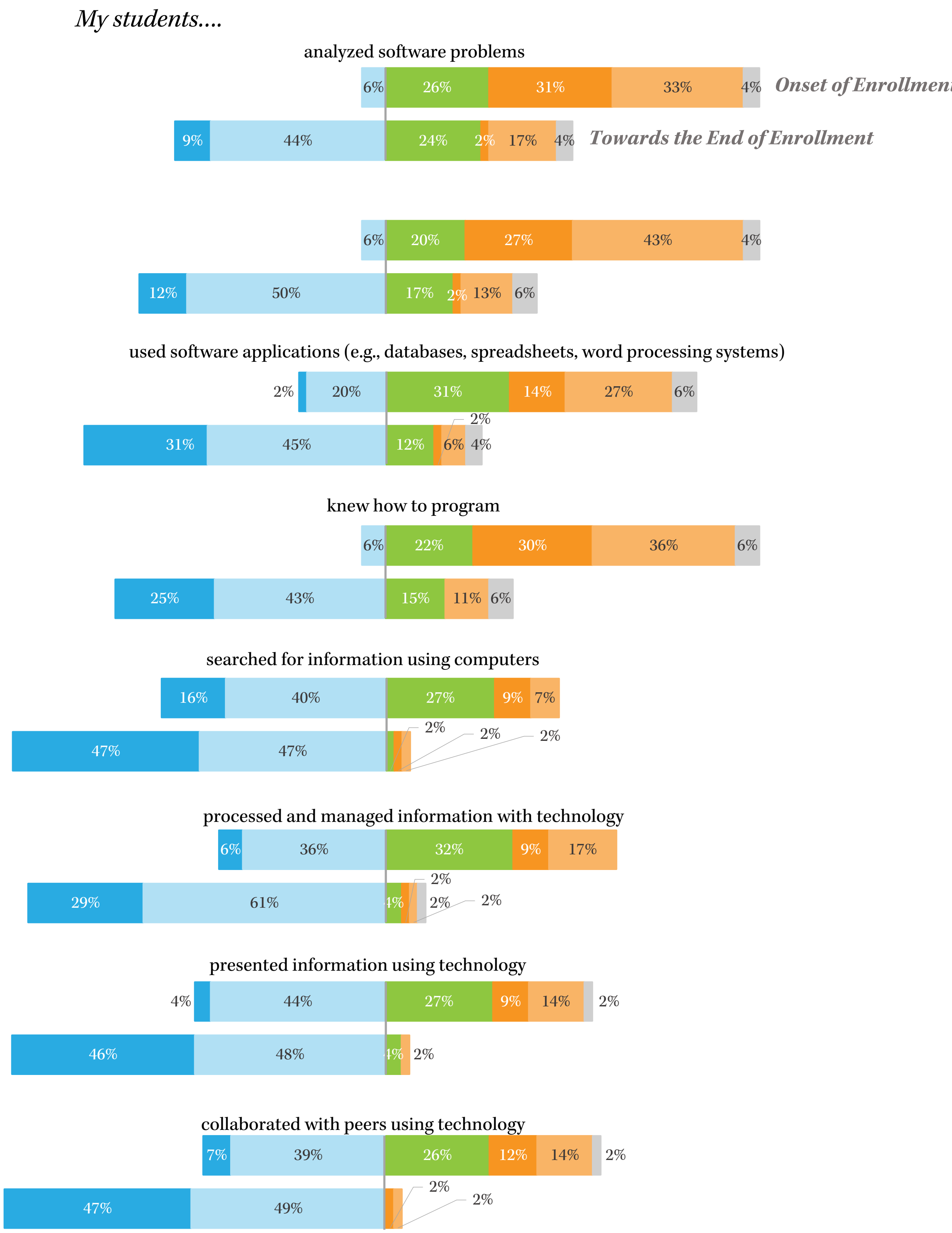


Figure 33. Teachers' Perceptions of Students' Technical Skills in Computing at the Start and End of Enrollment



Key Findings on Teacher Outcomes

An Important Majority of Teachers Strongly Agree or Agree That Integrating Computing into their Non-Computing Courses Improved Their Outcomes in Computing

Teachers were provided with various indicators of each teacher outcome in computing (i.e., computing competence, computing confidence, views about equity and access in computing, views about teaching that integrates computing, use of project-based and experiential pedagogy, and teaching attitudes) and were asked to specify the extent to which they agree that teaching a computer-enhanced course helped nurture these attributes. As Figures 34-39 illustrate, an important majority of teachers strongly agreed or agreed that teaching a course that integrated computing helped them cultivate the various attributes associated with each outcome. For example, between 64% and 92% of teachers, depending on the indicator, strongly agreed or agreed that teaching a computer-enhanced course helped improve their views about teaching that integrates computing (Figure 37). Eighty-seven to 93% of teachers, again varying by the indicator, strongly agreed or agreed that teaching a computer-enhanced course helped them cultivate more culturally responsive and equity-focused views about participation in computing (Figure 36). Between 77% and 97% of teachers strongly agreed or agreed that they developed key computing competencies from teaching a course that integrated computing (Figure 34). Concerning their teaching attitudes, 73% to 77% of teachers strongly agreed or agreed that teaching a computer-enhanced helped improve this outcome (Figure 39). Between 77% and 91% of teachers strongly agreed or agreed that their confidence to use computing in their instruction increased because of teaching a computer-enhanced course (Figure 35). And 84% to 85% of teachers strongly agreed or agreed that teaching a computer-enhanced course helped encourage their use of project-based and experiential teaching strategies (Figure 38).

Despite the generally affirmative responses from teachers about the impact that teaching a computer-enhanced course had on their outcomes in computing, it is important to note that their responses were less positive on some outcome indicators than others. For example, only 64% of teachers strongly agreed or agreed that teaching a computer-enhanced course convinced them that teaching that integrates computing "is more effective" than teaching that does not (an indicator of views about teaching that integrates computing; Figure 37). Only 73% of teachers strongly agreed or agreed that their "interest in teaching" increased because of teaching a computer-enhanced course (an indicator of teaching attitudes; Figure 39). Only 77% of teachers strongly agreed or agreed that teaching a course that integrated computing helped them gain "mastery of different technologies that I can use in my instruction" (an indicator of computing competence; Figure 34). And 77% of teachers strongly agreed or agreed that teaching a redesigned course helped them feel that they were "skilled in using relevant educational software" (an indicator of computing confidence; Figure 35).

Figure 34. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on their Computing Competence

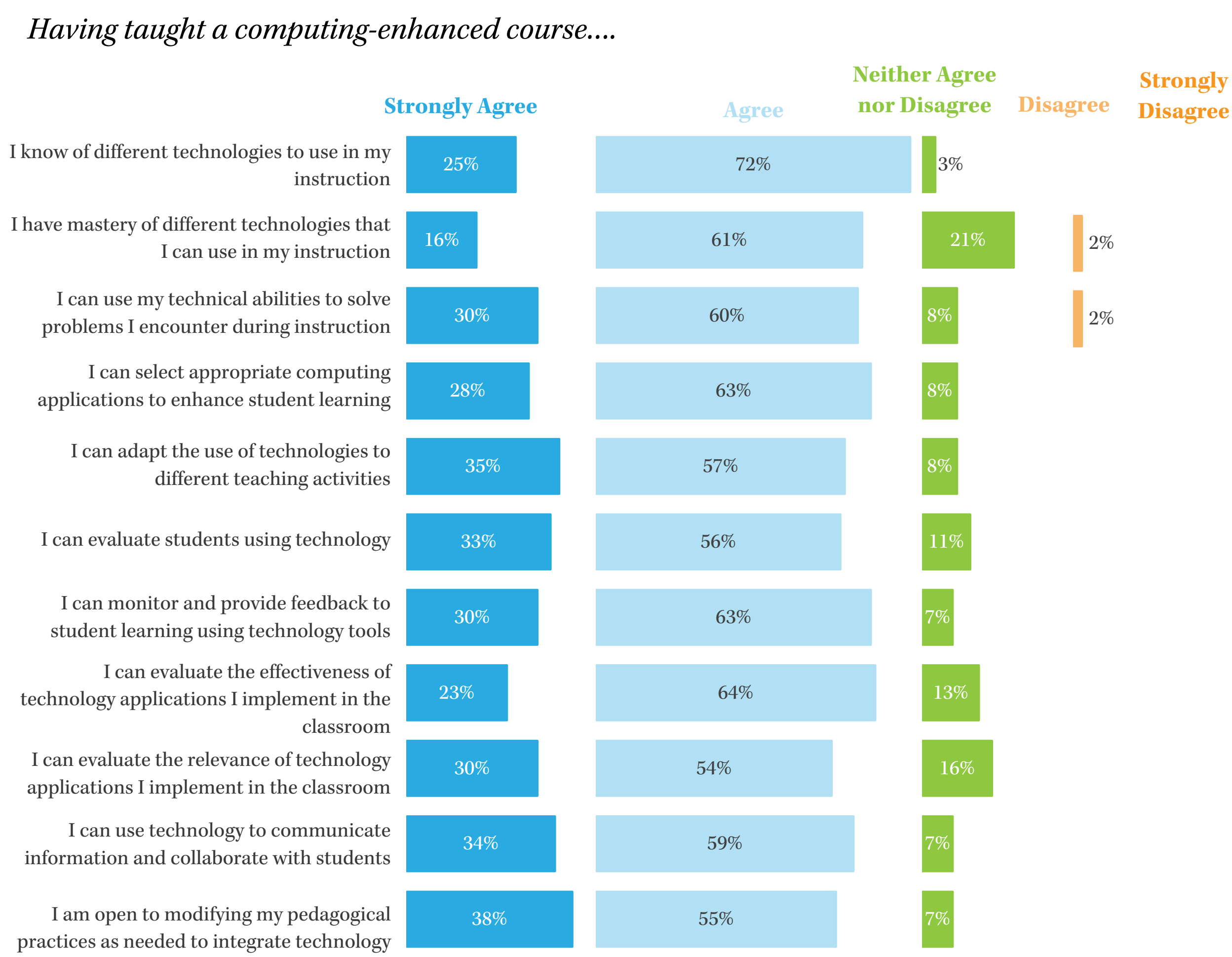


Figure 35. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on their Computing Confidence

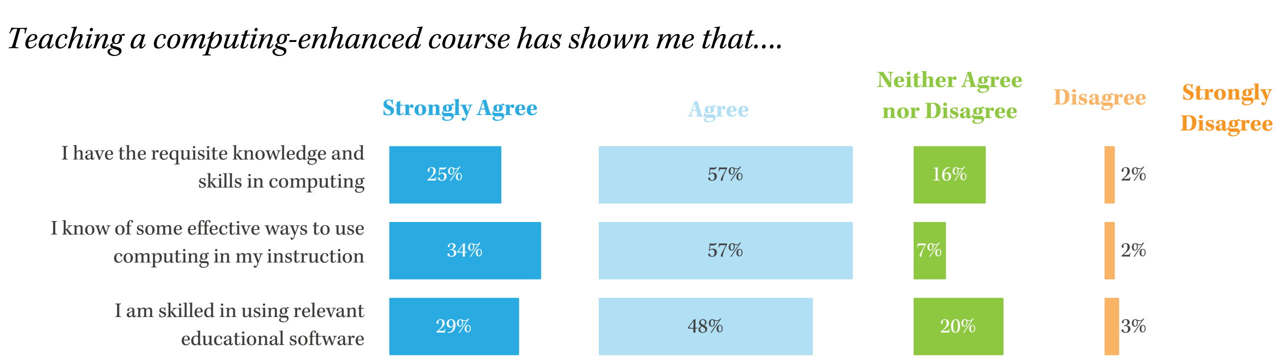


Figure 36. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on their Views about Equity and Access in Computing

