Utah STEM Action Center Annual Report FY2020

STEM Action Center
Annual Report to the Education Interim Committee November 15, 2020

The following report is being submitted to the Education Interim Committee by the STEM Action Center. The report contains the following requested information:

1. **The Board shall report the progress of the STEM Action Center, including the information described in Subsection (2), to the following groups once each year:**

2. **The report described in Subsection (1) shall include information that demonstrates the effectiveness of the program, including:**
    a. **the number of educators receiving high-quality professional development;**
    b. **the number of students receiving services from the STEM Action Center;**
    c. **a list of the providers selected pursuant to this part;**
    d. **a report on the STEM Action Centers fulfillment of its duties described in Subsection 63M-1-3204; and**
    e. **student performance of students participating in a STEM Action Center program as collected in Subsection 63M-1-3204(4).**

The number of educators receiving high quality professional development

The STEM Action Center (STEM AC) supports high quality professional development through the professional learning (PL) program that aligns resources to locally identified STEM- related professional learning needs and solutions with activities such as coaching, mentoring, self-reflection, off- contract work, and effective professional learning communities (PLCs). The STEM AC also provides professional development to support educators that are participating in other programs such as the K-16 Computing Partnership program, the K-12 Math Personalized Learning program, programs with our STEM in Motion team (e.g., Leap into Science) and the annual STEM Best Practices conference.

K-12 PROFESSIONAL LEARNING

The PL program supported 74 grants in the 2019-20 school year, directly impacting 10,519 educators. The program design varies greatly within this grant program and includes solutions to locally identified issues with compensation for off-contract work, scheduled time within a teacher's workday for lesson study in a PLC, substitutes allowing educators to observe examples within their community, and videos to be used for self and peer reflection.

COMPUTING PARTNERSHIPS

A total of 50 educators, as part of the K-16 Computing Partnership program, received professional development for Computer Science Discoveries and Computer Science Principles during the 2019 summer workshops. There were also 102 elementary educators who participated in the Computer Science Fundamentals workshops. The funding for professional learning opportunities in computing was provided by an industry partner grant (Hill Air Force Base) and a partnership with Code.org.

K-12 MATH PERSONALIZED LEARNING

Educators and administrators from 546 schools received professional learning for the use of the K- 12 Math Personalized Learning tools as part of the contracts with the product providers. This training ensured that educators were able to integrate the use of the software effectively as a supplement to their instruction.

STEM IN MOTION

Leap into Science is a nation-wide program that integrates open-ended science activities with children's books, designed for children ages 3-10 and their families. Informal educators are trained to offer programs in community settings like libraries, museums, and out-of- school time programs to engage under- served audiences in accessible and familiar settings. The Leap into Science (LIS) program supported the training of 60 educators in FY19. Each educator then used their training to offer at least three workshops in rural or urban underserved parts of their community during FY20. The 60 trained educators offered 3 workshops each, with an average of 25 participants for an approximate of 4,500 individuals impacted. The three SIM team members hosted additional nine workshops with an average of 25 participants for a total of 225 individuals impacted.

ROBOTICS LIBRARY

The Robotics Library program is funded through a grant with Marathon Petroleum and consists of five robotics equipment kits placed strategically across the state. Throughout FY20, 42 educators were trained by STEM Action Center staff to use the robotics library. Additionally, using a train-the-trainer model, the STEM Action Center trained 4 educators responsible for training other educators in their region of the state. In addition to ongoing in-person training in the use and integration of these kits, there are now video trainings designed to help educators learn and troubleshoot their robotics before and during use. A total of 39 out-of-school educators participated in virtual STEM facilitation training, and another 28 viewed the recorded training after it occurred. This training focused on STEM facilitation and high quality STEM activities for educators who were unfamiliar with STEM practices.

STEM BEST PRACTICES CONFERENCE

The annual STEM Best Practices provided a variety of professional learning opportunities for educators. The Best Practices conference focuses on experiential learning activities for educators. The Best Practices conference was hosted on June 10, 2019, and over 700 educators from around the state participated. The theme for the conference was Equity Elevated. This event was cancelled in 2020 due to the coronavirus. The intent is to resume the conference once it is safe or on a virtual platform.

The number of students receiving services from the STEM AC and the number of students that accessed resources from the STEM AC are as follows:

- *Classroom grants:* 19,403 students were impacted by the funded classroom grant projects.
- *Competition grants:* more than 2,000 students were impacted through participation in STEM-related competitions
- *K-12 Math Personalized Learning Program:* 190,970 students had access to supplemental math software
- *STEM Fest:* more than 12,000 students participated in STEM Fest, which took place at Mountain America Expo Center October 7-8, 2019
- *Organization grants:* approximately 11,500 students were impacted through participation in STEM activities and events; due to the restrictions resulting from the coronavirus epidemic many programs were rescheduled for the following year or canceled; some of our grantees have extended their contracts into the FY21 fiscal year
- *Sponsorships:* The Center supported and exhibited at 36 STEM events, thus impacting more than 110,000 students, parents, educators, administrators, community and industry partners.
- *STEM in Motion (SIM):* 6,171students were impacted through participation in the SIM programs
- *Girls Who Code Club Network:* 141 girls participated in clubs
- *Code.org:* 7,826 students
- *K-16 Computing Partnerships:* 10,870 students (participating in 350 new Computer Science class sections), 10,702 students participating in various outreach and engagement activities, 112 students participating in work based learning activities.

A list of providers selected pursuant to this bill:

See Appendix A.

A report of the STEM AC fulfillment of its duties described in subsection 63M-1-3204

(a) STEM Action Center (STEM AC) Staff and Roles - 63M-1-3204; 1(a), (c) (i)

The STEM Action Center (STEM AC) consists of the Executive Advisory Board, a Division Director (Dr. Tami Goetz), Program Director (Sue Redington), Collaboration and Program Development Manager (Kellie Yates), Research and Implementation Manager (Clarence Ames) and Community and Innovation Manager (Lynn Purdin), an Administrative Assistant (Melanie Shepherd) and a Marketing and Communications Manager (David Wicai).

The STEM in Motion team (formerly the Utah STEM Bus team) consists of three team members (Becca Robison, Julienne Bailey, and Colleen Fisher). A part-time director for the Utah STEM Foundation was added in May 2017 (Allison Spencer), along with a Utah STEM Foundation Board. The STEM AC also works collaboratively with several other state agencies (e.g., Utah Department of Workforce Services, the Utah Department of Heritage and Arts, the Office of Energy Development, Governor's Office of Economic Development etc.) to support STEM education and workforce and economic development. The STEM AC currently has two undergraduate interns that support a variety of activities in the Center.

The STEM AC works with high school juniors and seniors, as well as undergraduates for the STEM Ambassadors program. The STEM Ambassadors help with numerous outreach and engagement efforts such as events like STEM Fest and other community events, and help to build content on the STEM website.

The ambassadors commit to serving a minimum of 20 hours each year and upon completion of their "ambassadorship," they receive a certificate and award. There were a total of 40 STEM Ambassadors at the STEM Action Center as of the end of FY20.

The STEM AC reports to the STEM Action Center Executive Advisory Board, with its membership and duties defined by statute. This model has worked well, with the Board providing tremendous financial and in-kind support, as well as oversight of the STEM AC's strategy, process, and accountability. The ability of the Board to have a strong role in the direction of the STEM AC, providing guidance to the Director, has led to considerable buy-in from industry and the Utah State Board of Education office. The Board has representation from industry, the Utah State Board of Education, the Utah System of Higher Education, the Utah Department of Higher Education, and the Utah Department of Workforce Services.

(b) Private entity engagement - 63M-1-3204; 1(d); 2 (e)

UTAH STEM FOUNDATION

Industry support is crucial to the mission of the STEM AC in order to connect companies into the classroom, increase STEM workforce opportunities in Utah, and enhance STEM funding and resource opportunities. The Utah STEM Foundation, with its vision and mission aligned to the STEM AC, helps to create the bridge from education to the private sector. The Foundation has helped to build relationships with industry and the resulting support has been provided in a variety of ways including cash donations, grants and sponsorships, program collaborations and in-kind support through volunteer efforts. The Utah STEM Foundation was added to the STEM AC's statute, thus allowing for the creation of a public foundation. It became official on May 10, 2017, having received the Letter of Determination from the Internal Revenue Service. The Foundation has an advisory board with industry support from Marathon Petroleum, (formerly Tesoro), Boeing, Open Text, Comcast, Micron, MHTN Architects, KM Shinn Consulting and US Synthetic. A part-time director (Allison Spencer) oversees the functions and activities of the Foundation Board, as well as the receipt of all donations from corporate partners. The Foundation Board continues to develop and expand on many new and existing community partners and donors, who are in turn increasing their donation each year.

Programs that are supported by the Foundation include:

The Utah STEM Foundation helps to support STEM Fest, STEM in Motion, the STEM Magic Show with Paul Brewer, STEM Best Practices, Girls Who Code Club Entrepreneurial Challenge, Innovation Incubators (classroom/competition) grants, funding for the new STEM Innovation Hub, and STEM entrepreneurial efforts statewide.

Cash Donations for fiscal year 2020:

Boeing-$55,000
ARUP-$8,704
Barr Engineering-2,000
Bennion Family-$100
Centeva- $1,000
Comenity Capital Bank $5,000
Dominion-$45,000
Facebook- $50,000
Fidelity-$5,000
Griffiss Institute/Hill AFB-$250,000
Jeff R. and Katie Nelson Family Foundation-$5,000
Larry H. Miller-$50,000
Church of Jesus Christ of Latter-Day Saints-$15,000
Micron-$38,500
Northrop Grumman-$5,000

Utah STEM Foundation Grant Funding

The Utah STEM Foundation has been critical in leveraging grant opportunities for the STEM AC, in particular, those that are affiliated with industry partners.

The following new grants were secured during the fiscal year 2020: the Boeing Air Quality Collective: partnering with Weber State University to work with high school students to conduct air quality research through the High Altitude Reconnaissance Balloon for Outreach Research (HARBOR) program. The project will implement the project in 12 outreach sites statewide ($50,000 donated from Boeing);

Continued support for the Girls Who Code Entrepreneurial Challenge program. The Challenge is a unique opportunity for young girls to take the projects that they have worked on in their Girls Who Code Clubs to the "next step" in developing the app. Boeing funded the Utah STEM Landscape Analysis which is a partnership between the Utah Education Policy Center at the University of Utah and the Utah Data Research Center (formerly the Utah Data Alliance) at the Utah Department of

Workforce Services. The report will be a dynamic, interactive data clearinghouse that monitors key indicators in STEM education and workforce development that help to track success of STEM efforts in the state. The report is in its final stages of approval to be released in December of 2020.

Utah STEM Foundation Highlight

The Utah STEM Foundation is pleased to donate $50,000.00 to Utah's nonprofit organizations in FY20. This donation recognizes the importance of the integration between STEM and the arts and the need for support of cultural nonprofits operations during the coronavirus outbreak. Donated funds will support the operational needs of cultural nonprofits and nonprofits focusing on health and human services.

In-Kind Contributions for fiscal year 2020:

MHTN Architects has contributed several hundred hours and in-kind contributions designing the new STEM AC offices, including the Innovation Hub. MHTN supports creating an optimal STEM learning environment, and has been integral in providing this generous service to the STEM AC. R&O Construction contributed nearly $40,000 in kind work for the new STEM AC Innovation Hub.

Utah STEM Foundation Donor Highlights

- ARUP selected the Utah STEM Foundation as one of the benefactors of their Employee giving program for the next 2 years. ARUP has also been a very supportive sponsor of STEM Fest.
- Boeing supports STEM efforts that demonstrate collective impact and has donated $50,000 in FY20 to work on an Air Quality Project with High School Students in Utah. (see below).
- Open Text (formerly) Carbonite donated and assisted in the creation of The Girls Who Code Club Network with an Entrepreneurial Challenge and continued their donation in FY20 for another Entrepreneurial Challenge in the future.
- Comcast has been a champion by assisting to fund programs, STEM events, as well as create and distribute communication materials to promote awareness for STEM.
- Hill Air Force Base has worked closely with the STEM AC and Utah STEM Foundation to allocate funding to educators, schools, and other organizations, providing STEM opportunities statewide.
- Facebook donated $50,000 to work collaboratively with Mortensen and Edify to create a pilot of augmented and virtual reality training modules for construction safety. These modules will incorporate the science and technology that relates to construction site safety.
- Intermountain Healthcare has championed STEM curriculum efforts, bringing career awareness to students and educators statewide. They are supporting the creation of middle school and junior high outreach and engagement resources, such as an interactive board game, to promote healthcare careers.
- The Larry H. & Gail Miller Family Foundation has also played an integral role in bringing STEM to schools statewide with the STEM in Motion Program.
- Micron supports the STEM in Motion program and has also worked closely with the STEM AC and Utah STEM Foundation to allocate funding to educators, schools, and other organizations that are providing STEM opportunities. Additionally, in FY20, Micron has been producing and donating more than 1,000 masks each week for coronavirus support statewide. In addition to their production

contribution, Micron Technologies had made a generous $20,000 donation to the Utah STEM Foundation to support ongoing printing of personal protection equipment in vulnerable areas needing resources. Micron's commitment to this initiative helps to ensure Utah meets its goal of producing 10,000 face shields for medical professionals.

- US Synthetic has championed bringing partnerships to the STEM community, and has been our largest sponsor of STEM Fest every year since our inaugural event.

SPONSORED EVENTS

The STEM AC uses a portion of its operational budget, leveraged with industry support, to sponsor various events. Sponsored events help to provide exposure to STEM education and career opportunities for students and communities.

The following list includes examples of programs and events that received STEM Action Center sponsorship funding in FY20:

CSforALL Annual Conference

The CSforALL Summit is an annual convening of the national community of computer science educators, researchers and activists to mark progress and announce new commitments to reach the goal of access to rigorous, inclusive, and sustainable computer science education for all US students. The STEM AC submitted an application to host the annual summit in 2019. There were seven other cities across the country that submitted, but Utah secured the bid to host the 2019 national summit. The summit was co-hosted with the University of Utah and located in various locations on the university campus.

The Summit included over 90 speakers, local and national, and nearly 1,000 attendees. Sponsors of the Summit included the University of Utah, Ivanti, JPMorgan Chase, Lockheed Martin, Microsoft, Dominion Energy, Dell Technologies, Hill Air Force Base, and Carbonite to name a few.

Multicultural Youth Leadership Summit

The Multicultural Youth Leadership Summit is an annual event for several thousand 7th, 8th, and 9th grade students and educators held in support of Governor Gary R. Herbert's College and Career Ready initiative. This engaging and dynamic one-day program aims to motivate all students to pursue higher education and become leaders of Utah. The 2019 summit was successful, with 750 students attending from all over the state.

STEM Day on the Hill & STEM Signing Day

STEM Day on the Hill, which took place on Monday, March 2, 2020, was a celebration of all things STEM in Utah. This event welcomed more than 300 people through Utah's Capitol Rotunda to experience and visit with some of Utah's prominent STEM industry leaders and partners.

This year, STEM Signing Day presented by Boeing, was held in conjunction with STEM Day on the Hill. Twenty five students from around the state were selected based on their merits and pursuit of STEM in school to attend Signing Day. Just like Signing Day for athletes, Utah STEM Signing Day celebrated students across the state as they make their commitments to education programs focusing on Science, Technology, Engineering, and Mathematics in college.

Utah Day of the Girl

We continue to focus on engaging underrepresented groups and broadening participation in STEM, of which females constitute a collective majority. It is vital to our mission of ensuring Utah's long-term economic prosperity by advancing awareness of the need for Utah's increased investment in girls' education and the provision of economic opportunities. The Utah Day of the Girl Luncheon impacted more than 300 females, emphasizing the importance of young women to the future workforce. The event was celebratory in tone and atmosphere, reinforcing the Girl Scouts of Utah initiatives to draw a greater number of girls toward STEM careers. The event took place at the Salt Lake Marriott Downtown at City Creek on October 11, 2019, and the STEM AC awarded $1,250 in sponsorship funding.

Craft Lake City DIY Fest

The STEM AC is committed to supporting STEM education and believes that the arts and humanities are critical to supporting the creativity that elevates STEM. Craft Lake City's DIY Festival, held at the Utah State Fair Park from August 9-11, 2019, hosted a STEM Building where the STEM AC interacted with students, parents, and industry members for three days. More than 20,000 community members attended the event, which the STEM AC sponsored at $1,500.

Utah STEM Fest

The STEM AC, together with Utah's STEM industries, showcased exciting STEM career paths in our fifth statewide STEM Fest, which took place on October 6-7, 2019 at the Mountain America Expo Center. The event opened with a general public night which drew approximately 3,000 Utahns, including professionals, post-secondary students, families, and children of all ages. Just under 100 sponsors from industry, government and higher education offered hands-on learning exhibits at STEM Fest and more than 12,000 students from schools statewide attended the event during the school-group sessions. This event was managed in partnership with Utah Media Group (UMG), who coordinated and collected all corporate donations to cover the costs associated with renting the exposition space and coordinating the event. Additionally, UMG created and placed event advertisements, and produced and supplied all printed materials such as flyers and event signage. The STEM AC provided partial bussing scholarships that facilitated equal opportunities for participation from schools outside the Wasatch Front.
Some schools came from towns more than 300 miles away to attend.

STEM Best Practices Conference

The 2020 STEM Best Practices Conference was cancelled due to the coronavirus. Fortunately, we still have commitments from educators, presenters, and keynote speakers to bring back the conference in 2021 using the theme "You Get What You Play For". Since the 2020 conference was cancelled, the STEM AC team has been working to find ways to still bring relevant and best practices to educators so they can still learn from each other and stay motivated.

One of the initiatives that we pursued to address this was the launch of the Utah STEM Network Facebook Group. Created in partnership between the STEM AC and the Utah System of Higher Education, this page is dedicated to creating a community space for people to share resources, inspire innovation and creativity, and welcome dialogue among peers. Our hope is that this page becomes a regular tool for educators to use outside of the STEM Best Practices Conference.

STEM Night with the Stars

The Salt Lake City Stars hosted kids of all ages for a fun night of STEM learning at their game presented by Med One Group and Adidas on Friday, January 24, 2020, at Vivint Smart Home Arena when they hosted the Stockton Kings.

Families arrived early to check out all the fun interactive concourse exhibits for kids, focusing on how science, technology, engineering and math can relate to sports.

During halftime, three outstanding students in STEM were recognized for their work and passion for STEM in Utah. Each student received a signed basketball and SLC Stars T-Shirt. The students and their families were given free tickets to the game as well.

The following students were recognized:

Brooklin Lance
Hillcrest High School

Vanessa Jasso
Provo School District

Samantha Hansen
Jordan Ridge Elementary

STEM IN MOTION (SIM)

The STEM in Motion Program, formerly known as the Utah STEM Bus (USB) brings exciting STEM activities and resources to schools and communities all across Utah. Due to an expansion of opportunities and experiences that the program offers, the team name was rebranded to the STEM in Motion (SIM) program, rather than the Utah STEM Bus program. The outcomes from a SIM experience include increased student engagement and enthusiasm for STEM activities, increased teacher awareness of STEM education, and increased industry investment in STEM.

The SIM team currently uses STEM curriculum that provides experiential, real-world, project-based learning opportunities for students. The program also ties classroom-learning experiences to STEM AC classroom grants to help educators get the resources they need to continue the lessons after the SIM team has left. The connection to STEM careers is what makes the SIM program unique from many other informal STEM programs in Utah.

The team works closely with the Utah State Board of Education (USBE) to make sure all curricula are aligned to Utah Core Standards and have career pathways tied to local Utah companies. The STEM AC received a grant for $1.5 million in 2016 from Marathon Petroleum (formerly Tesoro) to fund the design, purchase, retrofitting, and operation of a mobile classroom. The Utah Transit Authority (UTA) donated two, 40-foot buses and a ten-person van to the STEM AC. The first bus was retrofitted and had its debut on August 16, 2017, at the Utah State Capitol, with Governor Herbert having the honor of cutting the ribbon. The van, nicknamed the Micro USB, has been retrofitted and wrapped to help engage students, educators, families and industry partners at events around the state. The STEM in Motion team has been actively engaged in partnering with local companies to enhance the curricula selection every year. Programs will rotate in and out every two years depending on teacher interest to keep programs exciting for educators and students.

Currently, the SIM team offers either a 45 minute or 2-hour programs for grades K-8. The new STEM curriculum materials are thoroughly tested before each school year. Several schools have offered to help review the curriculum materials to ensure that the materials align with standards, are age and grade-appropriate, and are a good learning experience. The educators receive two professional development hours that can be used for re-licensure points in exchange for their participation and feedback.

The current curriculum includes:

- Physics and Forces (K-3)
- Bee-bots (K-3)
- Hands-on Coding (1-3)
- Power Tiles (1-3)
- Web of Life (2-4)
- Sphero Robotics (2-8)
- Senses and the Brain (3-6)
- App Development: (4-8)
- Mars Mission: (4-8)
- Audio Engineering: (4-8)
- Game Design & Statistics: (4-8)
- Renewable Energy: (4-8)

	2017-2018	**2018-2019**	**2019-2020 *impacted due to the coronavirus**
Schools Visited	53	64	47
Students Reached	8,437	10,780	6,171
School Districts Visited	19	20	17
Total Programs Presented	337	449	288

During the 2019-2020 school year, registration for the SIM program closed within a few days of opening, and had a waitlist of over 200 schools. The SIM team has also appeared at a variety of public and private events reaching 44,165 people throughout the state. Notable events include the Hill Air Force Base Airshow, STEM Fest, Ogden Pioneer Day Parade, Junior Achievement Career Fair in the Navajo Nation, Utah Rural Schools Conference and Utah Educators Association Conference. Over 60% of the schools the SIM Team goes to are Title 1 schools, and over ⅓ of all students are qualified for free or reduced lunch.

Surveys administered to students before and after participation in a SIM experience reported that 75% of students had an increased interest in STEM after the SIM experience, and 65% of students had an increased interest in having a career in STEM after a SIM visit. Based on teacher feedback surveys after a STEM in Motion visit, over 90% of educators said the SIM program introduced their students to new material and provided a learning experience not usually available in their school. Further, 99% of educators surveyed would recommend the STEM in Motion experience to other educators. This program provides opportunities and access to STEM education that educators and students may not get in any other capacity.

Here are some additional teacher testimonials about the STEM in Motion Program:

"Our presenter was fabulous! She had my students fully engaged and excited through the entire lesson."

"THANK YOU for funding this fabulous program. I just wish we could have more opportunities. This program is amazing!"

"Many thanks for working with our school. I know my students thoroughly enjoyed learning about their brains. I heard positive feedback from other sessions as well. Hope you can come back soon!"

"I think it was an incredible experience for my students and they loved it. Thank you so much!"

In addition to classroom visits, the SIM team works on a variety of other outreach programs, including the Robotics Library. The Robotics Library project started with a $30,000 donation from Marathon Petroleum and the belief that robotics resources should be accessible to every educator in Utah. Five robotics kits were created with the support of the donation and the kits are housed strategically around the state.

Each kit includes a variety of robotics equipment designed to be developmentally appropriate for grades K-12: 5 Bee-Bot robotics, intended for grades K-1; 10 Ozobot Bit robots, intended for grades 2-3; and 10 LEGO Mindstorms EV3 robots, intended for grades 4-12. These kits are housed at the four rural education service centers: the Southeast Education Service Center in Price, Utah; the Southwest Educational Development Center in Cedar City, Utah; Central Utah Educational Services in Richfield, Utah; and Northeastern Utah Educational Services in Heber City, Utah. One kit is housed at the STEM Action Center offices to be loaned to schools along the Wasatch Front. Educators can check out this equipment free of charge from any of these locations, and are provided free training and professional development to ensure educators feel comfortable with using the technology in their classrooms. Currently the impact of this program is being assessed to determine the feasibility of scaling the program to additional kits.