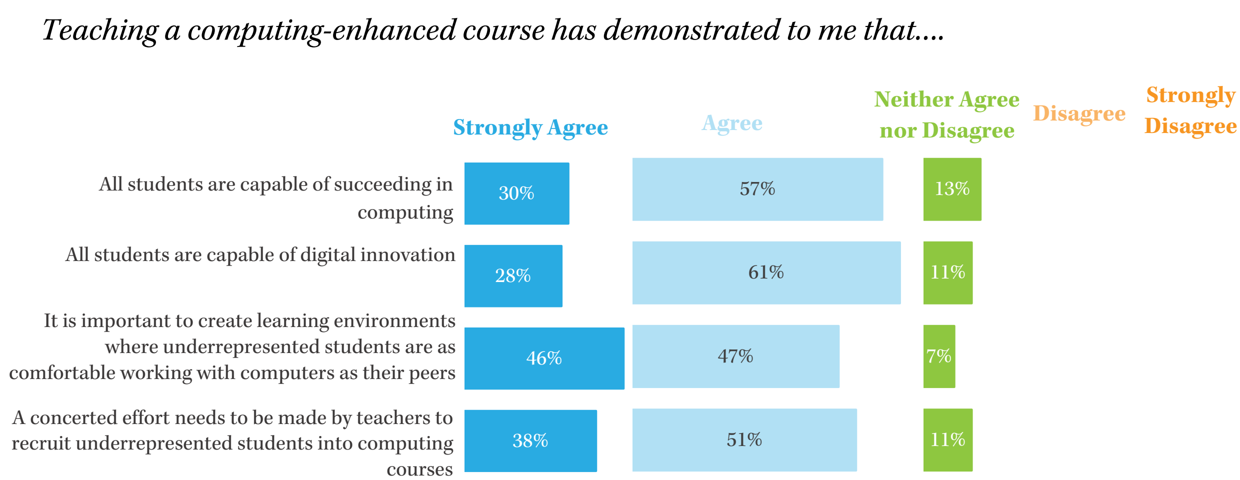


Figure 37. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on their Views About Teaching That Integrates Computing

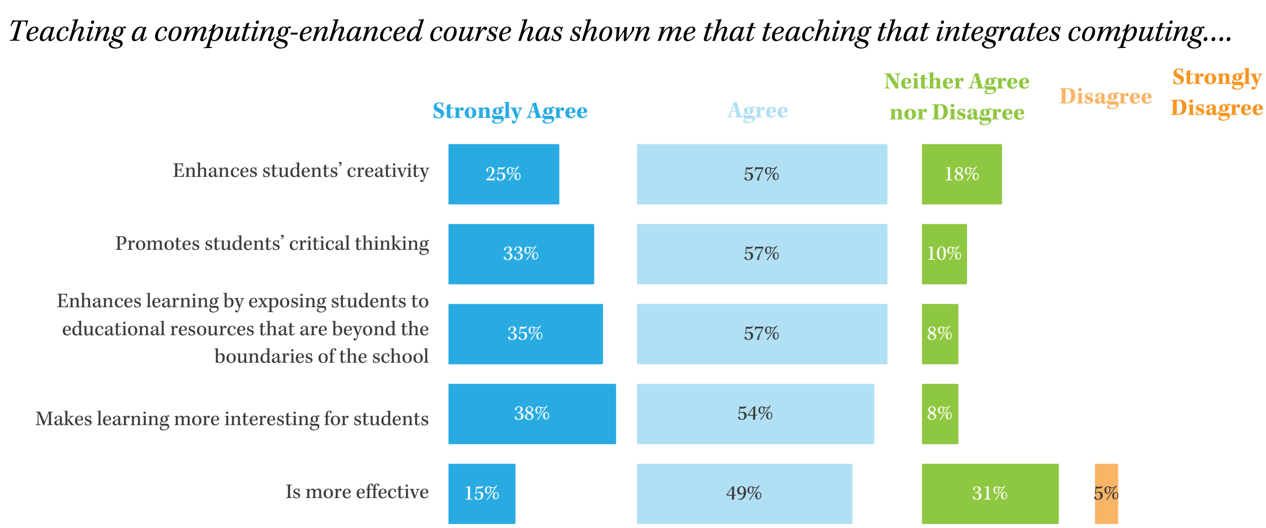


Figure 38. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on their Use of Project-Based and Experiential Pedagogy

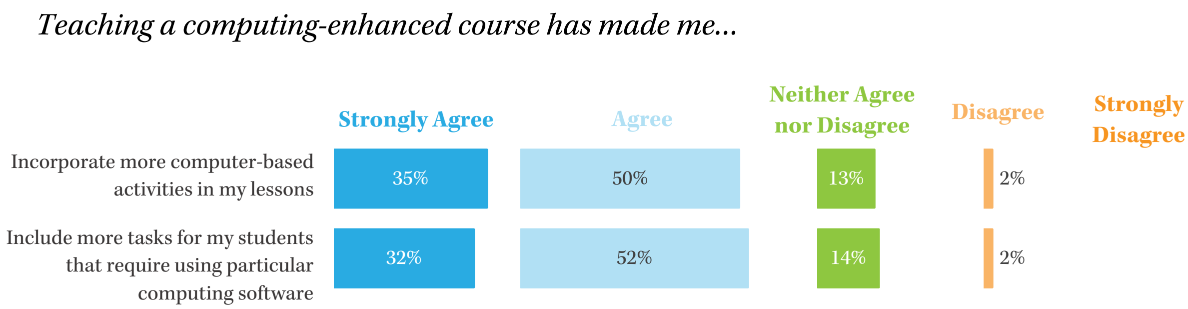
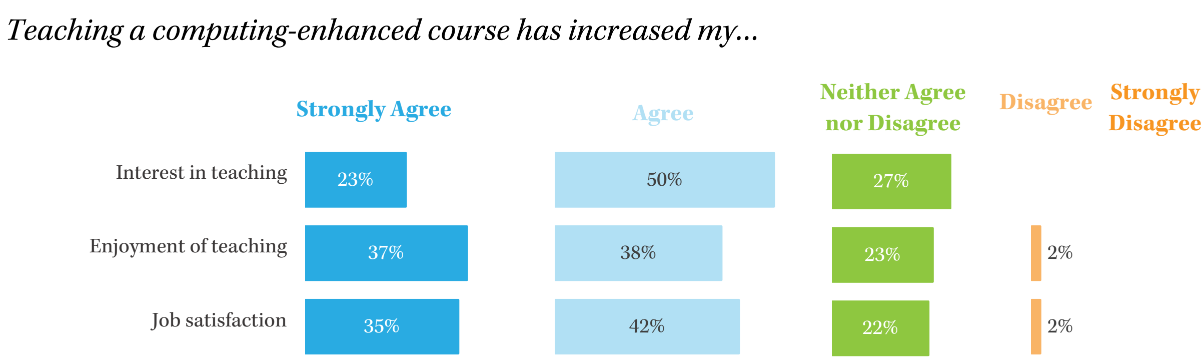


Figure 39. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on Their Teaching Attitudes



Teachers' Experiences with Integrating Computing in Existing Courses

Teachers were invited to reflect on their experiences with integrating computing into their non-computing courses. More specifically, they were asked to address how digital technologies were used in their classrooms and the challenges, if any, they experienced with teaching a technology-enhanced course.

Teachers Who Integrated Computing in Their Non-Computing Courses Used It for Four Key Purposes

As the themes and comments in Table 2 reveal, teachers who integrated computing into their existing, non-computing courses utilized the digital tools for their lesson planning, to provide experiential or hands-on learning to students, and for testing. Additionally, they had their students research, organize, and present information to the class using digital technologies and web-based programs.

Teachers Who Integrated Computing in Their Non-Computing Courses Experienced Several Challenges with The Initiative

As Table 3 illustrates, teachers who enhanced their courses with technology were challenged with insufficient access to technology, disparate levels of technology proficiency among students, technological issues, lack of time to effective integrate technology, disproportionate focus on training students in basic skills, personal lack of experience with chosen software, and students' divided attention.

Table 2. How Teachers Integrated Technology in Their Non-Computing Courses

Lesson Planning	"Classroom computers were used daily from retrieving the daily lesson to production of learning." "Data, lesson plans, communication with students."
Experiential Learning	"Had the kids write narratives after they programmed their narrative on Scratch Jr. They created cause and effect relationships by using Ozobots. They used the computer program Imagine Learning to develop literacy and iPad skills. They used Osmo apps and tiles to practice letters, numbers, shapes, and economics." "I used computing to have my students understand and practice coordinate graphs." "I use the computer to show students extensions. They practice on the skills taught and are able to firm up the concepts." "In art I showed them the various avenues for generating art on a computer."
Researching & Presenting Information	"Presentations, various software, applications." "Research and presenting information to class in history, science via PowerPoint." "Research, handing in of assignments, communication." "Students used computers in my class to research many different topics, write papers, cite sources, check their grades, take assessments, organize and present information."
Testing	"Testing, learning games, extensions like scratch." "They took tests using Canvas. They had the chance, on Fridays, to choose an activity from approved activities (Freckle, Tumblebooks, Storyline Online)."

Table 3. Challenges Teachers Faced with Integrating Computing in Their Non-Computing Courses

Insufficient Access to Technology	"Having the computers in class when I really needed them. We need more tech." "I did not have enough computers and enough adults to help students navigate the computer." "Not having enough "working" elements such as circuit boards, sensors, LEDs, etc., for all students to participate fully." "Not having one to one devices or reliable internet."
Disparate Levels of Proficiency	"Not all students were as confident on a computer as others were. They needed more help." "One of the biggest challenges is getting everyone on the same "page." Some students are so much more adept, that they hurry through without a lot of instruction, while other students need more scaffolding." "Students specific backgrounds and prior proficiencies with technology."
Technological Issues	"Google forms were finicky. Getting google classroom to work smoothly from teachers to students and back." "Internet issues, creation time, and loss of information." "Not having one to one devices or reliable internet." "Student frustration when STEM tools batteries didn't stay charged during the whole activity." "Students Chromebooks being broken or not working effectively." "The Scratch website was unreliable." "We occasionally faced technical difficulties that needed to be surmounted."
Lack of Time	"Finding time to do it all." "Lack of time to really give the students a strong skill."
Disproportionate Focus on Basics	"Making sure that the students know the process of getting on the computer and knowing passwords. For the younger grades it is really hard for each of them to remember all the passwords." "Students outside of my computing course have no foundation of coding. Too much extra time to teach them basics and then incorporate coding activities."
Teachers' Lack of Experience with Software	"It takes time to learn the new technology myself. I wish I had more prep time and collaboration time with my team on learning the new technology tools." "Learning the programs myself."
Divided Attention	"It is sometimes hard to have the students stayed focused on the assignment while on the computer." "Keeping the students focused on the project at hand and not getting sidetracked." "Since students were more aware of the things their computers could do, they wasted time playing with the settings. They kept getting side-tracked with things they wanted to do instead of focusing on the work they needed to do."

PART SIX:

OUTREACH AND STUDENT ENGAGEMENT ACTIVITIES

Teachers who supervised computing-related outreach and student engagement activities were asked about the impact that these activities had on key student outcomes in computing. The student outcomes of interest are those identified in **Figure 1 - Teacher and Student Outcomes in Computing Assessed by the Current Evaluation** and include computing self-efficacy, computing interest, computing engagement, cognitive skills in computing, technical skills in computing, and intentions to pursue computing. Teachers were also asked to evaluate the influence that their supervisory involvement in these activities had on their views about equity and access in computing. This outcome was also the most appropriate to evaluate for teachers who oversaw out-of-classroom activities as the other teacher outcomes in computing were mostly concerned with attributes relevant to curricular practice. This section addresses key findings related to these survey items.