The STEM for Life grant from Intermountain Healthcare is focusing on kits and activities that promote healthcare careers that are in high demand. The targeted projects link skills, aptitudes and passions to careers in fun, and engaging ways. For example, a Healthcare board game has been designed and is in pilot phase for check-out to educators.

The game will be available at the Education Resource Centers, along with the Robotics Kits described previously. The game is for a 6-8 grade level, and provides a healthcare crisis in Utah that students will have to solve through their different roles as healthcare professionals. The students will role-play as a different Intermountain Healthcare professional and work together to help stop an outbreak before it overtakes the state. This game will provide meaningful exposure to lesser-known careers through Intermountain Healthcare, and let students explore firsthand what these professionals do.

The SIM team has also created professional development videos targeted for non-traditional educators. These trainings are customizable according to the needs and skill level of participants. The training covers anything from basic STEM facilitation, to how to develop engaging, high-quality STEM content for students in extended-day programs, summer programs, childcare facilities, and more.

Educators will be able to integrate SIM visits with more in-depth classroom STEM exploration. All the curriculum programs, as well as other video challenges and lessons created by the SIM team are available on Canvas for educators to add to their lesson plans and share with students. The curriculum is also made available to educators in the form of PDF documents, so that educators can access any resources used, recreate any activities, or explore any concepts as part of their continuing STEM instruction.

The SIM team has adjusted quickly to the need for online and virtual instruction due to the coronavirus. The team has adapted the in-person instruction to an immersive kit model for nearly all of their activities. The school year curriculum kits will provide educators with 10 of the current curriculum offerings that are normally used for classroom instruction, packaged in a kit form. Educators can check out these kits for a 2-week period. The kit includes all of the materials needed for various activities, pre-recorded lessons, activity guides, and live video calls with the instructor. They also include video chats with industry professionals to relate the curriculum topic to real-world STEM careers. This new expansion on the STEM in Motion program will bring our curriculum to even more schools, and allow students to immerse themselves in the materials for a longer period of time.

While learning loss has always been an issue during the summer months, the problem was exacerbated by the coronavirus and students being out of school for more than just the summer. In response, the SIM team created early math and science kits, our To Learn Series, which could be taken home and kept by a child. These kits targeted students in kindergarten and first grade and combined math skills with art, movement, and engineering. The SIM team also partnered with Clever Octopus to create a life-science-based kit for the same age group. These kits were distributed to Tooele School District and Library as well as to diverse groups around Salt Lake County.

(c) R&D role of STEM AC - 63M-1- 3204; 2 (a)- (c); (f)

THE VALUE OF THIRD PARTY EVALUATION

Anytime an organization undertakes to evaluate its own programs, there is potential for bias. To increase accountability and research integrity, the STEM AC continues to integrate rigorous third-party evaluation for the following programs: K-12 Math Personalized Learning, Professional Learning, and K-16 Computing Partnerships. The STEM AC has a contract for third party evaluation with the Utah Education Policy Center (UEPC) at the University of Utah, which supports credible third party evaluation that sustains a high level of fidelity and objectivity. The parameters of the evaluation (such as metrics and data that is to be collected) are defined by the requirements of the STEM AC's statute, and recommendations by the third-party evaluator, the Utah State Board of Education (USBE), and LEA partners.

Comprehensive logic models are created for all programs, and the outputs and outcomes defined in the logic models drive the evaluation process. The STEM AC team reviews the third party evaluation scope annually to ensure that the data fulfills the metrics identified in the logic models for each program. The STEM AC team also looks for opportunities to take on elements of the evaluation work (e.g., surveys) that have reached a point where they can be easily deployed. This allows the STEM AC to work with UEPC to keep the evaluation work innovative and always asking new questions and ways to track longitudinal outcomes.

Product partners education partners, industry leaders, and research centers from this state and other states have contacted STEM Action Center staff to ask questions about how to conduct rigorous research on their programs. Due in part to this reputation, the Center has received additional opportunities, such as the STEM Landscape Analysis grant (see below) from Boeing, to make positive impacts on K-12 education through industry partnerships.

THE INTEGRATION OF R&D INTO STEM AC PROGRAMS

An additional R&D function was added to the K-12 Math Personalized Learning program beginning with the 2017-18 school year. The STEM AC worked with the State Procurement Office to create a process to allow new math personalized learning programs, which met all of the requirements of the original RFP, to be piloted at limited capacity (minimum of 1,000 students and maximum of 3,000) for two years, at no cost to the participating LEAs and be willing to be integrated into the evaluation process. Outcomes from the new products are compared to products currently under contract. If the performance of students using a new product meets or exceeds the average performance of students using other personalized learning products, that product will be added to an approved vendor list. In FY20, four new products were cleared to begin the pilot process starting in the 2020-2021 school year. Out of seven providers who initially applied to participate, two programs made it through the initial review process. For one of the programs, there was a statistically significant positive relationship between product use and student achievement, and that product was moved onto the approved vendor list. The analysis showed that in the 2017-18 school year, students using the program 30 minutes a week or more were 150% more likely to reach grade level proficiency compared to students without access to software provided by the STEM AC. While one year doesn't give us enough information to draw conclusions, these results appear promising and we are anxious to see what data from their first full year on the approved vendor list.

The STEM AC is working to focus on several areas of assessment that will target the tracking of longitudinal data. Specifically, data that supports the practice of increased, and ongoing, access to STEM activities can make a difference in student choices and success in STEM.

The STEM AC received a grant from Boeing to initiate a landscape study to capture the current state of STEM education and employment in Utah. Working with the Utah

Data Research Center (UDRC) and the Utah Education Policy Center (UEPC), the STEM AC will examine trends and patterns in enrollment, graduation, and employment in STEM over multiple years. The goal is to identify factors that increase students' likelihood to persist in STEM fields over time. Another goal of the study is to determine if companies are finding talent easier, or finding employees that are better prepared to succeed in their companies, thus resulting in higher retention. The data will be used to inform monitor and determine strategic responses to programs, as well as marketing and communications efforts.

(d) Review and acquire STEM education- related technology - 63M-1-3204 2 (c)

There are several programs at the STEM AC that review new education-based technologies that can help to supplement instruction in classrooms, as well as informal and community-based efforts. The criteria for review focus on quality of the resource, user friendliness for implementation in a variety of environments, implementation support included with the resource and cost effectiveness that will impact scalability and sustainability.

The K-16 Computing Partnership program has provided continued opportunities to review resources that support coding and other areas of integrated computing. There were several programs and products included in awarded grants during the 2019-20 school year that include BootUp, 4-H Extension Code Playbook, Code.org, WozU, Codechangers, and Google coding.

The STEM AC works to review and acquire new math personalized learning technology every two years. The goal is to ensure that we are always providing our students and educators with the best resources available.

One goal of the STEM in Motion (SIM) program is to identify and utilize new and innovative approaches in technology. In FY20, Nepris was identified as a platform that has the potential to connect educators and learners to industry in a meaningful way. Nepris allows educators to request live interactions with industry professionals that range from facility tours to project mentoring for students. Educators can access a video library composed of thousands of pre-recorded industry interactions and micro-videos. To date, Nepris is connected to over 39,100 industry professionals and has impacted more than 500,000 students across the country.

Augmented Reality/Virtual Reality (AR/VR) is emerging as a resource that has the potential to transform classrooms and benefit a wide variety of learners. Throughout FY20, the SIM team reviewed and vetted a number of AR/VR platforms as they relate to STEM and interdisciplinary educators. Companies vetted include Seek, SparkXR, BurrCastleXR, EON Reality and VidIt. The Center is exploring effective and innovative ways in which to use AR/VR to augment outreach and engagement, as well as pilot the technology in classrooms to supplement instruction.

The STEM AC received a National Science Foundation (NSF) grant, Linking Attitudes and Behaviors to Student Success (LABS2). This grant is working to develop AR/VR modules that can be used by counselors and educators to expose students to simulated experiences for high demand, skilled and technical careers such as those in engineering and healthcare.

The STEM AC works diligently to secure federal (such as the NSF grant previously described) and corporate grants (such as the Boeing grant previously described) that support projects and ideas, which are aligned with the Center's strategic plan, but increases the STEM AC's ability to bring new and innovative tools to Utah classrooms at no cost. These grants are ideal to pilot new STEM resources in a low risk approach, providing proof of concept and effectiveness of the resource.

(e) Use resources to bring the latest STEM education learning tools into the classroom - 63M-1-3204 2 (f)

The STEM AC is committed to identifying new STEM resources strategically to help target gaps and needs in STEM education. The STEM AC works closely with education partners and the STEM community to identify gaps and needs in STEM education, both for classrooms and for informal STEM opportunities. The intent is to connect new STEM education learning tools and resources as potential solutions to the identified gaps and needs in order to support and improve STEM instruction. This is described in the previous section as it relates to several of the STEM AC programs.

The annual STEM Best Practices conference has been in place since 2015 and has the main goal of bringing together Utah STEM (and non-STEM) educators to showcase the latest learning tools in the classroom. This provides an opportunity to share ideas and promote the use of the latest in STEM resources.

The R&D mechanism that is integrated into the K-12 Math Personalized Learning program (discussed previously) is a good example of how the STEM AC works to identify and assess the best resources for math instruction. There are several STEM AC programs that "fuel the innovation engine" of the Center.

(1) The STEM AC provides small Innovation grants, through the Innovation Incubators micro-grant program. These funds are awarded to classroom educators to support the design and implementation of new STEM activities. This grant program is discussed in detail in the following sections.

(2) The K-16 Computing Partnership program provides opportunities to support promising practices in K-12 computing education. For example, Lindon Elementary in Alpine School District initially intended to implement a train-the-trainer model for integrating computing in its classes. After their trainer left the district, the project morphed to the development of an innovation/makerspace called The Garage, which integrated everyday computing skills into traditional academic areas, provided training and professional development to educators weekly, and offered all 4^{th}-6^{th} grade students access to 6 different media forms: programming, web design, stop motion animation, robotics, 3D printing and sound and audio. The Garage has hosted countless school's administration, is now being replicated at Manti Elementary in South Sanpete, and is inspiring other schools' innovation/makerspaces.

Cache County School District expanded its pipeline efforts in elementary and junior high to include authentic high school computer science internships. Cache County led an 8-school consortium with Emery School District, Logan School District, Central Utah Educational Services and Southeastern Education Service Center. These internships provided individual mentors to students on the IT Pathway, who earned at least one industry certification. This model is being replicated in a new consortium of six rural school districts for FY21-23.

(3) The Utah STEM in Motion (SIM) team members are constantly developing and testing new resources.

For example, the SIM team has started creating professional development webinars for educators to learn how to use certain STEM technologies, and dive deeper into the curriculum materials presented to them during STEM in Motion visits. The Robotics Library will also bring new and innovative tools into Utah classrooms at no cost. Educators can check out a variety of different robotics classroom sets from their nearest resource library and have step by step tutorials on how to use the robots, and in-depth curriculum to guide their classes in their exploration.

The end of the 2019-20 school year provided an unexpected opportunity for the SIM team to pivot and implement new ways to adapt their "in person" curriculum materials and activities to a blended model. This shift helped to improve the STEM AC resources offered to students and educators. This adaptation was in response to the coronavirus, but has proven to be highly successful and effective so far.

The reputation of the STEM AC, both locally and nationally, has resulted in the STEM AC being invited to join existing partnerships, or apply for grant funding to launch new programs. These programs bring new resources to educators, parents and the community. These programs include: (1) the NSF INCLUDES program that supports broadening participation in STEM (2) the Utah Air Quality Challenge (3) Utah STEM Landscape Analysis (4) multiple Department of Defense grants and; (5) several Department of Education grants. The collaborative projects have leveraged partnerships with numerous organizations including the Utah State Board of Education, several Institutions of Higher Education (IHEs), multiple LEAs, Utah After School Network, United Way, Americorp etc. (6) Leap into Science (7) STEM for Life (8) UBTech Robotics.

(f) Support of STEM-related competitions, fairs, and camps, and STEM education activities - 63M-1-3204; 2 (d)

The STEM AC funds and oversees the Innovation Incubator program. This program includes three micro-grant opportunities: (1) Student Competition (2) Classroom and (3) Organization grants.

COMPETITION GRANTS

Studies show that students who participate in STEM competitions are much more likely to pursue STEM careers (Miller, et al, 2018). The STEM Competitions Grant is intended to support K-12 students' participation in STEM competitions. Applications for the grant program must be completed by a school-level representative on behalf of the students benefiting from the grant in order to be accepted. The school-level representative will oversee the funding and be responsible for reporting outcomes. Competition grants cover costs for supplies, registration, and other expenses related to participation in STEM fairs, camps, and competitions. Schools may request up to $100 per participating student, and receive funding based on the strength of their application. Scores are generated by a review team made up of other grant applicants and focus on sustainable student impact. Students are required to apply for a grant requesting funds from their school, and student projects are funded pulling from the overall school award. Before the end of the school year, each awarded school must submit detailed receipts and project completion reports showcasing what students accomplished. During a typical year, representatives from the STEM AC visit as many sites as possible to help judge events, talk to educators and students, and get a feel for what schools are doing around the state. This year, travel was restricted and the school year ended early, so we reached out to educators directly and asked them to report on how things went, what they were able to accomplish, and how projects impacted students.

Educators reported that students mastered content that could translate directly into STEM careers (such as design, programming, and debugging), and developed 21st century skills (e.g. collaboration, creativity, persistence) in ways traditional classroom learning doesn't always facilitate.

"Project-based learning for STEM Competitions increase student interest in science, technology, engineering, and math (STEM) because they involve students in solving authentic problems, working with others, and building real solutions to real world problems. Students learn to reflect on the problem-solving process and learn best when encouraged to construct their own knowledge of the world around them. Each student got to complete an original research project of their choosing. They learned a lot about their field in particular, and about scientific research in general. They got to work with professionals in their field, and learn about careers. They also got a lot of encouragement from adults and from each other to keep going through the hard parts of the process and were successful in completing their projects, giving them confidence that they can succeed in the future. Several have already indicated they want to continue doing research, and past students have continued to participate in college and post-baccalaureate research."

- Cameo Lutz

Grantees stressed that access to these opportunities helped them reach traditionally marginalized students that would have been unable to participate in programming without these funds. In many cases, grantees indicated that without STEM AC support, they would not be able to run these programs at all. Many grantees also highlighted the fact that this grant allowed them to focus fully on helping the students because it eased the burden of scrounging for resources that usually occupies much of their time that would otherwise be spent mentoring and coaching.

"As an educator in a school with many students on free/reduced lunch, I refuse to charge my team to be able to participate. The possibility of this program changing kids' futures is too great for me to turn down a kid because of their family's situation. I ask them to work as a team to find sponsors, write grants, and participate in fundraising. A key part of that is the STEM AC grant. I was able to provide this opportunity to more kids than I otherwise would have."
- Clief Castleton

"This grant allowed for the necessary purchases of supplies and fees that gave the scholars the ability to experience these unique STEM competitions. Without them, [we] would not have been able to participate."
- Peggy Downs

The grant program is popular and for the 2019-20 school year grants were awarded to 45 schools. In their project completion reports, grantees also reported that participation in these opportunities positively impacted students' confidence in STEM subjects, helped develop important interpersonal skills, and even resulted in students choosing to go to college and choose STEM majors. Though many programs had to shift due to unusual circumstances this year, which resulted in a few disappointments, nearly all grantees were able to provide engaging activities resulting in increased STEM interest and engagement among their students.

"It is hands on, it is fun, and kids get into it in more depth than can ever be achieved in a classroom. Our kids worked a total of 7704 hours in this season as of the state tournament. We were successful. We attended 10 different competitions and competed against 161 different VEX teams from across the United States (34 different states). In these competitions, the individual teams in our club won 10 Tournament Champion trophies, 6 Design Award trophies, 4 Robot Skills Champion trophies, 4 Judges Award trophies, 2 High School Excellence Award trophies, and 1 Middle School Excellence Award trophy. Three of our teams were invited to VEX Worlds, which sadly was not held due to Covid-19."
- Preston Richey

CLASSROOM GRANTS

Classroom grants directly support educators to pilot inventive approaches to STEM education, recognizing that innovative curricular resources developed by local educators need to be replicated and spread as widely as possible throughout the state. For FY20, a total of 221 grant applications were received. Of those applications, 121 proposals (55%) received a portion of the funds requested. Applications are scored by previous classroom grant awardees and STEM AC staff using a rubric to determine which proposals will be funded. The amount of funding for classroom grants in FY20 totals just over $115,000.00, with an impact on 19,403 Utah students. Due to coronavirus school disruptions, 11,200 of these students were impacted in the 2019-2020 school year, with the remaining 8,203 students projected to be impacted in the 2020-2021 school year. In FY20, 26% of classroom grants were awarded to educators that identified their students as rural. A summary of the LEAs, grades, and number of students are included in Appendix B.

Lesson plans were collected from awardees in order to facilitate increased access to and involvement with innovative STEM curricula throughout Utah. These resources have been made available to Utah educators via the STEM Action Center's website. Grant awardees were also asked to present their project in a session as part of the STEM Best Practices conference, which was ultimately cancelled in 2020 due to coronavirus. Participants receiving support are expected to complete a final report that describes outputs and outcomes. These reports are critical to educators that choose to utilize the shared materials as it provides follow up information and suggestions to other educators. Responses on the final report vary greatly, but several awardees commented this year on allowing students to learn to love science:

"The materials were used to do in-class labs and activities to engage students in doing real science and engage them further in the learning process. This was evident in my attendance rates on days where labs and activities were performed. Most "normal" classes of chemistry would have several students absent. My lab days often had 100% attendance."

"I had two 8th graders wanting to join Science Olympiad mid-way through the season because they enjoyed science from my class."

"My students never want to miss science day and now they make predictions about many other things and love to conduct experiments to test theory whether in the classroom or at home. We really sparked a love of science in the entire classroom."

Educator's beliefs about student learning were also changed through this grant program, as evidenced by:

"This project and grant helped me to understand just how much student engagement centers around meaningful experiences. I understand now that a student really won't understand something unless they can experience it. I had often been frustrated before when I would explain the concept to a student several times and they still wouldn't get it. Now I let a student experience it and the light bulbs come on!"

"I believe this grant helped me to see how much my students are capable of when they use their imaginations."

"This grant changed my life and my way of thinking. I watched students take positive action in designing plans on their own and outside of class for addressing global issues. I watched students become positive role models for younger students. I watched students become empowered to change the world. I saw students fall in love with science and math and problem solving. I had students understand and communicate that local decisions and actions can have impacts on the global environment. I used to wonder if I really made a difference as a teacher. I felt like this project, this year, will empower these kids for the rest of their lives. I can honestly say, this year I did make a difference."

ORGANIZATION GRANT

The STEM AC supported 42 Organization Grants with student impact projected to be over 11,000 students, with $94,150 allocated from the operational budget. Due to the coronavirus; many STEM organizations had to pivot their programming to support online or socially distanced STEM activities. Most of the programs who received funding were able to continue their programs and spend their grant funds as they had outlined in their original application. Some of the programs were unable to follow through with their programming in FY20 so the STEM Action Center executed no-cost contract extensions to allow for the funds to be used in FY21 and the programming shifted to support the organizations current needs. Examples of the organizations include, Boys & Girls Clubs of Greater Salt Lake & Weber/Davis areas, Southern Utah University, Utah State University, YMCA of Northern Utah, Grand County School District, University of Utah, Alliance for Innovative Education, Spy Hop Productions, etc. A couple of the STEM Organization Grant awardees are listed below in more detail:

- Utah State University, USU Extension Youth Programs: The purpose of this project was to supply STEM outreach to underserved youth in Salt Lake county, including partnerships with afterschool programming, county wide events, and culminating activities on May 4th and Discovery Days (formerly Salt Lake County Farm Fest). Due to the coronavirus the culminating activities did not happen in the format originally planned, but we were able to adjust to an online format and complete all of the outreach components of the grant. We partnered with afterschool programming to provide STEM outreach in high-need, low income populations at several schools in the Salt Lake Valley. Once the schools closed in mid-March, we moved these efforts to a mix of online programming and take-home activities for youth and families. Through these efforts we were able to reach our targeted audiences, albeit in a different format than originally planned.

- YMCA of Northern Utah Summer Camps: Despite unprecedented challenges this year, we were able to continue operating our STEM Summer Day Camps at two locations. Due to Weber State Ogden campus closures, we made arrangements to operate our STEM camps at Ogden Preparatory Academy and Layton Christian Academy. We operated our program for nine weeks, each with a STEM-related theme such as Vehicles and Coding, Engineering Adventures, The Sun & Our Stars, Design & Construct It, and Technology Week. Youth participated in hands-on activities and practiced STEM skills like coding, engineering, digital movie production, environmental science, and robotics (using LEGO Robotics curriculum). Our goal for our youth is to become inspired and to look forward to continuing their STEM learning. Each theme was supported by STEM professionals in these fields, who came as Guest Speakers to present to youth about their education, hobbies, and careers. We continued the tiered instruction approach we implemented last year. Campers were divided into learning groups based on their grade level and Staff created lessons that reflected state-wide STEM Core Standards for each grade level. Youth were able to learn at a pace that was neither too advanced nor too basic for their learning level for a better experience.

(g) Identification of best practices being used outside the state and learning tools for K-12 classrooms - 63M-1-3204 2 (h and i)

The STEM AC team continues to reach out to other states to explore best practices and position the State of Utah as a leader in STEM education and talent development. The STEM AC has been one of several state organizations that were invited to work with the Office of Science and Technology Policy at the White House to review and update the federal strategic plan for STEM education.

The STEM AC has been a member of several national organizations such as STEMx and STEMConnector over the past several years. The STEM AC leadership determined that due to budget constraints that operational funds could be used more effectively for other programs. This has not prevented the STEM AC from engaging and working with other STEM leaders in other states. The STEM AC Director has participated in the annual Midwest STEM Directors Symposium for the past six years, and attends other STEM events such as the annual Washington STEM conference. The STEM AC has worked with the Education Commission of the States on several "thought leader" efforts for their reports such as Early STEM Learning and best practices for state STEM initiatives. The STEM AC is a partner on a regional and national NSF grant program, INCLUDES, with numerous states to support broadening participation.
The STEM AC, along with numerous other partners, won the bid (8 cities applied) to host the 2019 CSforAll National Summit on October 21- 23, 2019 at the University of Utah. The theme was systemic change for computer science education and there were nearly 1,000 participants from across the country.

The STEM AC team has adapted several best practices from other states including the new *To Learn* early math kits that were developed during spring of 2020 and will be deployed and evaluated over the 2020-21 school year.

(h) Provide a Utah best practices database - 63M-1-3204, 2 (j)

The STEM Action Center website provides access to best practices and content that targets students, parents, educators, and industry partners. The website was redesigned in 2019 to better serve the STEM education community, offering a dynamic and informative user experience for all stakeholder groups. The new website launched in

June 2019, complete with a repository of STEM content, showcasing innovative STEM ideas for use in the classroom and at home. This resource will allow educators to submit resources of their own, rate the resources provided by peers, provide feedback, and connect with other Utah educators. Information on best practices for STEM in Utah and links to high-quality STEM resources hosted by other websites will also be featured. The new website includes information regarding STEM events and activities across the State; a description of these events, along with dates, locations, and a point of contact. All of this will inform the annual STEM Best Practices Conference, allowing us to provide more targeted, robust opportunities for educators.

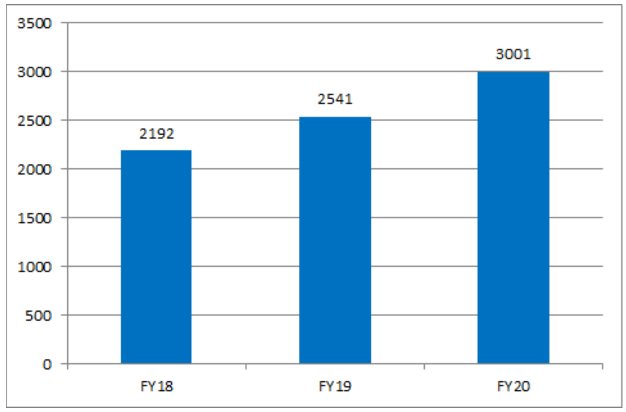
The coronavirus pandemic motivated a shift in how resources are being provided on the website. Resources were identified and organized to better support home learning and online instruction. The result is the STEM in the Home page, which has received positive feedback from parents and teachers.