Key Findings on Student Outcomes

The Eleven Most Offered Computing-Related Outreach and Student Engagement Activities Are Not Equally Effective at Improving Student Outcomes in Computing

Teachers were provided with 11 computing-related outreach and student engagement activities as well as the option to write-in other activities not already identified that they had supervised. Further, they were asked to indicate whether or not they observed an improvement in their students' outcomes in computing towards the close of participation in the different activities. Besides the 11 activities covered in Figures 40-44, other computing-related outreach and student engagement activities were noted by teachers including *Cybersecurity*, *Drones*, *Girls Who Code*, *Mouse Robotics Activity*, *Target Tutoring*, and *3D Printing* to name a few. However, because of the sizeable number of responses received concerning the 11 pre-identified activities, we highlight only them in Figures 40-44.

As these figures illustrate, noticeable variations exist in teachers' perceptions about the effectiveness of each activity in bringing about the desired student outcomes in computing. As Figure 40 shows, teachers who supervised *Other Robotics Clubs* (70%) and *Coding Clubs* (62%) were much more likely to indicate that they observed an increase in students' self-efficacy by the end of participation in the activities, compared to teachers who supervised other activities, most notably, *Hack-a-thons* (20%) and *First Tech Challenges* (22%). As the other figures also suggest, teachers who supervised *Other Robotics Clubs* were also most likely to indicate that they observed an increase in students' computing interest (78%; Figure 41), computing engagement (74%; Figure 42), computing skills (78%; Figure 43), and intentions to pursue computing (63%; Figure 44) at the end of participation in the activity, compared to teachers who supervised other activities. Contrastingly, only about a third or less of teachers who supervised *Hack-a-thons* and *Family Hour of Code* indicated that they observed an increase in any given student outcome toward the end of participation in the activities.

Figure 40. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Self-Efficacy

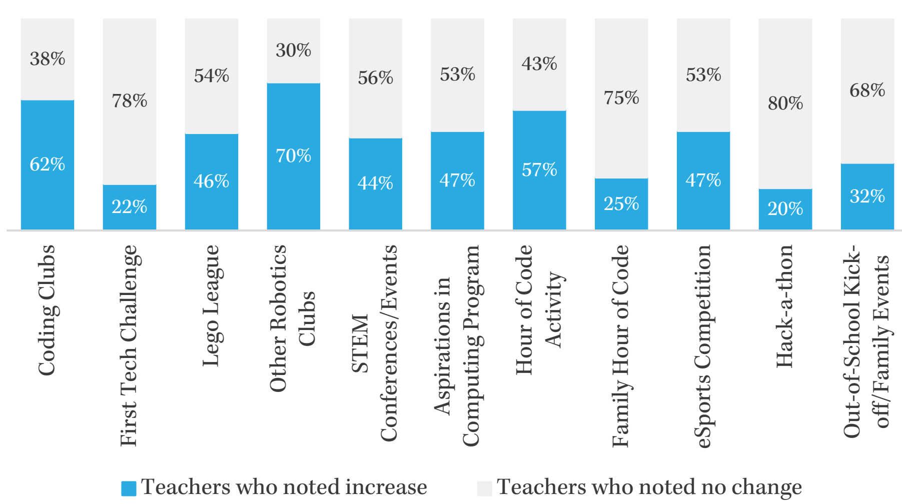


Figure 41. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Interest

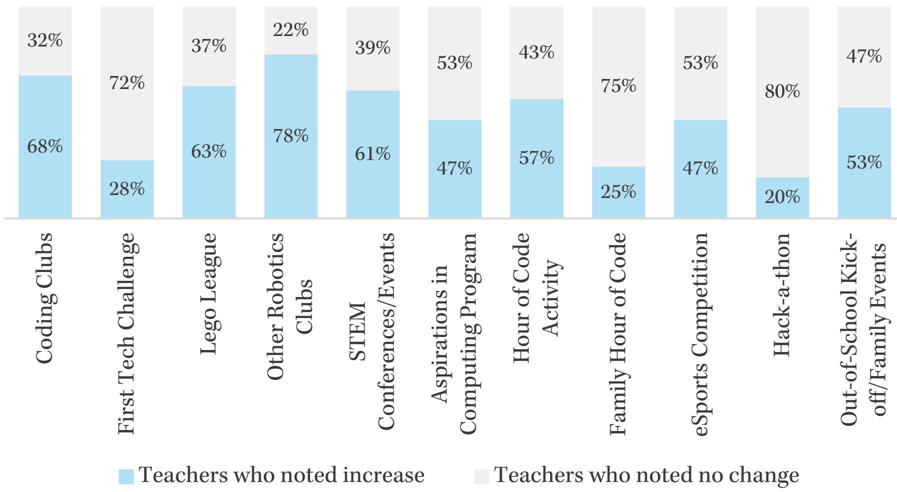


Figure 42. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Engagement

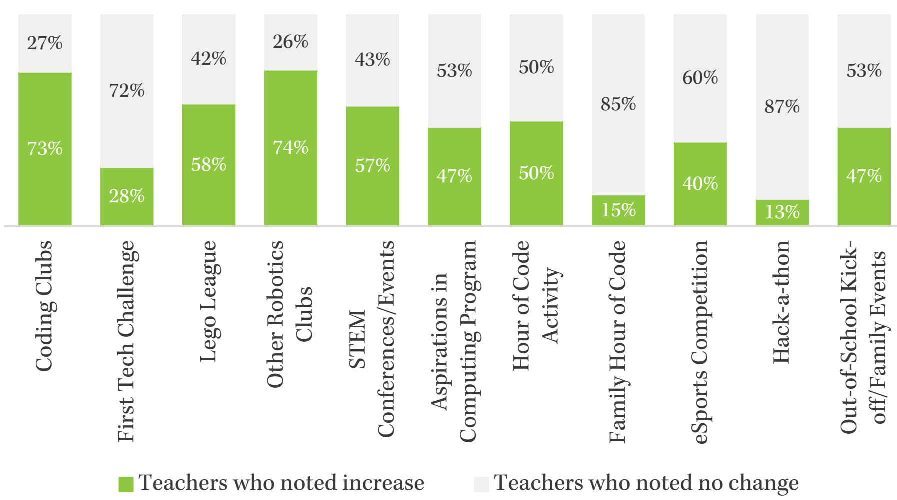


Figure 43. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Skills

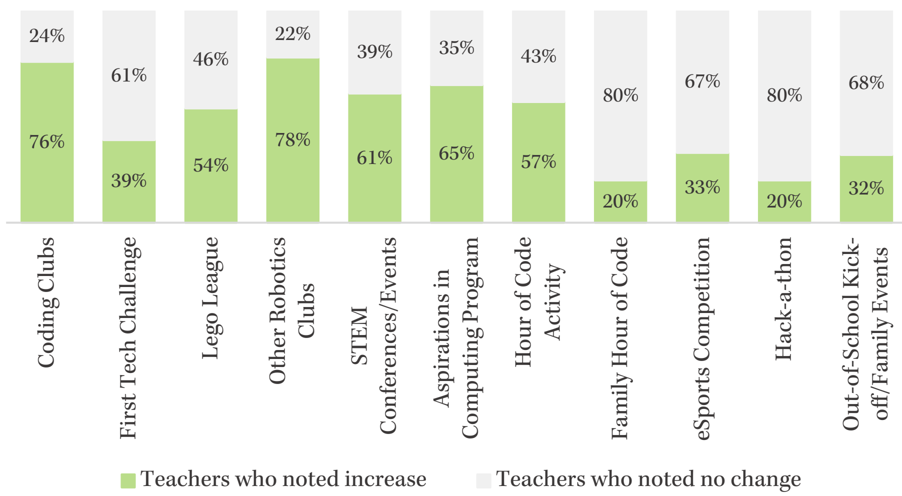
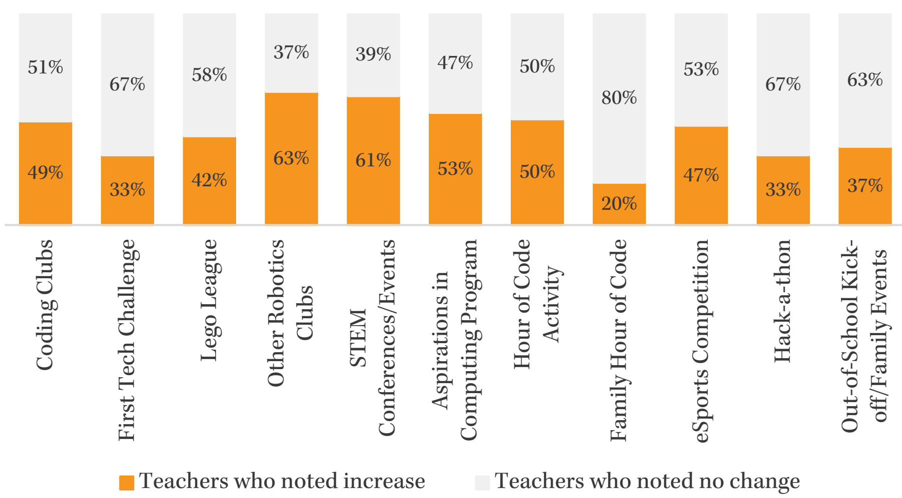


Figure 44. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Intentions to Pursue Computing



The Eleven Most Offered Computing-Related Outreach and Student Engagement Activities Are More Effective at Improving Certain Student Outcomes in Computing than Others

The variations in teachers' assessment of the effectiveness of each computing-related extracurricular activity in improving student outcomes aside, Figure 45 suggests that these 11 activities together are generally more effective at improving certain student outcomes in computing than others. When grouped together, the 11 most offered computing-related out-of-classroom activities appear to be most effective at increasing students' computing interest, following by their computing skills, computing engagement, intentions to pursue computing, and lastly, computing self-efficacy. As Figure 45 illustrates, 50% of teachers indicated that they observed increased interest in computing among students who participated in these activities towards the end of participation, compared to 43% of teachers who noted that they observed an increase in students' self-efficacy in computing during the same time frame.

Figure 45. Average Percent of Teachers Who Observed an Increase in Students' Outcomes in Computing Across Top 11 Outreach and Student Engagement Activities

Most Teachers Who Supervised Computing-Related Outreach and Student Engagement Activities Strongly Agree or Agree That Their Students Achieved the Desired Outcomes in Computing Towards the End of Participation in the Activities

Data represented in Figures 46-48 is inclusive of all teachers who oversaw computing-related outreach and student engagement activities, including those activities not covered in Figures 40-45. As Figures 46-48 illustrate, teachers were queried about the extent to which they agree that their students possessed indicators of cognitive skills in computing, technical skills in computing, and intentions to pursue computing at the start of participation in extracurricular activities and also at the end of participation. Given the relative infrequency of extracurricular activities, as compared to curricular activities, it seemed most appropriate to only ask teachers who supervised out-of-classroom activities more nuanced questions about the three aforementioned student outcomes that seem to be the target of these sort of activities.

As Figures 46-48 show, teachers who chaperoned computing-related outreach and student engagement activities were much more likely to strongly agree or agree that their students demonstrated cognitive skills in computing (Figure 46), technical skills in computing (Figure 48), and intentions to pursue computing (Figure 47) at the end of these activities rather than at their beginning. Moreover, the majority of teachers strongly agreed or agreed that their students' exhibited each indicator of the three outcomes at the end of participation in these activities.

The general similarities in teachers' assessments notwithstanding, notable differences are also present in their perceptions of students' outcomes at both points of observation. Teachers were less likely to strongly agree or agree that students possessed certain indicators of cognitive skills in computing and technical skills in computing at the beginning of participation in extracurricular activities than they were to share the same sentiments concerning indicators of students' intentions to pursue computing. To give an example, between 13% to 35% of teachers, depending on the indicator, strongly agreed or agreed that students' possessed cognitive skills in computing at the start of participation in computing-related out-of-classroom activities (Figure 46) compared to 40% to 54% of teachers who strongly agreed or agreed that students exhibited intentions to pursue computing at the start of participation in activities (Figure 47). In a similar vein to cognitive skills in computing, as low as 8%, 12%, and 16% of teachers strongly agreed or agreed that students possessed certain indicators of technical skills in computing at the beginning of participation in computing-related outreach and student engagement activities (Figure 48). These indicators of technical skills in computing include being able to "analyze software problems," model solutions to known or unknown software problems," and "program" respectively.

Concerning student outcomes at the end of participation in computing-related outreach and student engagement activities, teachers were similarly more likely to respond affirmatively that their students demonstrated intentions to pursue computing than they were to respond affirmatively about their students possessing cognitive skills in computing and technical skills in computing. Ninety-three to 96% of teachers, depending on the indicator, strongly agreed or agreed that their students exhibited intentions to pursue computing (Figure 47), compared to 58% to 79% of teachers who shared the same sentiments about their students demonstrating cognitive skills in computing (Figure 46), and 72% to 90% of teachers concerning their students demonstrating technical skills in computing (Figure 48).

Figure 46. Teachers' Perceptions of Students' Cognitive Skills in Computing at the Start and End of Participation

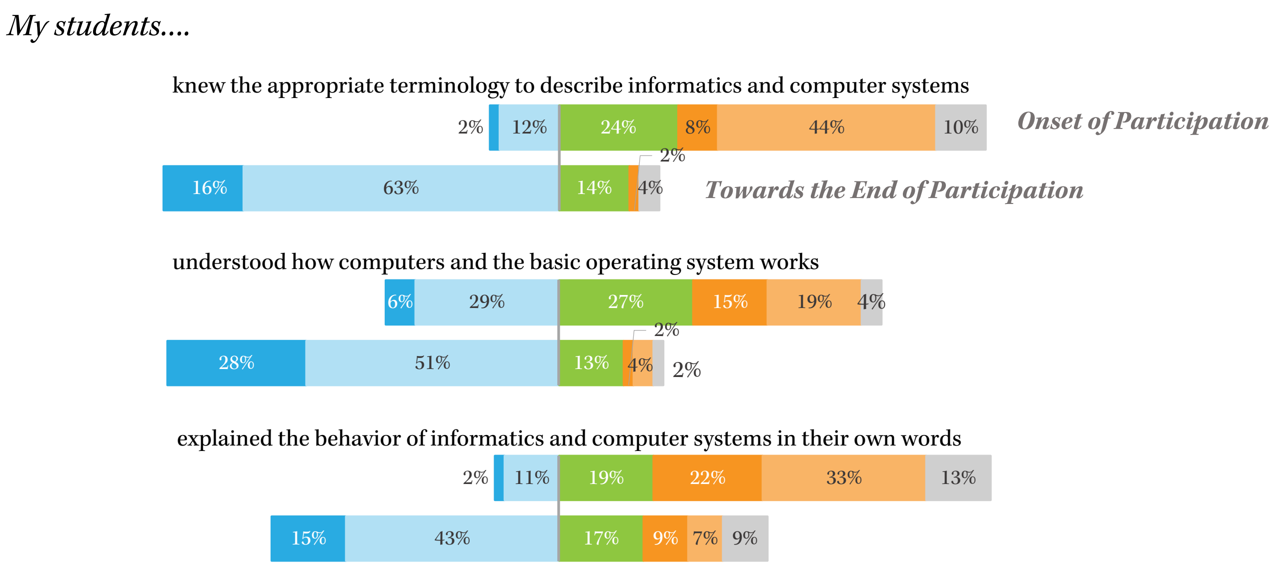


Figure 47. Teachers' Perceptions of Students' Intentions to Pursue Computing at the Start and End of Participation

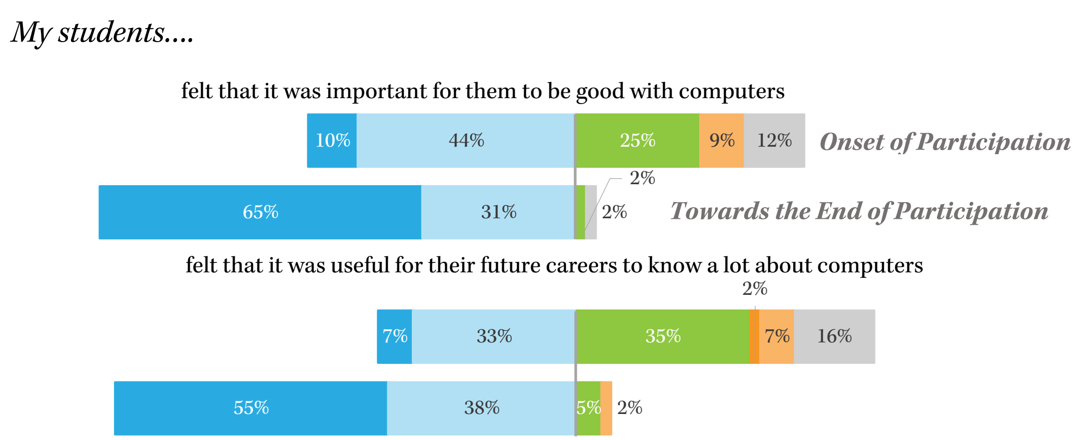
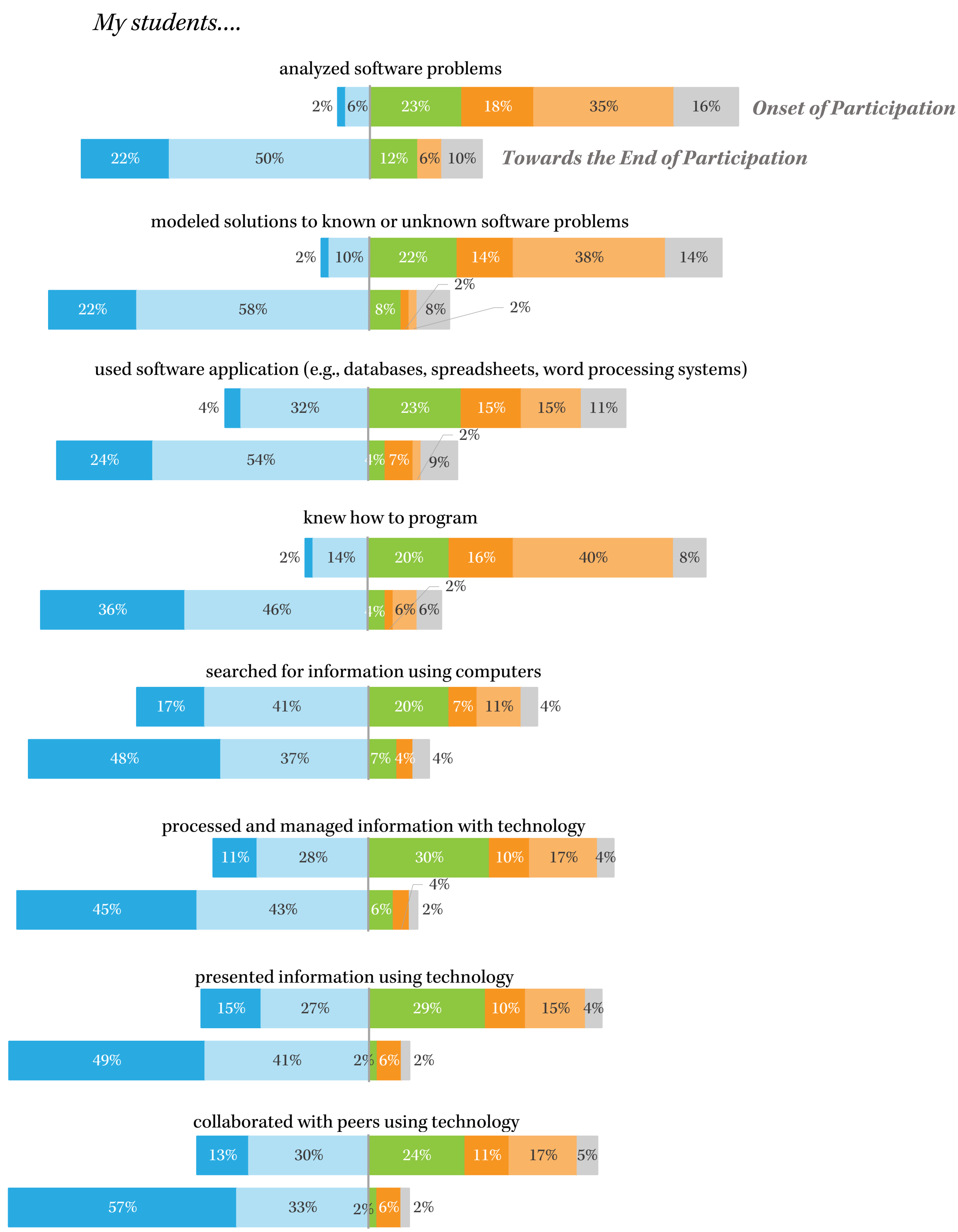


Figure 48. Teachers' Perceptions of Students' Technical Skills in Computing at the Start and End of Participation

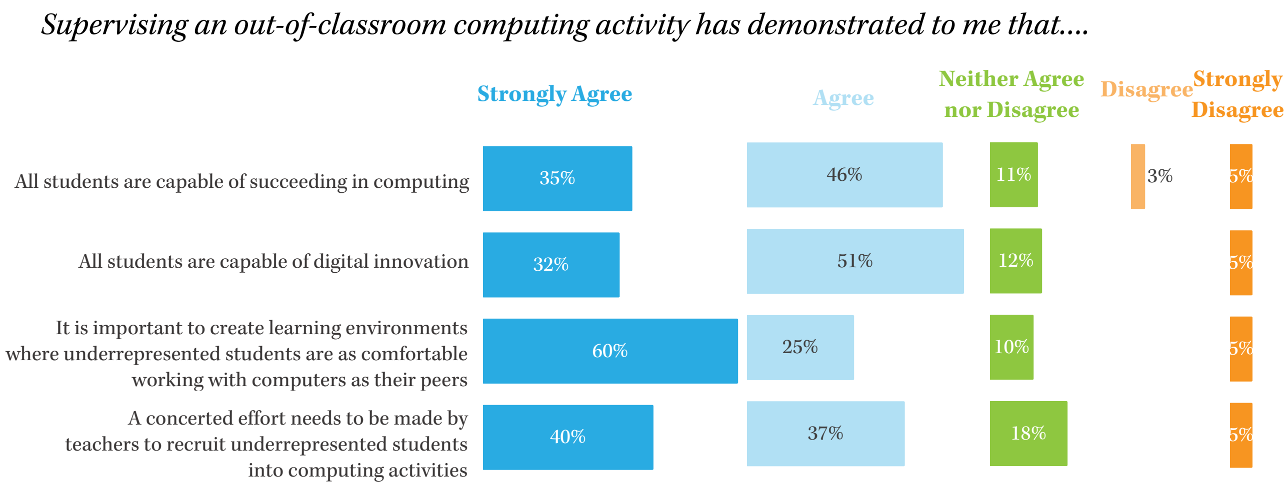


Key Findings on Teacher Outcomes

An Overwhelming Majority of Teachers Strongly Agree or Agree That Supervising Computing-Related Out-of-Classroom Activities Improved Their Views About Equity and Access in Computing

Teachers were asked to indicate the extent to which they agree that supervising a computer-related extracurricular activity helped them cultivate culturally responsive and equity-focused views about participation in computing. As Figure 49 illustrates, an overwhelming majority of teachers, between 77% and 85%, strongly agreed or agreed that supervising a computing-related out-of-classroom activity helped improve their views about equity and access in computing. While the lowest majority of teachers (77%) strongly agreed or agreed that this supervisory experience helped to show them that "a concerted effort needs to be made by teachers to recruit underrepresented students into computing," the highest majority (85%) strongly agreed or agreed that the supervisory experience demonstrated to them that "it is important to create learning environments where underrepresented students are as comfortable working with computers as their peers."