(i) Keep track of how the best practices database is being used and how many are using it - 63M-1-3204 2 (k) i and ii

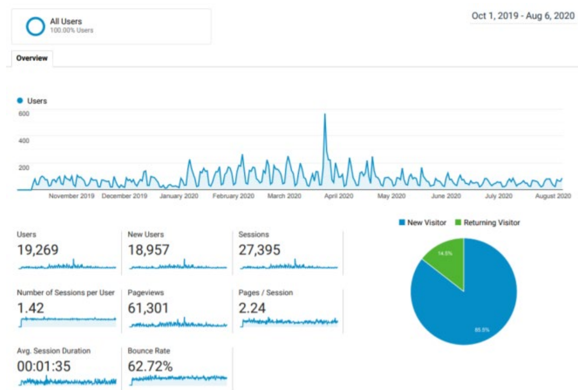
The STEM AC website was equipped with new analytic tools to provide better insight as to how people are engaging with the content. Since the relaunch, there were almost 20,000 website users. The STEM AC website continues to be a reliable resource for educators, students, parents and industry professionals looking to engage with STEM education in Utah. The website saw a significant spike in traffic in March/April of 2020 due to our ability to quickly provide in-home resources for families during the coronavirus shutdown (i.e., STEM in the Home).

The STEM AC social media accounts also saw growth in FY20:

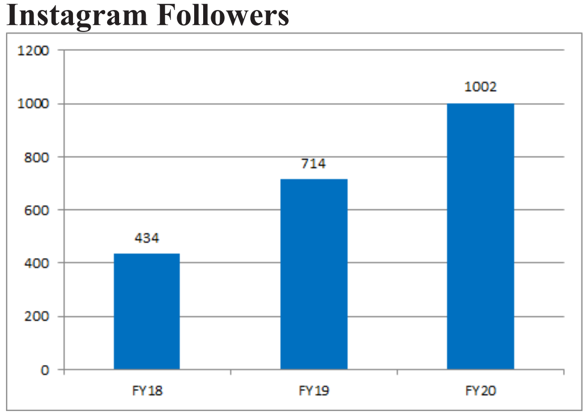
Facebook Likes



Website Traffic



Instagram Followers



Our social media pages continue to be a key resource for the STEM AC to engage directly with our constituents and keep them updated with recent news and information regarding STEM in Utah and throughout the nation. The web assets help to promote STEM opportunities to all stakeholders in the spirit of fostering an online network dedicated to STEM education and, ultimately, economic growth in related industries. Critical to dissemination of high quality content, the social media accounts drive traffic to the main website, stem.utah.gov.

It is worth noting however, that the STEM AC website will transition again to a new platform in FY21 to better fit within the online structure of the Utah Department of Heritage & Arts. The move to an X-Theme platform, supported by DTS, will provide the opportunity to unify our branding within DHA and better communicate with constituents.

(j) Join and participate in a national STEM network - 63M-1-3204 2(l)

The STEM AC, as discussed previously, has determined that resources can be accessed readily without paying for membership in the national organizations such as STEMx or STEMConnector. There are greater benefits to attending key conferences or symposia to engage with the larger network of state STEM leaders. Further, several of the national organizations have become more member-focused and less about providing services, which diminishes the role that they can play for an organization such as the STEM AC.

(k) STEM School Designation - 63M-1-3204, 2 (n)

The STEM AC, working with the Utah State Board of Education (USBE), generated a comprehensive plan for a STEM School Designation program, which was included in the FY15 annual report. The USBE and the STEM AC Executive Board approved the criteria in FY15. Over the course of applying for designation, schools complete a self-evaluation on 10 overarching dimensions, which break down into 37 elements. Each element is evaluated by the applicant school and scores are supported with narrative and artifact evidence submitted to the review committee. The review committee is composed of STEM AC and USBE staff, as well as administrators planning to apply the following school year, in addition to each applying school providing a reviewer as well. It is important to note that the application to become a designated STEM School is not easy. It takes time and considerable thought and strategy. In spite of the level of work required to complete an application, there has been considerable excitement. The first solicitation for applications was released in early September of 2015, with 19 schools awarded a designation at one of the four designation levels in FY16. An additional 12 Dual Language Immersion schools were also granted STEM School Designations.

In FY17, seven additional schools were awarded new designations, with an additional school applying for a higher level of designation. Nine schools were awarded designations in June 2018, three of which were existing awardees that had applied for an increase in designation level, resulting in 43 STEM school designations across the state of Utah. In FY19, eight new schools and one school seeking an increased designation level applied and were awarded a designation. In FY20, there were also seven new STEM School Designations, one school receiving an increased level of designation, and two schools that received redesignation throughout the state in FY2020. There are currently 58 STEM schools across the state. Designations are recognized for five years, requiring a school to reapply at the end of that time to maintain the designation. For schools that use reviewer feedback to create and implement improvements within those five years, a modified application process is used to increase the designation level. A summary of the awardees is included in Appendix C.

(l) Support best methods of high-quality professional development for K-12 STEM Education - 63M-1-3204 2 (o)

In the 2019 General Legislative Session, the funds allocated to STEM AC for the professional learning program were allocated to USBE. STEM AC worked with USBE to ensure support for the ongoing grants with USBE funds. Additional changes to the program for the 2019-2020 school year include a single survey, administered at the end of the year, which asks educators to reflect on their growth over the school year. Grant site administrators are also being asked to participate in virtual PLCs to share their experiences with each other throughout the year.

The STEM AC supports LEA-designed effective professional learning associated with STEM via the Professional Learning program. Funded projects must align to the Utah Effective Teaching Standards (UETS) developed by the Utah State Board

Education (USBE). Specifically, standards 3: Learning Environments, 4: Content Knowledge, 5: Assessment, 7: Instructional Strategies, and 8: Reflection and Growth, were identified as those that could be directly impacted by this grant program.

All funded proposals must align with the definition of highly effective professional learning, as defined in HB 320 from the 2014 general legislative session. One component that is crucial to these plans' success is effective professional learning communities (PLC's), which have educators work in small teams to identify areas for growth, and then work as a team to collect data and make instructional changes. Recent research shows that, particularly in mathematics instruction, effective PLCs as a component of professional learning have demonstrable positive effects on student performance (Motoko & Guodong, 2016). Other studies demonstrate with longitudinal data that effect PLCs are key to facilitating change in teacher change in areas such as curriculum, instructional strategies and effectiveness, and a change in practice and belief of participating educators. This type of professional learning also develops structure, a collaborative culture, and the development of effective learning activities (Choi Fung Tam, 2015). All grant participants are required to (1) work toward improved STEM-related instruction and (2) film themselves and watch for personalized learning goals through self-reflection.

Participants are also asked to complete a survey at the end of the school year by our external evaluator, Utah Education Policy Center (UEPC). One finding from this survey indicates an increase in the integration of math and science from FY19, a positive implication for STEM in general, with only 8% of survey participants stating they did not teach STEM. This is a decrease from the previous year, which had 16% of respondents stating they did not teach STEM. Educators still feel the least prepared to integrate engineering, though 74% felt their ability to integrate this skill set had increased due to their professional learning in the 2019-2020 school year. Positive trends continue when further examining survey responses, with 92% of respondents indicating their participants had been professionally rewarding experiences. Respondents indicated satisfaction with their professional learning opportunities, and gave the following as some of the reasons for recommending STEM professional learning:

- Increased student engagement
- Increased teacher content knowledge
- Facilitated educators' acquisition of new skills
- Improved teacher's instructional practices
- Increased educators' confidence

Another finding from the survey was the increase in educators skills in the following areas:

- Teaching elementary math standards
- Teaching elementary science standards
- Teaching STEM lessons
- Creating new STEM lessons

Survey responses also indicate positive effects associated with teacher retention and job satisfaction. and student engagement and development of necessary STEM skills such as critical thinking, communicating, collaborating, and being self-directed learners. Additionally, respondents indicated an increase in their abilities to provide students opportunities to learn from mistakes, and an increase in her ability to engage with students more equitably. For more in-depth analysis, see the UEPC Professional Learning report.

Grant funds are used for a variety of purposes, primarily off-contract time, incentives for completing additional work off-contract, substitutes for work-day efforts, recording devices, conference transportation and registration (within the state of Utah), as well as other locally designed and supported STEM learning opportunities. Applicants can apply for either a one-year or three-year grant. Of the 78 projects funded in FY20, 30 were three-year grants in their second year, and 27 were grants in their third of three years. Typically, one-year grants act as a pilot for a project that will turn into a three-year grant in the future.
Anecdotally, these three-year grants have increased teacher participation as they demonstrate a long-term focus on improving STEM within s school or LEA. For more information and additional data, including survey results from the end of the school year after project implementation, see the full report by Utah Education Policy Center in Appendix E.

(m) Recognize a high school student's achievement in STEM Fairs, Camps and Competitions- 63M-1-3204, 2 (p)

The STEM AC partnered with several organizations including the University of Utah, Boeing, and the Utah Jazz organization to publicly recognize student achievement in STEM throughout the state. These programs included a public nomination process as well as an award ceremony to recognize their efforts.

In addition to these programs, the STEM AC showcases the work students and educators are doing around the state using website and social media resources. It is our responsibility to not only promote the work the STEM AC does, but also the work students, educators, and communities are doing to support and promote STEM all over the state.

(n) Develop and distribute STEM information to parents of students being served by the STEM AC - 63M-1-3204, 2 (r)

In a normal year, pre-coronavirus, the STEM AC reaches out to parents at various STEM events, such as the Craft Lake City DIY fair, STEM expo events, and other sponsored events. Parents are encouraged to sign up for the newsletter and to follow the STEM AC on social media, where they can learn about STEM events across the state and student grant opportunities. The annual STEM Fest provides engaging opportunities for families to attend on the open Family Night. A specific section on the website is dedicated to students, where parents and students both can learn the significance of STEM and also keep up to speed on the latest events.

Toward the end of FY20, the STEM AC and the Utah System of Higher Education partnered to create the Utah STEM Network, a public Facebook page dedicated to creating a community space for people to share resources, inspire innovation and creativity, and welcome dialogue among peers. Whether someone is a K-16 educator, parent, community member, or industry professional, this page will connect them with others who share a passion for STEM in Utah.

Again, during a normal year, the STEM in Motion (SIM) team drives the STEM Bus to STEM nights and other events at various elementary schools throughout the year, and opens the bus up to communities to learn more ways to get involved in STEM. Further, the SIM team supports the Leap into Science program that provides STEM and reading events at several community venues across the state. Parents, and their children, are a focus of the Leap into Science program and helps to promote reading through engaging topics in science.

(o) Support targeted high-quality professional development for improved instruction in education, including improved instructional materials that are dynamic and engaging and the use of applied instruction - 63M-1-3204, 2(s) i - iii

In the 2019-20 school year, educators and administrators from 546 schools received professional learning for the use of the K-12 Math Personalized Learning tools as part of the contracts with the product providers. Working with our third-party evaluation team, we strive to identify best practices and target professional learning opportunities to meet the needs of educators. The STEM AC team conducted its third annual multi-week "road trip" across the state to provide additional professional learning to educators for the use of the math personalized learning tools. The STEM Roadshow consisted of five events around the state of Utah during the last week of July and the first week of August 2019. These events were designed to get the year off on the right foot, providing educators with opportunities to collaborate, share successes, find solutions to challenges, and receive professional development related to products provided by the STEM Action Center. Across all five locations (St. George, Richfield, Orem, Salt Lake, Layton, and North Logan) 257 participants attended.