Figure 49. Teachers' Perceptions of the Impact of Supervising Computing Outreach Activities on their Views about Equity and Access in Computing



Teachers' Experiences with Supervising Computing-Related Outreach and Student Engagement Activities

Teachers who supervised computing-related extracurricular activities were asked to provide a more detailed account of their experiences in this role. Precisely, they were asked to discuss if out-of-classroom computing activities helped facilitate students' learning in the classroom (and how), and if out-of-classroom computing activities aided to increase the engagement of students who are less-participatory in the classroom (and why).

Teachers Who Supervised Computing-Related Out-of-Classroom Activities Identified Several Ways in Which These Activities Benefited In-Class Learning

As Table 4 shows, teachers regarded out-of-classroom activities highly for the advantages it presented for learning in the classroom. More specifically, teachers noted that involving students in out-of-classroom computing activities extended the learning already occurring in the classroom, supported the application of learned concepts through hands-on experience, and increased students' knowledge and proficiency in course content, their critical thinking and problem-solving skills, and confidence.

Teachers Who Supervised Computing-Related Out-of-Classroom Experiences Found It Beneficial for Increasing Engagement Among Less-Participatory Students

As the themes and comments in Table 5 suggest, out-of-classroom activities were successful at engaging students who participated infrequently in the classroom due to of their small group format, hands-on nature, and collaborative emphasis that worked to strengthen student relationships.

Table 4. Teachers' Responses About How Out-of-Classroom Activities Support Students' Learning in the Classroom

Extension of Classroom Learning	"Yes, we used coding projects that related to their language arts lessons. i.e. we picked a bee and flowers to show how pollination works." "Yes, the students were able to continue learning programming skills outside of the classroom which increased their knowledge." "Yes, some of the same activities we did in the out-of-classroom activities they used the same skills in the classroom."
Increased Knowledge & Proficiency	"It increased their math skills which is evidenced by improved benchmark test scores." "Yes, the students were able to continue learning programming skills outside of the classroom which increased their knowledge." "Yes! Many of my students who were in robotics or STEM related clubs had more interest and knowledge when it came to using computers in class."
Increased Critical Thinking & Problem Solving Skills	"Helped with their problem solving skills." "Group projects motivated my students to work together and solve problems." "Somewhat- mostly in the areas of problem solving and collaboration skills." "It is good brain development. They become better problem solvers in all areas of education." "Yes, it did by providing them engaging ways to build critical thinking, problem solving and collaboration skills." "Yes, any topic of interest in which a student voluntarily seeks out information and learning, supports their thinking and reasoning skills."
Increased Confidence	"It was incredible to see the additional confidence and skills that came as a result of their participation in the program. " "Students learned to use their computers with confidence."
Additional Hands-On Experience	"Yes -- Students were able to explore deeper and have more hands-on, engaged learning through the WOZ U lesson kits." "Gave our students opportunities to use computers to create not just complete a specific assignment." "Gave them real world application of learned concepts." "Providing the different projects at the Innovation Center gave the students hands on learning/real life application for the curriculum they had been taught in their classrooms."

Table 5. Teachers' Views About If and Why Out-of-Classroom Activities Are Successful in Engaging Students Who Are Less Participatory in the Classroom

Use of Small Groups	"They had to work in small groups and share ideas. "Yes, small group." "Yes. Being a smaller group and all girls, the quiet girls felt safer to speak up and contribute." "Yes - we were actively involved with small groups using programmable Spheros, Ollies, drones, 3D printers, Ozobots. Students participated and loved the activities."
Hands-On & Engaging Activities	"Many rowdy students found a place that engaged and excited them." "It took something they thought was boring and inapplicable and made it fun, hands on and applicable to their life." "Sometimes, because they could work with technology." "Yes, regular school day stuff is not hands on for the most part. They are also interested in it." "Yes. It was more like playing a game." "Yes. They were more interested in participating when computers and other technological items were to be used."
Strengthened Student Relationships	"It strengthened relationships with peers, allowing students to be more comfortable participating in class." "Yes, we were able to build relationships and skills that students accessed and utilized to benefit them in the classroom. Absolutely an amazing effect size." "Yes. I have students who are deep thinkers that aren't usually extroverted. When we would do activities in our classroom that involved coding, they would help other students…It really helped them to be more social with their peers."

PART SEVEN:

WORK-BASED LEARNING EXPERIENCES

Teachers who assisted with finding appropriate placements for students involved in work-based learning experiences were queried about the impact that these activities had on key student outcomes in computing. The student outcomes of interest are those identified in **Figure 1 - Teacher and Student Outcomes in Computing Assessed by the Current Evaluation** and include computing self-efficacy, computing interest, computing engagement, cognitive skills in computing, technical skills in computing, and intentions to pursue computing. Unlike in prior sections, the discussion below on key findings does not include percentages due to the low count of teachers (n < 10) who responded to survey questions pertaining to work-based learning experiences.

Key Findings on Student Outcomes

The Three Main Forms of Work-Based Learning Experiences Are Not Equally Effective at Improving Student Outcomes in Computing

Teachers who helped with identifying and connecting students to local providers of work-based learning experiences were asked to indicate whether or not they observed an improvement in students' outcomes in computing following their participation in internships, apprenticeships, and job shadows. Findings from these teachers' responses suggest that internships, apprenticeships, and job shadows have varying levels of impact on student outcomes in computing. For example, while a few teachers noted that they observed an increase in the computing self-efficacy of students who participated in internships, none reported observing similar improvement among students who participated in apprenticeships or job shadows. Teachers were also more likely to indicate that they observed an increase in computing skills among students who participated in internships than those who did apprenticeships or job shadows. However, teachers were more likely to note that they observed an increase in computing interest, computing engagement, and intentions to pursue computing among students who participated in apprenticeships as compared to the other two forms of work-based learning experiences.

The Three Main Forms of Work-Based Learning Experiences Are More Effective at Improving Certain Student Outcomes in Computing than Others

When teachers' assessment of the different forms of work-based learning experiences are aggregated, findings suggest that these placements are generally more effective at improving certain student outcomes in computing than others. For example, teachers were most likely to note an increase in computing skills among students who participated in work-based learning experiences, followed closely by computing engagement and intentions to pursue computing. Moreover, they were much less likely to note an increase in computing interest and computing self-efficacy among students who participated in work-based learning experiences.

All Teachers Strongly Agreed or Agreed That Their Students Possessed the Desired Outcomes in Computing Towards the End of their Participation in Work-Based Learning Experiences

Teachers who assisted with identifying and placing students in work-based learning experiences were asked to specify the extent to which they agree that students possessed the indicators of cognitive skills in computing, technical skills in computing, and intentions to pursue computing at the onset of participation and also at the end of participation in these programs. Given teachers' tangential involvement in work-based learning experiences (i.e., they merely aided to connect students to providers of work-based learning experiences and thus, did not supervise students in these contexts), it seemed appropriate to limit the fine-grained questions about student outcomes posed to these teachers to those that pertain to student outcomes that are more readily discerned and were likely brought up in the process of matching students to placements (i.e., cognitive skills in computing, technical skills in computing, and intentions to pursue computing).

As gleaned from their responses, teachers were much more likely to strongly agree or agree that students possessed cognitive skills in computing, technical skills in computing, and intentions to pursue computing at the end of their participation in these activities rather than at the beginning of their participation. To provide an illustrative example, *no* teacher strongly agreed or agreed that students possessed any of the three indicators of cognitive skills in computing at the onset of their participation in these activities. The three indicators of this student outcome include "knowing the appropriate terminology to describe informatics and computer systems," "understanding how computers and the basic operating system works," and "explaining the behavior of informatics and computer systems in their own words." However, *all* teachers strongly agreed or agreed that students possessed each indicator of cognitive skills in computing by the end of their participation in work-based learning experiences.

Unlike their assessment of students' cognitive skills in computing at the beginning of participation in work-based learning experiences, teachers sometimes strongly agreed or agreed that students exhibited technical skills in computing and intentions to pursue computing at the onset of participation in these programs. However, much like their assessment of students' cognitive skills in computing at the end of participation in work-based learning experiences, *all* teachers strongly agreed or agreed that students possessed technical skills in computing and intentions to pursue computing by the end of their participation in these activities.

PART EIGHT:

PROFESSIONAL LEARNING IN COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Teachers who participated in professional learning activities concerned with computer science and information technology were asked to evaluate the influence that these activities had on their computing competence, computing confidence, views about equity and access in computing, views about teaching that integrates computing, use of project-based and experiential pedagogies, teaching practice, and teaching attitudes. This section covers key findings on these survey items.

Key Findings on Teacher Outcomes

Regardless of Type, Professional Learning Activities Are Similarly Effective at Improving Any Given Teacher Outcome in Computing

Teachers were asked to indicate whether or not they observed an improvement in their outcomes in computing following participation in various types of professional learning activities. These activities included *STEM/computing events*, *trainings at school/district*, *modeling by computing expert in teacher's class*, *online courses/webinars*, *college classes*, *accredited classes by vendors*, and *out-of-school conferences/workshops*.

As Figures 50-55 show, there is some, though not much, variation in teachers' assessment of the effectiveness of the various professional learning activities at improving any given outcome. For example, a comparable percentage of teachers (between 56% and 67%) noted that they observed an increase in their interest in equity and access in K-12 computing courses following participation in professional learning activities (Figure 50). Also, between 63% and 75% of teachers who participated in professional learning activities indicated that they were more aware of the importance of teaching computing by the end of participation in these activities (Figure 51). Additionally, a somewhat lower percentage of teachers, between 42% and 54%, noted that they observed an increase in their satisfaction with teaching following participation in professional learning activities (Figure 55).

Figure 50. Percent of Teachers Who Did or Did Not Observe an Increase in Their Interest in Equity and Access in Computing

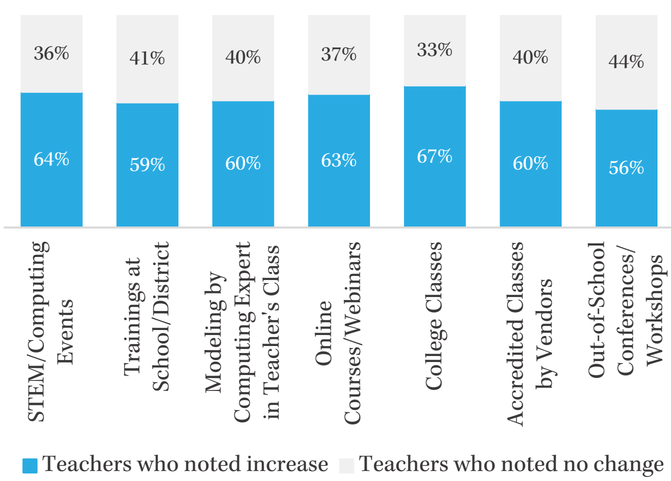


Figure 51. Percent of Teachers Who Did or Did Not Observe an Increase in Their Awareness About the Importance of Teaching Computing

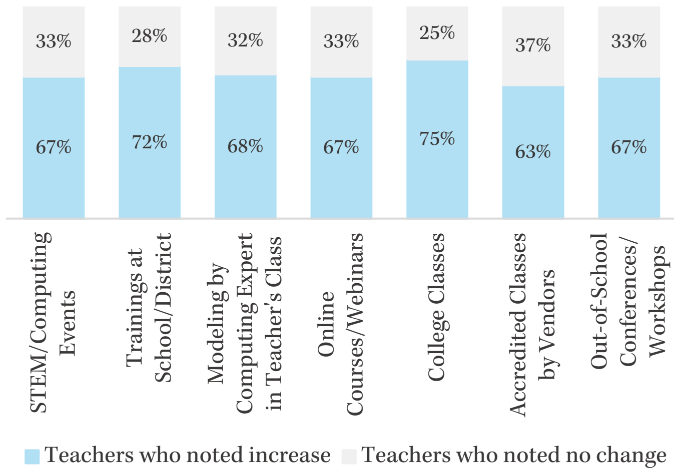


Figure 52. Percent of Teachers Who Did or Did Not Observe an Increase in Their Confidence to Teach Computing

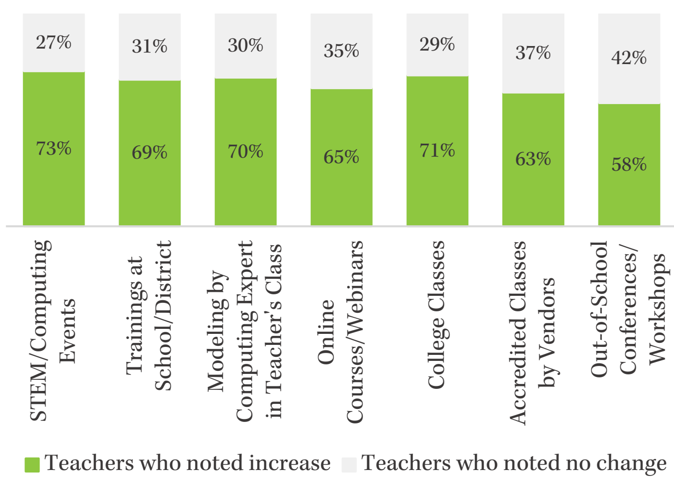


Figure 53. Percent of Teachers Who Did or Did Not Observe an Increase in Their Use of Project-Based and Experiential Pedagogies

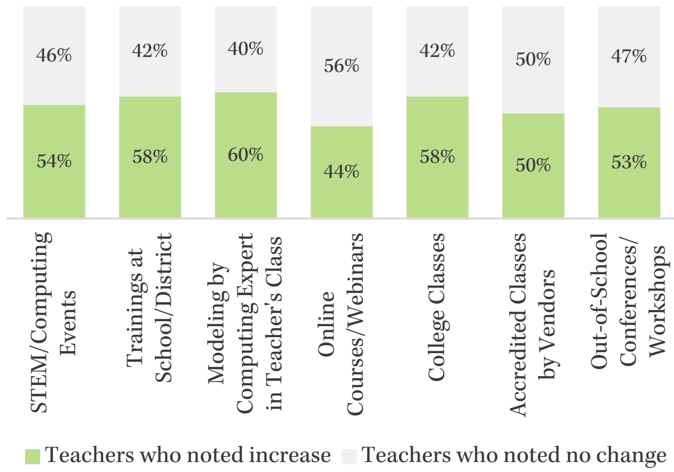


Figure 54. Percent of Teachers Who Did or Did Not Observe an Increase in Their Integration of Computing in Non-Computing Courses

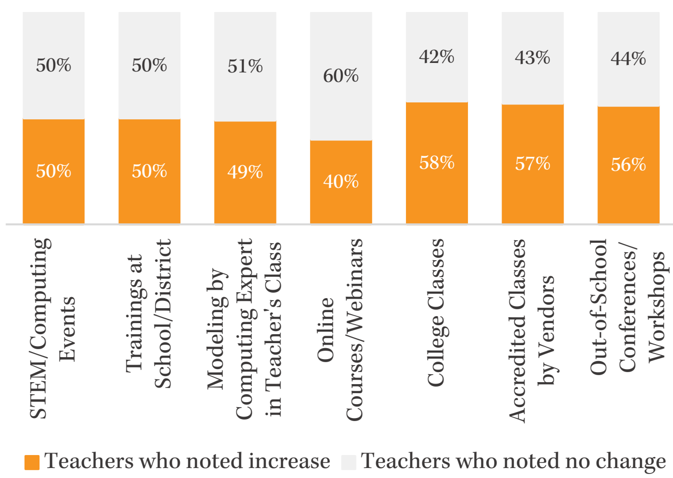
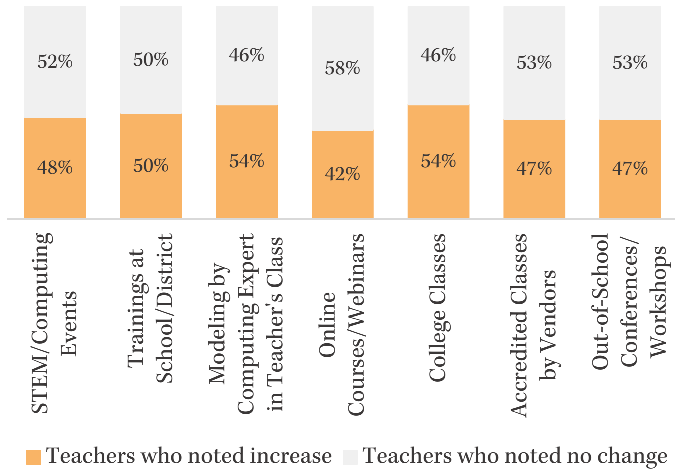


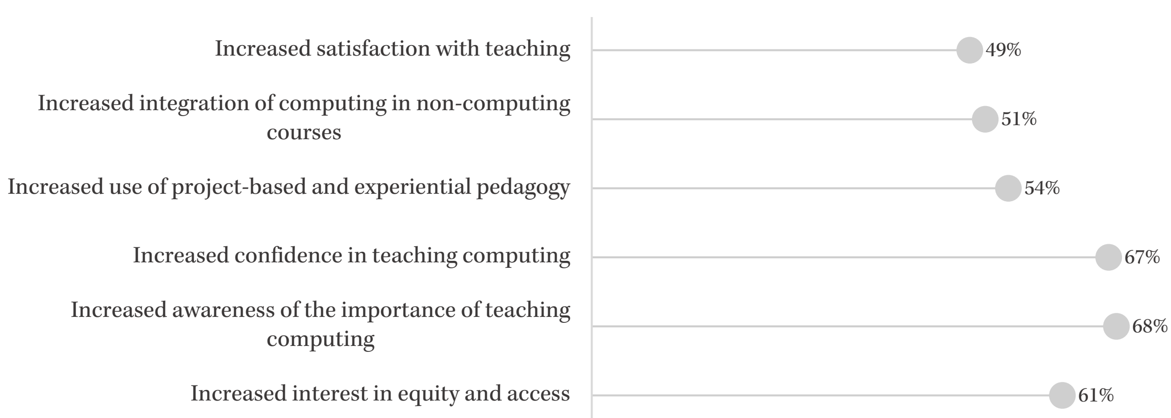
Figure 55. Percent of Teachers Who Did or Did Not Observe an Increase in Their Satisfaction with Teaching



Professional Learning Activities Are Generally More Effective at Improving Certain Teacher Outcomes in Computing Than Others

When professional learning activities are aggregated, the teacher outcomes in computing that they most or least impact become more apparent. As Figure 56 shows, professional learning activities are most effective at increasing teachers' awareness of the importance of teaching computing, followed closely by their confidence in teaching computing. Sixty-eight percent and 67% percent of teachers, respectively, indicated that they observed an increase in their awareness of the importance of teaching computing and confidence to teach computing following participation in professional learning activities. Professional learning activities, however, appear to be least effective at increasing teachers' satisfaction with teaching with only 49% of teachers noting that they observed an increase in this outcome following participation in professional learning.

Figure 56. Average Percent of Teachers Who Observed an Increase in Their Outcomes in Computing Across the Seven Professional Learning Activities



An Overwhelming Majority of Teachers Strongly Agree or Agree that Participating in Professional Learning Activities Improved Their Computing-Related Outcomes

Teachers were provided with various indicators of each teacher outcome in computing and were asked to specify the extent to which they agree that participating in professional learning activities helped nurture these attributes. As Figures 57-62 illustrate, an overwhelming majority of teachers strongly agreed or agreed that participating in professional learning activities helped them cultivate the various attributes associated with each outcome. Put another way, vary rarely did teachers strongly disagree or disagree that professional learning activities helped improve their outcomes in computing. For example, between 81% and 91% of teachers, depending on the indicator, strongly agreed or agreed that engaging in professional learning helped them cultivate more culturally responsive views about participation in computing (Figure 58). Seventy-four percent to 94% of teachers, depending on the indicator strongly agreed or agreed that participation in professional learning activities helped them develop key computing competencies (Figure 57). Between 82% and 85% of teachers noted that participation in professional learning activities helped them increase their use of project-based and experiential teaching strategies (Figure 60). And while somewhat less likely to strongly agree or agree that professional learning improved their attitudes towards teaching, 76%, 77%, and 84% of teachers, respectively, indicated that they strongly agreed or agreed that participating in professional learning increased their "job satisfaction," interest in teaching," and "enjoyment of teaching" (Figure 62).

Figure 57. Teachers' Perceptions of the Impact of Professional Learning on their Computing Competence

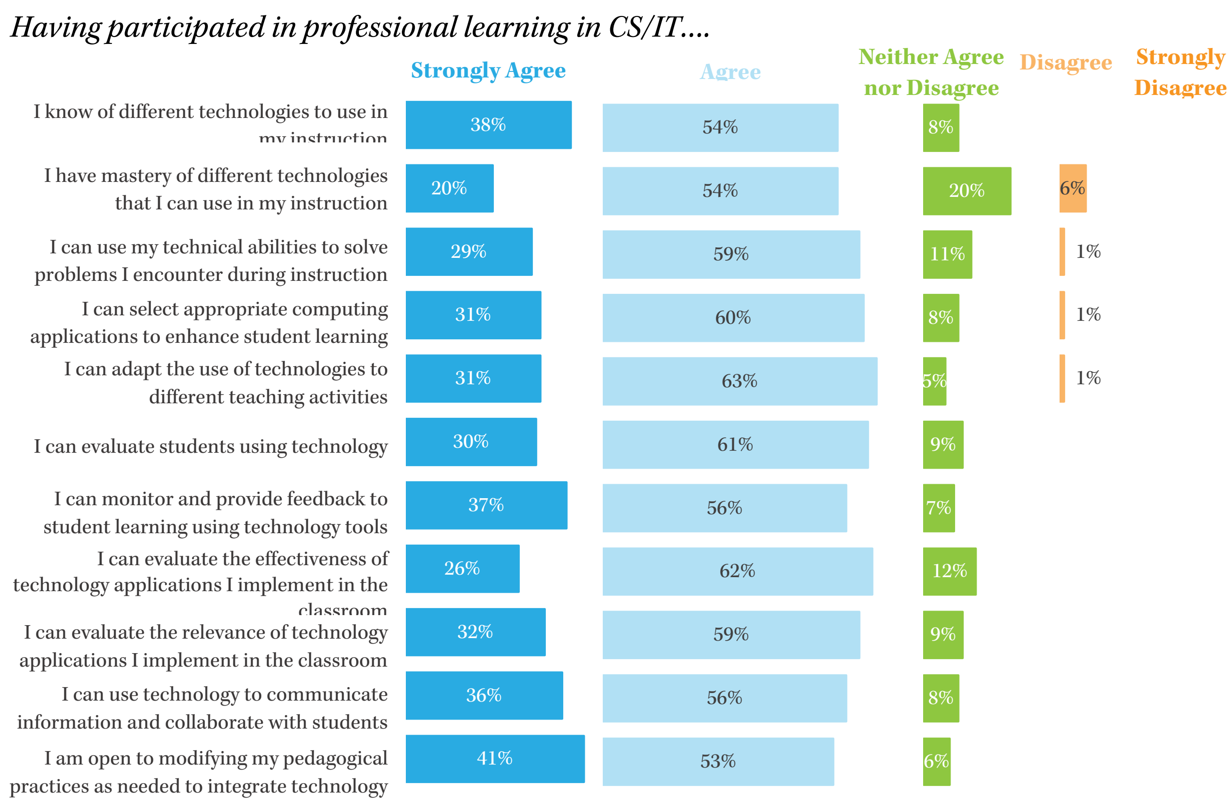


Figure 58. Teachers' Perceptions of the Impact of Professional Learning on their Views about Equity and Access in Computing