The STEM in Motion (SIM) team designed and created 600 STEM kits to teach early learning math and science skills aligned with K-1st grade standards. This was in partnership with Project Child Success out of Washington State, and the three kits used a To Learn model designed originally by Project Child Success. The To Learn model incorporates early math concepts into every day fun activities that children enjoy. The pilot kits focused on Paint to Learn, Build to Learn, and Move to Learn. These kits are distributed directly to students without cost, and tie content areas to early math concepts to provide engaging activities for students and important examples for parents. The fourth kit, *Insect Hotel*, was created in partnership with Clever Octopus and focuses on early science skills such as observation and data recording. 130 kits were distributed through the Tooele, San Juan and Kane School Districts as part of an initial pilot program. Initial survey data is positive from the pilot and will be used to develop future early learning kits and programs.

(p) The Board may prescribe other duties for the STEM AC in addition to the responsibilities described in this section - 63M-1-3204, 3

Utah Department of Heritage & Arts (DHA)
The Utah Legislature determined that the STEM AC needed to look for a new "home" agency during the 2019 Legislative Session. There were several options considered, such as the Department of Workforce Services, the Department of Heritage and Arts and the

Utah State Board of Education. The final decision was to move the STEM AC to the Utah Department of Heritage and Arts (DHA). There were several factors that supported the choice: the overall governance structure of DHA was appropriate for the STEM AC, the STEM AC already had several project collaborations with divisions of DHA (e.g, the State Library Division and the Division of Utah History), most of the divisions within DHA supported education-based programs and the fund raising function of the STEM AC was aligned to directions desired by the DHA.

The STEM AC Executive Board has the statutory authority to approve a new physical location for the Center and approved the new Columbus Hub for the STEM AC. The Hub is located at 3848 S. West Temple in South Salt Lake and is a mixed use facility for the Columbus Serves (affordable housing for adults with disabilities and some limited retail space). The STEM AC will be located on the ground level and will have a 2,000 square foot Innovation Hub to house several local community-based FIRST and VEX robotics teams. There will also be a new STEM Artist in Residence program in the new location. These programs will launch in FY22, once the coronavirus outbreak is contained.

K-16 COMPUTING PARTNERSHIP INITIATIVE

The STEM AC, in partnership with USBE, identified a critical lack of access in Utah schools to computer science and information technology (CS/IT) opportunities for students. In 2017, with strong support from industry, STEM AC secured $1.255M ongoing to launch the first computing grant initiative in Utah (SB190), now known as the K-16 Computing Partnership Initiative. The STEM AC, working with partners from USBE, industry, DWS, LEAs, the Computer Science educators Association (CSTA), the Utah State Superintendents Association (USSA), community and cultural organizations and higher education institutions, built out a strategy to support the creation of articulated computing programs, beginning in K-6 and seamlessly transferring through secondary and post-secondary. The results were two key strategic actions: (1) support an industry-led effort to secure legislative funds for funding to LEAs in the form of a competitive grant program and (2) an industry-led collaboration to develop an apprenticeship program in computing. The current grants were identified through two formal, competitive solicitations, with external review of all submissions. Applicants submitted grant requests for 2-3 years of funding. The first solicitation, awarded in 2017, received 24 applications with 10 grant awards. The second solicitation, awarded in early 2018, received 23 grant applications with 19 grants awarded. Fifty-five percent of these awards were located outside of the Wasatch Front. Appendix D provides an outline of the grantees and their funded activities.

Input from STEM AC partners helped to inform funding requests and define the criteria for the grant framework and proposal activities, which address the resource gaps preventing LEAs from offering comprehensive computing programs in K-12. The activities, as defined in the Request for Grants (RFG), include:

- innovative outreach, engagement and awareness activities with a focus on equity and access for all Utah students
- robust and industry-relevant content for courses
- increasing the number of middle and high schools with CS/IT courses
- integration of coding, with a focus on computational thinking, for elementary classrooms
- classroom engagement with industry partners
- professional learning opportunities to increase the number of qualified educators
- work-based learning opportunities
- effective articulation with post- secondary partners that increases retention of students in undergraduate programs
- increased industry advocacy

Qualitative and quantitative data was collected from grantees in September 2019, January 2020 and at the end of the school year. Third-party evaluation analysis indicates positive outcomes and provides formative guidance regarding how to improve the program and identify future, additional needs. For more information and additional data, see the full report by Utah Education Policy Center in Appendix XX.

During FY20, 10,870 students enrolled in 350 new computing class sections, and 11,702 students participated in outreach and engagement activities. (Note: students may have participated in more than one activity.) Figure 1 provides detail regarding the types of outreach and engagement activities provided. Decreased participation from Fall 2019 to Spring 2020 is due in part to the school closures due to the coronavirus. However, many grantees were able to continue their clubs through online methods.

Figure 1: *Summary of Outreach and Engagement Grant Activities*

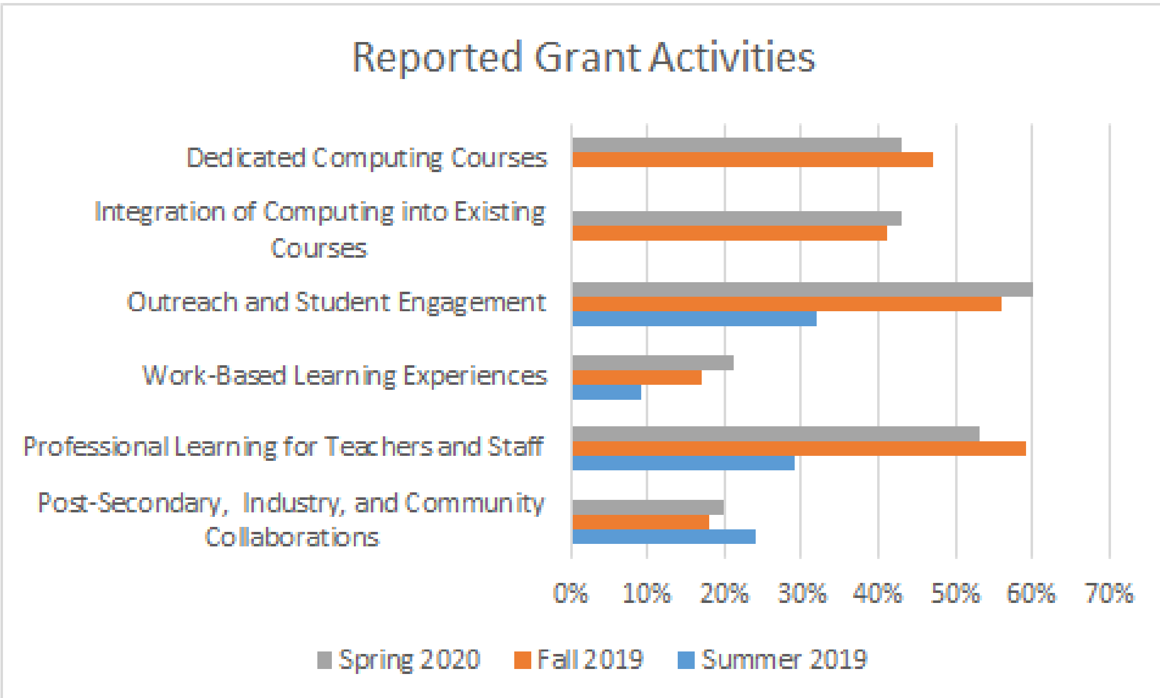
	Summer 2019		Fall 2019		Spring 2020	
Activity Type	**Hours Offered**	**# Students Served**	**Hours Offered**	**# Students Served**	**Hours Offered**	**# Students Served**
Coding club	168	238	703	828	1693	672
First Tech Challenge	0	0	53	34	44	34
Lego League	52	16	535	392	156	259
Other robotics club	0	24	0	40	30	30
Student conferences/events	0	0	31	1102	18	108
Aspirations in Computing Program	0	0	0	0	20	160
Hour of Code	0	0	423	2645	50	1143
Family Hour of Code	0	0	0	143	6	32
eSports Competition	0	0	0	0	65	76
Hack-a-thon	0	0	8	85	0	0
Out-of-School kick-off family events	0	0	22	960	44	1861
Other	295	220	380	79	65	461
Total	515	498	2155	6368	2191	4836

*Students may have participated in multiple activities.

Source: UEPC Computing Partnership Semester and Annual Reporting Tools

Grantees identified strategies that best addressed the specific computing needs of their school or district. A majority of grant activities focused on teacher professional development and before/after school programming, as seen in the summary of program activities in Figure 2.

Figure 2: *Reported Grant Activities*



Source: UEPC Computing Partnership Semester and Annual Reporting Tools

In addition to output measures, third-party evaluators utilized open-ended questions through reporting and teacher surveys. This data suggests that LEAs observed increased knowledge and skills in educators and increased interest in teaching computing. The LEAs also observed improved attitude and improved skills among students, as well as, increased interest in computing and increased interest in and completion of industry certifications. After student participation in outreach and engagement activities, 93%-96% of educators, depending on the indicator, either strongly agreed or agreed that their students exhibited intentions to pursue computing, and 72%-90% of educators reported their students demonstrated technical skills in computing.

The following are sample survey responses.

Student gains:
"Our students have gained confidence, skills and knowledge in what computer science entails and has to offer them in the future."

"Students have learned that computational thinking skills are life skills, and are motivated to continue learning."

“They [students] have been able to learn more about careers in CS and have learned that these careers are something that they can aspire to become.”

Teacher gains:
“Educators have gained an increased understanding of the ‘whys’ and the ‘how’s’ of integrated computational thinking in the classroom. They have also received tools to help them achieve success in the area.”

“79% of computer educators ranked the importance of Computer Science 9 or 10 on a scale of 1-10. This shows a huge increase in teacher attitude. They have so much to teach but most are now ranking CS as the most important thing they teach students. educators are enthusiastic and motivated by the content.”

Grantee responses also identified challenges with implementation that include lack of staff and the disruption to or cancellation of planned activities due to the coronavirus.

Based upon LEA input and FY20 grantee data, the FY21-23 RFG that was released in December 2019, emphasized out-of-classroom programs and the creation of innovation/makerspaces. Seventeen grantees were identified from 37 applicants through one competitive solicitation, with external review of all submissions. Applicants were awarded funding for 3 years, beginning July 1, 2020.

Additional K-16 Computing Initiative Partnerships
The K-16 Computing Partnership initiative leverages additional partnerships.

Code.org
Since FY17, collaboration with Code.org and key Utah industry partners has allowed the STEM AC to provide teacher professional learning endorsement workshops for specific courses in the computing pathway. Hill Air Force Base funding and in-kind donations from Dell EMC supported participation by 92 middle school educators (CSD) and 80 high school educators (AP CSP), with an additional 320 elementary educators (CSF) supported directly by the STEM AC. As a result, 4654 high school students, 9631 middle school students, and 16,243 elementary students were impacted, for a total program impact of 30,528 students.

Girls Who Code
The STEM AC collaborates with the Girls Who Code Club Network (GWC) to support the creation and facilitation of GWC Clubs across Utah. In November of 2017 there were five GWC Clubs in Utah. The STEM AC’s Foundation, working with GWC, Carbonite, and Comcast, have helped to grow the clubs to a total of 141 active clubs affiliated with the STEM Action Center. Carbonite, Comcast, Centeva, and Recursion have provided financial and site support in facilitating this event in FY19, and made available support for the FY20 event prior to its cancellation.

The Utah Computing Apprenticeship Consortium (UCAC)

The STEM AC has been working with the Utah Department of Workforce Services (Utah DWS) and industry partners to create the first computing apprenticeship program. Computing is defined as computer science, information technology, cybersecurity, software development and engineering, data analytics and artificial intelligence. This project, which originated in November of 2018 with the support of Senator Hatch's office, supports opportunities for students to be hired as apprentices, in an "earn while you learn" model. In June of 2019, DOL announced that WSU, in partnership with Salt Lake Community College, Davis Technical College, Ogden-Weber Technical College, the Utah DWS and the STEM AC, had been awarded $2M to begin scaling apprenticeships in IT and IT-related industries. WSU and its partners aligned closely with Silicon Slopes Apprenti, now Apprenti Utah, and continue to facilitate the assessment and matching of applicants to industry partners.