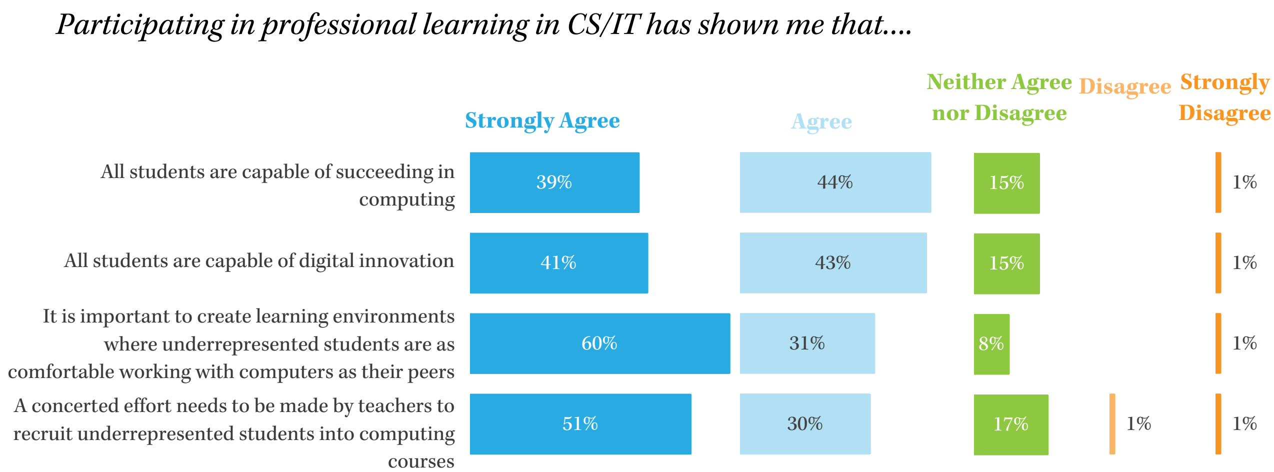


Figure 59. Teachers' Perceptions of the Impact of Professional Learning on their Views About Teaching That Integrates Computing

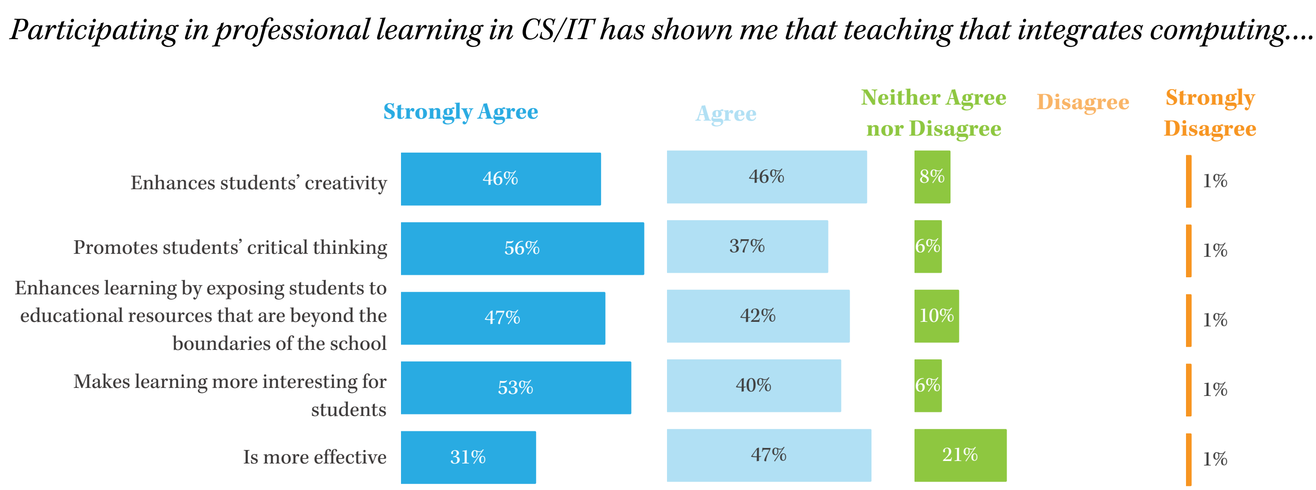


Figure 60. Teachers' Perceptions of the Impact of Professional Learning on their Use of Project-Based and Experiential Pedagogy

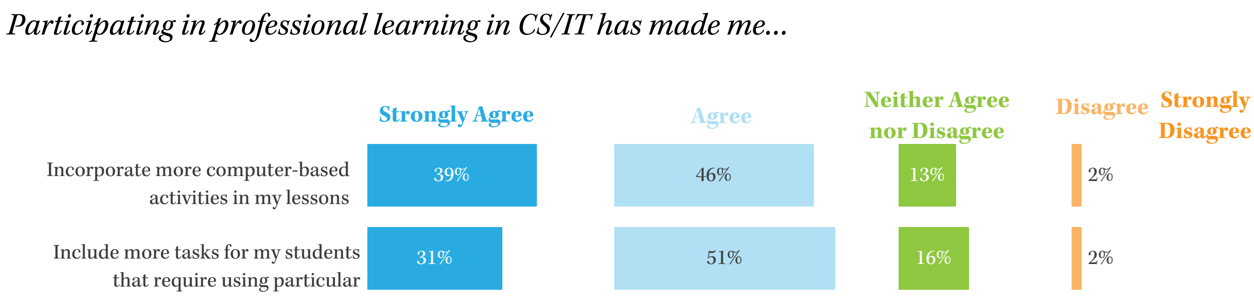


Figure 61. Teachers' Perceptions of the Impact of Professional Learning on Their Teaching Practice

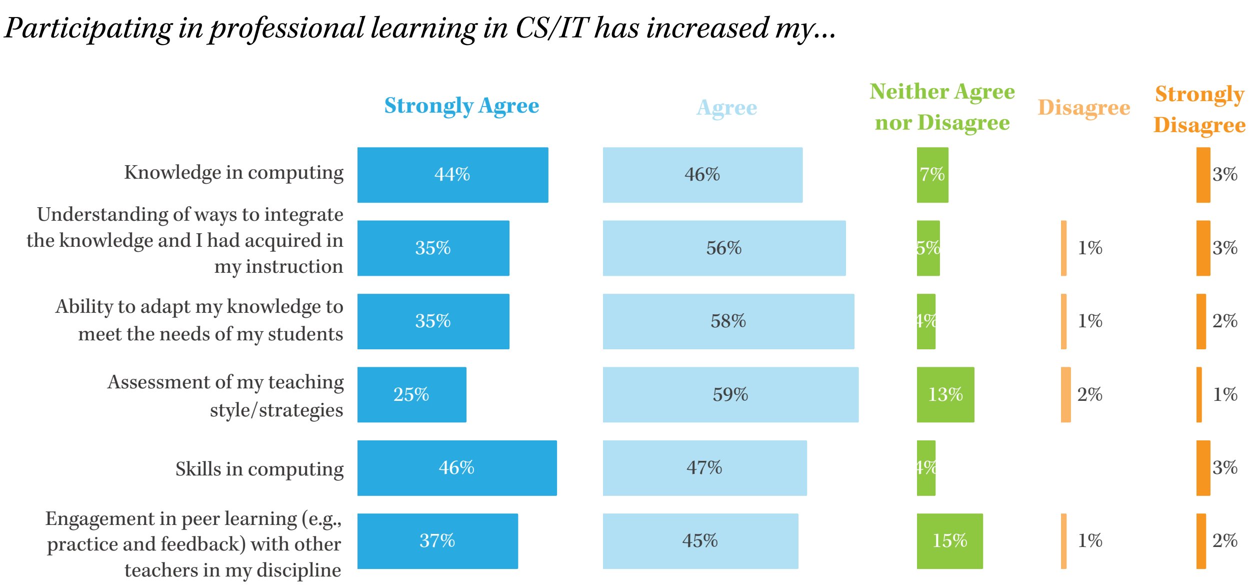
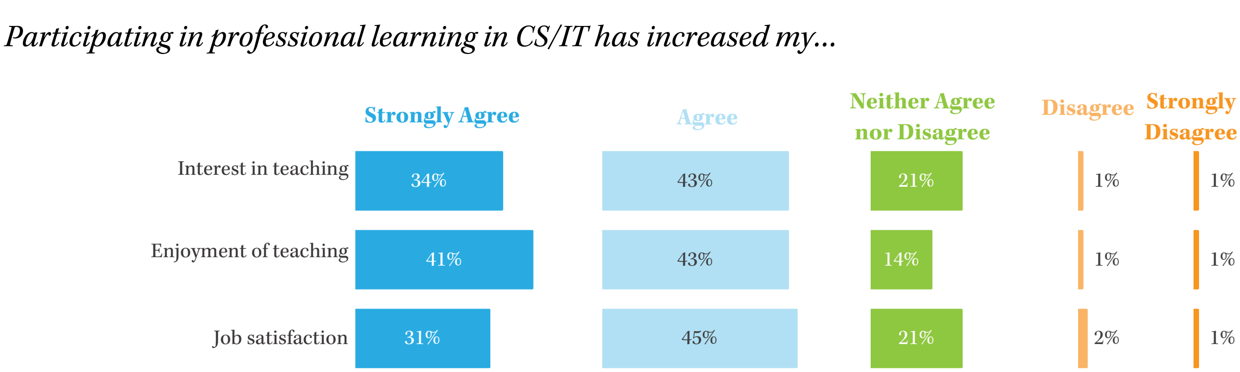


Figure 62. Teachers' Perceptions of the Impact of Professional Learning on Their Teaching Attitudes



PART NINE:

POST-SECONDARY, INDUSTRY, AND COMMUNITY COLLABORATIONS

Teachers who helped establish partnerships between LEAs and post-secondary institutions, industry, and community organizations were asked to evaluate the quality of these partnerships and their effectiveness in bringing about the student and teacher outcomes in computing identified in **Figure 1 - Teacher and Student Outcomes in Computing Assessed by the Current Evaluation**. As with the summary of key findings about work-based learning experiences in the seventh section of this report, percentages are not reported in this section due to the low count of teachers (n < 10) who responded to questions about post-secondary, industry, and community collaborations.