Utah companies have been engaged in the apprenticeship project for the past three years; these companies include Adobe, 3M, Ivanti, Comcast, Ancestry.com, Vivint, Microsoft, Google, Oracle, IM Flash, Goldman Sachs, eBay, Hill Air Force Base, AT&T, Inside Sales, OC Tanner, Utah Technology Council, Women's Tech Council, Silicon Slopes, BAE Systems, Intermountain Healthcare, Domo, Health Equity, Instructure and Orbital ATK.

National Science Foundation

Linking Attitudes and Behaviors for Student Success (LABS2)

The success of key STEM education efforts rely on an effective communication and outreach strategy, with an emphasis on programs that are in Career and Technical Education (CTE). It has been recognized in Utah, as well as in many other states, that CTE programs suffer from myriad negative misperceptions. In order to ensure that any efforts with CTE programs realize their full potential for participation, the stigma that plagues CTE programs needs to be addressed. The STEM AC and partners from higher education, the USBE, several LEAs and the Utah DWS, were awarded funding in 2018 for the Linking Attitudes and Behaviors for Student Success (LABS2) proposal from the National Science Foundation's Advanced Technology Education (ATE) program.

The focus of this grant is to work collaboratively to create a new communication and outreach strategy for Career and Technical Education (CTE) programs, which would include Computer Science and Information Technology (CS/IT). The grant was a "Workshop and Conference" grant for an 18-month duration and $100,000. The grant was evaluated and the reviewers recommended that the grant be funded, but be extended to a project grant for three years and an expanded scope and budget. The grant was funded on April 1, 2018 for three years and a total of $766,364. There have been two rounds of surveys conducted; the first survey was a general analysis of perceptions and knowledge around CTE programs. The second survey was designed to understand behavior around decision making with students when they consider CTE courses. The information from these responses is being analyzed for common themes or trends that will help to create customized messages that address beliefs, misconceptions and biases in each stakeholder group. The new communication strategies, with their messages, will be disseminated for the 2020-21 and 2021-22 school years to determine impact on CTE enrollments and perceptions. An emphasis will be placed on social media deployment. The LABS2 team will follow up with targeted focus groups and additional surveys to assess the impact of the messages and refine them.

Broadening Participation in STEM through Increased Equity, Inclusion, Diversity, and Access
A key focus of the STEM AC is to promote and support equity, access and inclusion to all students. There are several projects that the STEM AC participates in to meet this core element of its vision. The NSF INCLUDES project is a major project in which the STEM AC is a collaborator.
A consortium of partners, led by Utah Valley University, initiated the STEM Equity Pipeline in 2014, in partnership with the National Alliance for Partnerships in Equity (NAPE), the STEM AC and Park City School District. The pilot was funded by the National Science Foundation and has been a huge success. The overarching purpose of the STEM Equity Pipeline project is to use root cause analysis to determine the reasons why enrollments for underrepresented populations are unacceptably low in STEM education and career pathways. A pilot was conducted with Park City School District (PCSD) in their middle, junior, and high schools. The first year of root cause analysis was followed by data- driven changes during year two. Year three enrollments for girls in elect STEM courses increased dramatically. Data is being collected for Hispanic and Latino students for year four enrollments. The data from this project is available upon request.

The STEM Equity Pipeline project was completed, but a portion of the project, STEM Micro-Messaging, was found to be extremely useful for district partners. A Motorola Solutions grant was secured in April of 2018, which has helped to create a modified version of the micro-messaging training that is more scalable with respect to time and cost. The pilot for the modified version was conducted in spring of 2019 with 70 educators in the Davis School District. The workshop was initiated on March 28, 2019, with a full day of training, followed by two months for the participants to test chosen micro- messaging strategies for their classroom. The two months of classroom testing were followed by the second (and final) day of training in June that allowed the educators to share their experience and the outcomes, as well as refine and expand their strategy for the 2019-20 school year. The response from educators was overwhelmingly positive, including the following:

“We made a goal to incorporate a lot of growth mindset lessons, activities, posters, and language in our class. We started off this month by learning about the brain, hippocampus, amygdala, prefrontal cortex, etc. This week we just started having them work for little paper neurons to put on their ‘brains’ when they do hard things, are persistent, etc.”

“We are working together as a PLC. Our focus is to help our students understand that everyone can be a scientist. We are going to start the year with a ‘Draw a Scientist’ assignment. Students will be asked to draw a picture of a scientist and identify the attributes of their scientist. Then as a group, students will create a poster with a shared idea about what a scientist looks like and specified attributes. Then students will display their posters around the classroom and we will have a group discussion about the commonalities and differences in the pictures. We want to lead the students to identify missing attributes or if anyone feels like these pictures don’t represent them. We will share an experience from

Edwin Hubble where he 'reinvented himself' in order for other scientists to take him seriously by changing his look and behaviors to look more like an expected scientist. Throughout the rest of the semester we will highlight under- represented scientists each month, focusing on females and scientists of color. We will also work on developing a 'biography of a scientist' project for students to complete that will also place a focus on underrepresented scientists. We are also going to modify our 'cold call' techniques in the classroom. We will have cards or sticks with student names and we will actually separate them into piles based on gender. This will allow us to alternate calling on girls and boys so that it is equally done in the class. (One teacher) also noted that she focused on providing feedback to both boys and girls and not just to boys. At the end of the semester we will revisit our first assignment of drawing a scientist. Students will go back to their original groups and reflect on how their idea of a scientist has changed (or not). As a group, they will add to or create a new drawing of a scientist and list the particular attributes, with the hope that students' ideas will be more inclusive by the end of the semester."

The STEM micro-messaging pilot is being incorporated into another key project at the STEM AC, STEM Communities, in order to scale it to other educators across the LEAs.

The work initiated by the STEM Equity Pipeline has expanded to a two-year planning grant in the NSF INCLUDES program, Intermountain STEM (IM-STEM). The IM-STEM project is a collaboration between the National Alliance for Partnerships in Equity (NAPE), Utah and five other Intermountain West states (Colorado, Idaho, Wyoming, Nevada and New Mexico). The IM-STEM project focused on establishing a network of STEM leaders and state initiatives that collectively gathered best and promising practices in STEM education that broadened participation in STEM education. The IM-STEM project just concluded in June 2020, but the IM-STEM team has recently submitted a second planning grant to the NSF INCLUDES program to prepare for a full national INCLUDES Alliance. The Utah STEM AC is a co-lead on the national alliance planning grant and the intent is for the STEM AC to be the regional hub for the western US for the national alliance proposal.

Strategic planning - the next 3-5 years

The STEM AC embarked on an intensive strategic planning process in January of 2020. The STEM AC currently has a strategic plan that has reached its intended life span. The STEM AC team, with direction from the STEM AC Executive Board, determined that it would move ahead with the strategic planning process, in spite of the challenges that have resulted from the coronavirus outbreak.

The STEM AC is contracting with Kilo Zamora, from the University of Utah, who is an expert on community-based strategic planning. This approach was well-suited to the vision that the STEM AC had for the next 3-5 years. The first phase of the planning process focused on revising logic models for all of the programs in the STEM AC.

The logic models have been completed and the STEM AC is halfway through the second phase of the planning process: soliciting stakeholder input. Stakeholders for the STEM AC include partners in K-12 (educators, administrators and superintendents) and higher education, community and cultural organizations, other government agencies (i.e., the Governor's Office of

Economic Development, the Utah Department of Workforce Services, the Utah State Board of Education, the Department of Heritage and Arts etc), industry and business representatives, trade organizations and legislators. The full analysis of stakeholder input (focus groups and one on one interviews) should be complete by November 2020 and the new plan released by the end of the calendar year of 2020.

Math Mentors

The STEM AC received an Americorp planning grant for the Math Mentors program. The program represents the “next step” for the K-12 Math Personalized Learning program, which has achieved full operational status and is ready to serve as a “springboard” to new, innovative opportunities to support students and educators in math learning. The Math Mentors program will work with Americorp members and industry partners to bring mentoring and tutoring support to elementary schools. The mentoring will be provided independently, and in combination, with the supplemental math software. The design of the program is being adapted from a successful reading program that has been supported by United Way of Northern Utah.

Distance Learning

The STEM AC has always had a strong commitment to access and equity, with a focus on rural students and communities. The challenges that the coronavirus has created only amplifies the need for greater innovation and capacity for distance learning.

The STEM AC has a strong focus on supporting distance learning efforts in STEM. The STEM in Motion team, as previously discussed, has adapted all of the classroom instruction programs to a blended learning model, with kits that can be checked out, and online and video instruction to support educators with the kits. They are also designing and launching another series of kits for distance distribution for early math (To Learn) and have received additional funds to scale the kits to additional topics areas and capacity. The SIM team has also increased capacity for its rural library program that supports “mobile maker spaces” for robotics.

The STEM AC is working with a new online platform, Nepris, which is designed to leverage online and virtual engagement to connect industry professionals to the classroom.

The newly launched Utah STEM Network Facebook page is facilitating virtual engagement and sharing of STEM resources with parents, educators and the community.

The new Math Mentors program previously discussed will be designed to pivot between in person and virtual mentoring for math in the classroom.

Innovative Transition of Key Programs

The STEM AC is working to strategically transition the K-12 Math Personalized Learning and Professional Learning programs to their next iteration of innovation. The STEM AC recognizes that it is not always the most effective strategy to support open grant programs into perpetuity. The intent of many grant programs that are broad in focus is to learn more about the needs of partners and help to establish strategy and foundational programs that can be leveraged into the growth of STEM programming. The K-12 Math Personalized Learning program has been in operation for nearly seven years. It has demonstrated positive growth and proficiency in math for students for over three years. This program reflects an emerging opportunity for the STEM AC to serve as an incubator of innovative STEM programs. The STEM AC is exploring a mechanism that would allow for the transfer of the program to a new "home" and free up the existing funding to pilot and launch new and innovative programs to support math instruction. The early math To Learn series and Math Mentors represent two new areas of focus for supporting math.

The Professional Learning program is preparing to transition from an open, comprehensive grant program to focusing on the creation of a Utah STEM Master Educator Innovation Center (USMEIC). This Center will serve as an incubator of innovative ideas that target key areas of need in STEM education. The ideas will be researched, implemented and evaluated by Utah STEM educators. This will be a partnership with Institutions of Higher Education, LEAs and the USBE.

Outreach, Engagement and Partnerships

The STEM AC conducts the following outreach and engagement activities as a means to provide project support to educators and promote STEM AC resources. There are numerous outreach, engagement and partnership development activities that are included in previous sections, such as the industry engagement portion of the report.

The Director of the STEM AC conducts visits with district superintendents, and is working to create a STEM AC Advisory Board with district superintendents. The intent is to resume the effort when it is appropriate.

The ability to discuss gaps and needed resources with Superintendents is critical for the STEM AC. It ensures that the resources that the STEM AC provides are relevant and help the LEAs to create positive change for their students, educators, and communities.

The STEM AC continues to build relations with school boards including the Rural School Boards Association. The STEM AC has committed to attending the Rural School District Association meetings to understand more fully how to support rural districts and their STEM needs. The STEM AC has spent a great deal of time working with the Regional Education Service Centers (NUES, CUES, SESC and SEDC). The Utah STEM in Motion team works with the rural service centers to provide access to the kits that they have developed.

The STEM AC works with the USBE as part of a STEM Leadership Team that is creating shared communication materials to clarify roles and partnerships between the STEM AC and the USBE.

The STEM AC conducts site visits to various projects over the year. The following are examples of how the STEM AC team works to engage with partners across the state.

Classroom grants for the 2019-20 school year varied in scope and subject. While team members typically visit classroom grant recipients heavily in the months of March-May, these visits were not able to take place due to schools moving to distance learning formats in response to coronavirus. As such, only one visit was able to be completed for the classroom grant program. Of the 121 grants awarded 51 awardees were not able to fully implement their projects, also due to coronavirus disruptions. These grant awardees were given contract extensions to allow them to complete their proposed curricular changes and complete the grant reporting requirements in the 20-21 school year. The remaining program participants were able to complete their proposed projects and all associated reporting components. Greater detail regarding the classroom grants program can be found in preceding sections. A summary of all classroom grant awards can be found in Appendix B.