Key Findings on the Quality and Effectiveness of Partnerships

The Overwhelming Majority of Teachers Who Helped Facilitate Post-Secondary, Industry, and Community Collaborations Shared Very Positive Sentiments about the Quality and Effectiveness of these Partnerships

Teachers who helped establish partnerships between LEAs and post-secondary institutions, industry, and community organizations were asked to evaluate these collaborations in terms of whether clear strategies were provided for improving student outcomes in computing; whether clear strategies were provided for improving teacher outcomes in computing; whether all partners had a clear understanding of shared goals; the frequency of communication with partners about supporting students to achieve desired outcomes in computing; the frequency of communication with partners about supporting teachers to achieve desired outcomes in computing; the quality of communication within the partnerships; how well partners worked together; the effectiveness of partnerships in improving student outcomes in computing; and lastly, the effectiveness of partnerships in improving teacher outcomes in computing.

All teachers who helped establish partnerships indicated that they strongly agreed or agreed that clear strategies were provided within partnerships for improving each student outcome in computing. Similarly, all teachers, except one whose stance was neutral, noted that they strongly agreed or agreed that clear strategies were provided within partnerships for improving each teacher outcome in computing. Persisting with their very positive feedback, the vast majority of teachers strongly agreed or agreed that individuals within their partnerships had a clear understanding of shared goals. Also, all teachers strongly agreed or agreed that partners worked well together to achieve the desired student and teacher outcomes in computing.

Questions about the quality and frequency of communication within partnerships were also met with very affirmative responses from teachers. Regarding the quality of communication within their partnerships, all teachers strongly agreed or agreed that partners maintained clear, strong, and open lines of communication with everyone involved in the shared effort. Relatedly, the majority of teachers noted that people in their partnerships generally communicated weekly about how to support students to achieve desired outcomes in computing, and once a month about supporting teachers to achieve desired outcomes in computing.

Finally, concerning the effectiveness of partnerships, all teachers rated their partnerships as highly effective or effective at improving each student outcome in computing. Additionally, nearly all teachers rated their partnerships as highly effective or effective at improving each teacher outcome in computing.

PART TEN:

CONCLUSIONS AND CONSIDERATIONS

Utilizing a survey as its primary source of data, this report examined the impact of the Computing Partnerships Grants Program. First, it addressed the demographics of teachers, and by extension students, who were involved in grant activities. Second, it evaluated the effects that involvement in grant activities had on student and teacher outcomes in computing. The grant activities for which student outcomes were evaluated include *Dedicated Computing Courses*, *Integration of Computing into Existing Courses*, *Outreach and Student Engagement*, and *Work-Based Learning Experiences*. The grant activities for which teacher outcomes were evaluated include *Dedicated Computing Courses*, *Integration of Computing into Existing Courses*, *Outreach and Student Engagement*, and *Professional Learning in CS/IT*. Last, the evaluation investigated the quality and effectiveness of a sixth grant activity, *Post-Secondary, Industry, and Community Collaborations*. This section reviews key findings in relation to the study's aforementioned objectives. It also provides considerations for the Computing Partnerships Grants Program that are informed by the evaluation's findings, relevant research, and program objectives.

Summary of Findings

Demographics

This report's examination of grant participant demographics revealed that involvement in the Computing Partnerships Grants Program is rather widespread, both in terms of the participation of teachers and students from different local education agencies and grade levels. As findings more specifically reveal, teachers and students involved in grant activities came from 16 school districts, 1 tri-district consortium, and 5 charter schools. Additionally, they were spread across the entire K-12 continuum, from pre-kindergarten to grade 12, although grades 4, 5, 6 accounted for the highest percents of teachers, and by extension, students. As it concerns the particular grant activities in which teachers and/or students were involved, findings indicate that each of the six grant activities received some involvement from teachers and/or students, although four grant activities, *Professional Learning in CS/IT*, *Integration of Computing into Existing Courses*, *Dedicated Computing Courses*, and *Outreach and Student Engagement* garnered the highest levels of involvement from teachers and/or students.

Student Outcomes in Computing

As a second objective, this evaluation examined the impact that students' participation in Dedicated Computing Courses, Integration of Computing into Existing Courses, Outreach and Student Engagement, and Work-Based Learning Experiences had on their outcomes in computing. The student outcomes assessed include computing self-efficacy, computing interest, computing engagement, cognitive skills in computing, technical skills in computing, and intentions to pursue computing. Analysis of data for the *most popular offerings* for Dedicated Computing Courses, Integration of Computing into Existing Courses, and Work-Based Learning Experiences suggest that top offerings for these grant activities were most effective at increasing students' computing skills. Data on the *most offered* Outreach and Student Engagement activities revealed that top offerings for this grant activity were most effective at increasing students' computing interest, followed closely by their computing skills.

Concerning student outcomes at the *onset* and *end* of participation in grant activities, findings reveal that students were more likely to possess the desired outcomes in computing post-participation in grant activities than at the beginning of their participation. Teachers, however, tended to respond less affirmatively that their students possessed attributes associated with cognitive skills in computing and technical skills in computing compared to other student outcomes at the end of participation in grant activities. While this latter finding may seem to contradict earlier findings that suggest that popular offerings of grant activities are very effective at increasing students' computing skills, it is important to note here that the prior findings were based on the responses of a *subset* of teachers (i.e., those who taught or supervised students in the most popular offerings for each grant activity). Findings discussed in this paragraph, on the other hand, were drawn from a different set of questions that made no distinction between teachers who taught or supervised students in less or more popular offerings of grant activities.

Teacher Outcomes in Computing

Teachers who participated in Dedicated Computing Courses, Integration of Computing into Existing Courses, Outreach and Student Engagement, and Professional Learning were asked to evaluate their own outcomes from participating in these activities. The teacher outcomes assessed include computing competence, computing confidence, views about equity and access in computing, views about teaching that integrates computing, use of project-based and experiential pedagogy, and teaching attitudes. Findings reveal that a majority of teachers strongly agreed or agreed that their involvement in grant activities positively affected their outcomes in computing. A lower majority of teachers, though, tended to respond affirmatively about the impact of grant activities on an indicator of views about teaching that integrates computing (I believe that teaching that integrates computing "is more effective") and an indicator of computing competence ("I have mastery of different technologies that I can use in my instruction). Findings also reveal that the most offered Professional Learning opportunities are most effective at increasing teachers' awareness of the importance of teaching computing followed closely by their computing confidence.

Quality and Effectiveness of Partnerships

Teachers who helped establish partnerships between LEAs and post-secondary institutions, industry, and community organizations were asked to evaluate the quality and effectiveness of their partnerships based on several indicators. The indicators include whether clear strategies were provided for improving student outcomes in computing; whether clear strategies were provided for improving teacher outcomes in computing; whether all partners had a clear understanding of shared goals; the frequency of communication with partners about supporting students to achieve desired outcomes in computing; the frequency of communication with partners about supporting teachers to achieve desired outcomes in computing; the quality of communication within the partnerships; how well partners worked together; the effectiveness of partnerships in improving student outcomes in computing; and lastly, the effectiveness of partnerships in improving teacher outcomes in computing. As findings reveal, all or nearly all teachers provided very positive ratings in response to questions pertaining to each indicator. In other words, teachers rated the quality and effectiveness of their partnerships extremely highly.

Considerations for the Computing Partnerships Grants Program

Explore, and If Needed Increase, The Involvement of Qualified Computer Science Teachers, Female Teachers, and Educators of Color in Grant Activities

While the current evaluation examined the school districts, schools, and grade levels of teachers who participated in grant activities, it did not investigate their educational qualifications, gender, or race/ethnicity. As research studies have shown, the subject matter knowledge of computer science educators is crucial for their confidence and competence to teach computing, their knowledge of appropriate pedagogical practices (including those that are inclusive or culturally responsive), and their effectiveness in facilitating students' deep understanding of the subject (Joshi & Jain, 2018; Leyzberg & Moretti, 2017). Moreover, research studies have noted that, for underrepresented students, having access to same-gender or same-race educators is important for their self-concept and ability to resist sexist and racist stereotypes about who can participate in computer science or STEM more generally (Ma & Liu, 2015; Stout, Dasgupta, Hunsinger, & McManus, 2011). This is especially true, also, for female students of color who are doubly minoritized, by race and gender, and often do not have teachers that share their unique backgrounds and experiences (Yap, 2018). It is important, therefore, for the Computing Partnerships Grants Program to give attention to the educational background of teachers and the involvement of educators of color and female teachers in grant activities.

Identify and Expand Student and Teacher Access to the Most Effective Computing Courses, Activities, and Professional Learning Opportunities

As findings from the current evaluation reveal, some dedicated computing courses, outreach and student engagement activities, work-based learning experiences, and professional learning opportunities are more effective than others at improving certain student and teacher outcomes in computing. As such, furthering the outcomes of students and teachers in computing may require a thoughtful selection of courses and activities that are most effective and an expansion of these selected opportunities to school districts and schools participating in grant activities. Alternatively, it may be useful to conduct case studies on the most effective opportunities, glean information about what makes them impactful, and where possible encourage school districts and schools to integrate useful strategies from these effective courses and activities in the other opportunities they provide. Expanding access to effective opportunities, or improving the quality of all opportunities using empirical evidence from case studies, will help the Computing Partnerships Grants Program move the needle in increasing Utah students' acquisition of skills and knowledge necessary for success in computing.

Increase Parents' Awareness of Computing Opportunities and Involve Them in A More Integral Way

As research studies have found, generating early interest in STEM fields among school-aged students requires that schools, and other stakeholders, work in close concert with families (Onuma, Berhane, & Fries-Britt, 2020; Sanzenbacher, 2013). This sentiment is also reflected in the following statement by the National Parent Teacher Association in 2016, "to help all student access high-quality STEM programs in schools…families must be equal partners with all stakeholders" (Jackson & King, 2016, p. 8). To date, research studies in computer science education have consistently found that parents are not as informed as they should be of computer science offerings provided inside or outside of school (Google Inc. & Gallup Inc., 2016a). Given that their awareness and buy-in may be instrumental for increasing student involvement in computer science courses and activities, it is advisable that the Computing Partnerships Grants Program identify ways to generate awareness about opportunities among parents, and involve them in a more integral way in grant activities, in order to achieve the goal of broadening Utah students' participation in computing.

Provide Professional Development Opportunities to Teachers that Expose Them to the Various Instructional Technologies Available and How to Best Integrate Them in Their Teaching

As discussed in the *Summary of Findings* above, while most teachers agreed that they possessed the various indicators associated with computing confidence, they tended to respond less affirmatively about a particular indicator—"I have mastery of different technologies that I can use in my instruction." To be sure, findings from extant literature suggest that this issue is relatively common among K-12 educators. Many teachers, as research suggests, do not have sufficient exposure to the various instructional technologies available or adequate knowledge about how to effectively integrate available technologies in their teaching (DeCoito & Richardson, 2018; Gonzalez & González-Ruiz, 2017). Giving this finding from the evaluation, it may be useful for the Computing Partnerships Grants Program to provide technology-related professional development opportunities to teachers perhaps through forging partnerships with industry and institutions of higher education in Utah.

Create and Make Available a Repository of Co-Curricular Opportunities That Students Can Pursue to Further Develop Their Cognitive and Technical Skills in Computing

As discussed in the *Summary of Findings,* when asked to evaluate students' outcomes before and after participating in grant activities, teachers tended to respond less affirmatively that their students possessed indicators associated with cognitive and technical skills in computing after participating in grant activities. Given that cognitive and technical skills in computing are incredibly essential in today's society and are a non-negotiable requirement for STEM occupations (Fayer et al., 2017), it is necessary that important consideration is given to providing students' with access to, or at the very least information about, additional co-curricular opportunities—such as internships, dual enrollment programs, and certification programs—that can help to facilitate their acquisition of these important skills.

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