School visits were completed for the six new STEM School Designation recipients at the gold or platinum levels in the 19-20 school year.

STEM AC participated in the grand opening of the Windridge Elementary interactive STEM Lab, sponsored in part with STEM AC funding. Converted from a previous computer lab, the new makerspace's hands-on activities include building miniature robots, working with a 3D printer, and making films with a green screen. Principal Casey Pickett believes this new lab helped the school receive a platinum STEM designation from Utah STEM Action Center in May of this year.

The STEM Team also participated in the third annual Family STEM Night hosted by USU Extension Kane County 4-H and Kane Education Foundation at the new Kanab center. STEM AC helped to sponsor this event and also hosted one of 20 hands-on learning booths, which reached approximately 650 people including almost 500 students. The next day staff members toured Kanab's community makerspace, and elementary and high school classes. Kane County School District is a recipient of the Computing Partnership Grant program.

The STEM in Motion (SIM) team focuses on in-classroom instruction, giving both the students and educators a hands-on experience of STEM. In the last three years, the SIM team has spent over 1,000 hours in classrooms, working with these students to develop a passion for STEM starting in elementary school. The SIM team also works with educators to bolster their confidence and knowledge base to consistently teach high-quality STEM lessons in their classrooms.

Acquisition of STEM education-related instructional technology program – Research and development of education- related instructional technology (63M-1- 3205)

The STEM AC completed its seventh full year of training and implementation to support the K-12 Math Personalized Learning program (2019-20 school year). The overall goal of this program is to provide supplemental math support to educators and students in an innovative approach that includes: (1) ongoing research of best practices in the use of supplemental instructional tools (2) using a statewide approach to design and implement a robust analysis of the use of content-specific supplemental technology-based tools and (3) a statewide approach to implement a program that leverages state contracting and critical mass for cost-effective access and (4) integrating a mechanism that allows for continuous assessment of new products at no cost to the state.

A total of 190,970 students had access to licenses provided by the STEM AC for math personalized learning tools. The program covered 29% of all Utah students in grades K-12, with 39 districts and 58 charter schools participating (557 schools total). Six math personalized learning products were used during the 2019-20 school year. Buy-in at all levels is critical to success, and in 2019-20, each application required a signature from one district-level admin and one school-level admin, promising to ensure that students would have access to technology for at least 45 minutes per week to use the math software provided. We also required signatures from the IT Director at each LEA to ensure they were aware of any technology provided by the grant and that they would have adequate bandwidth and infrastructure prior to implementation. We also make efforts every year to provide summer learning opportunities for classroom educators to increase buy-in at the teacher level. We call this series of learning opportunities the “STEM Roadshow”, and travel the state with product providers, setting up regional meetings about a month prior to the start of school to get as many classroom teacher participants comfortable with the products they will be using over the course of the year.

All applications are required to list “on- site” contacts, which are verified by the district point of contact before the beginning of the school year. This ensures that product providers are able to distribute the majority of awarded licenses and facilitate professional development right at the beginning of the school year. Product providers are required to distribute licenses and arrange professional development before they receive payment, which has encouraged them to put forth extra effort to ensure timely completion of these activities. We also made sure that usage expectations were clearly communicated to administrators and math coordinators.

To allow school and district administrators to more strategically plan implementation, we open the application for the following school year early in the spring and send award notifications in April before budgets have to be completed. As this program has matured, we have found there is a difference between “fidelity”- using a product for a certain amount of time, and effective implementation. When working to ensure products are used effectively with over 100 thousand students, the easiest metric to look at is minutes of use. While this metric has been valuable, it does not provide a complete picture of what effective usage looks like. Over the past couple years, we have learned that we need to increase our focus on implementation strategies and effective use of reporting features as well. As we have worked to emphasize the importance of using these supplemental products strategically to facilitate better human connection between educators and students, administrators all over the state have expressed their support for this approach and their gratitude toward the STEM AC for understanding the important role of the teacher in high quality math instruction. We are working with educators to identify promising practices that may help improve student outcomes so that those practices can be shared with other educators throughout the state.

The third-party evaluation team for the STEM AC has been working with the USBE to access end-of-year test scores for 2018-19 to align with the use of digital learning tools. It was not certain that data would be available for the 2018-19 school year due to the issues associated with the end of year testing mechanism through RISE. However, limited data was collected and the STEM AC is working with evaluators to analyze the data. The STEM AC has completed a longitudinal analysis using data and the lessons learned from previous years to examine longer term trends with the math program and student achievement. The longitudinal analysis is included in Appendix E and demonstrates the cumulative relationship between product use and student achievement over multiple years.

Third-party evaluation report on performance of students participating in STEM Action Center programs as collected in Subsection 63M-1-3204(4).

The STEM AC continues to work with the Utah Education Policy Center to expand beyond basic metrics, to facilitate a more robust analysis that provides greater stratification of the data, as discussed previously.

The third-party evaluator has completed the annual report that includes assessment of the K-12 Math Personalized Learning, Professional Learning, Elementary STEM Endorsement projects, and K-16 Computing Partnerships. The report indicates that nearly all educators and administrators feel that access to these opportunities has had a positive impact on educators and students. For the math grant, more than half of the students report that using the software helped increase their confidence in math (see Appendix D).

The K-12 Math Personalized Learning report includes data from surveys administered by the third-party evaluator, license usage data, and longitudinal data examining trends on the relationship between product use and student achievement over time. In the past, these reports have shown that each year, students who use software effectively are more likely to reach grade level proficiency than students without access to software. The longitudinal report examines the relationship between product use and student achievement over time. The goal here is to understand whether positive effects of software are compounded over multiple years of product use, or if there is a plateau at some point, or a “point of diminishing returns.” In summary the analysis shows that the positive effects observed in the one year snapshots from prior reports remain consistent over time. This is important to know, because it means that generally students will continue to see the significant positive results over multiple years of use. For full details, please refer to Appendix E or contact Clarence Ames at cames@utah.gov.

ATTACHMENTS:
Appendix A: Selected Product Providers
Appendix B: Classroom Grants Summary
Appendix C: STEM School Designation Awardees
Appendix D: Computing Partnership Grant Awards
Appendix E: Utah Education Policy Center Report
(three parts: Professional Learning, Computing
Partnerships and Longitudinal Math Analysis)

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Selected Product Providers

Appendix A

HB Project	Vendor	Alignment
K-12 Math Personalized Learning	- Curriculum Associates (i-Ready) - Dreambox Learning - Imagine Learning (Imagine Math) - McGraw-Hill (ALEKS) - Mathspace - MIND Research Institute (ST Math)	✓ Contains individualized instructional support for skills and understanding of core standards ✓ Is self-adapting to respond to the needs and progress of the learner ✓ Provides opportunities for frequent, quick and informal assessments ✓ Includes an embedded progress monitoring tools and mechanisms for regular feedback to students and teachers

LEA and School	# Students	Grades	Rural?	Award Amount
Alpine School Dis	180	5	No	1500
Alpine School Dis	31	6	No	1143
Alpine School Dis	70	6	No	1200
Alpine School Dis	32	3	No	665
Alpine School Dis	150	3	No	1200
Alpine School Dis	53	9,10,11,12	No	1041
Beehive Science	84	9,10,11,12	No	999
Cache County Scl	90	6	No	559
Cache County Scl	120	11,12	Yes	816
Cache County Scl	62	5	Yes	238
Cache County Scl	60	6	No	1006
Cache County Scl	360	8	Yes	1157
Cache County Scl	700	1,2,3,4,5,6	Yes	1170
Cache County Scl	120	3	Yes	1170
Cache County Scl	25	2	Yes	655
City Academy	60	8, 10	No	1198
City Academy	80	10,11,12	No	1500
City Academy	70	7, 9	No	1190
Davis School Dist	60	6	No	1200
Davis School Dist	600	3,4,5,6	Yes	391
Davis School Dist	150	4	No	80
Davis School Dist	29	6	No	826
Davis School Dist	630	K,1,2,3,4,5,6	No	1004
Davis School Dist	120	7,8	No	792
Davis School Dist	35	4	No	1193
Davis School Dist	77	3	No	1194
Davis School Dist	55	10,11,12	No	958
Emery School Dis	142	9,10,11,12	Yes	1200
Emery School Dis	45	7,8,9	Yes	1500

Emery School Dis	140	3,4,5	Yes	1440
Entheos Academ	27	5	Yes	619
Freedom Prepara	500	9,10,11,12	No	1200
Freedom Prepara	50	9,10,11,12	No	1200
Granite School D	200	7	No	174
Granite School D	80	K	No	160
Hawthorn Acade	106	8	No	1198
Hawthorn Acade	63	K	No	948
Hawthorn Acade	125	K	No	958
Hawthorn Acade	81	3	No	1034
Hawthorn Acade	70	K	No	743
Hawthorn Acade	100	2	No	1079
Hawthorn Acade	63	9	No	1143
Hawthorn Acade	90	4	No	1140
Hawthorn Acade	27	2	No	593
Hawthorn Acade	108	2	No	513
Hawthorn Acade	100	K	No	1085
Hawthorn Acade	25	3	Yes	623
Hawthorn Acade	80	6	No	1130
Hawthorn Acade	27	2	No	1119
Hawthorn Acade	81	2	No	1158
Ignite Entreprene	20	4,6	No	407
Ignite Entreprene	42	6	No	779
Iron School Distr	320	8	Yes	1200
Iron School Distr	375	8	No	1200
Iron School Distr	100	11, 12	Yes	605
Jordan School Di	150	1	No	937
Jordan School Di	40	4	No	1133
Jordan School Di	150	4	No	1062
Jordan School Di	56	2	No	1199

Jordan School Di:	30	1	No	535
Jordan School Di:	25	3	No	155
Jordan School Di:	28	4	No	663
Jordan School Di:	200	4,5,6	No	1199
Jordan School Di:	100	K	No	223
Jordan School Di:	56	1	Yes	1185
Jordan School Di:	38	5	No	1200
Jordan School Di:	35	3,4	No	356
Jordan School Di:	24	1	No	1029
Jordan School Di:	100	K	No	1163
Jordan School Di:	21	K	No	891
Jordan School Di:	40	K	No	696
Jordan School Di:	90	K	No	795
Jordan School Di:	2000	10,11,12	No	1359
Jordan School Di:	24	2	No	577
Jordan School Di:	43	K	No	649
Jordan School Di:	30	5	No	1031
Jordan School Di:	450	7,8,9	No	1199
Jordan School Di:	25	6	No	1307
Juab School Distr	2300	,6,7,8,9,10,11,12	Yes	990
Lakeview Acader	100	9	No	1115
Millard School Di	75	3	Yes	975
Morgan School D	16	2	Yes	158
Murray School D	450	5	No	1500
Murray School D	96	5	No	399
Nebo School Dist	285	3,4,5,6	Yes	1200
North Star Acade	80	9,10,11,12	No	1028
Ogden School Di:	49	3	No	241
Ogden School Di:	485	3,4,5,6	No	1500
Ogden School Di:	150	5,6	No	1500

Park City School	400	7	No	1196
Pinnacle Canyon	26	1	Yes	897
Provo School Dis	80	7,8	No	1120
Provo School Dis	62	K	No	993
Provo School Dis	62	K	No	1114
Provo School Dis	65	K	No	1067
Salt Lake City Sch	375	8th	No	1140
Salt Lake City Sch	150	9,10,11,12	No	1159
Salt Lake City Sch	250	7	No	1182
Salt Lake City Sch	73	3	No	963
San Juan School	102	6	Yes	1149
San Juan School	250	9,10,11,12	Yes	1085
Soldier Hollow Cl	44	4	No	1065
South Sanpete Sc	25	1	Yes	933
South Summit Sc	520	5,6,7,8	Yes	697
Tooele School Di	60	1,2,3,4,5,6	Yes	1167
Uintah School Di	164	6	Yes	1114
Utah Military Aca	150	9,10,11,12	No	1200
Vista at Entrada	70	6,7,8	No	1119
Washington Cou	22	1	No	792
Washington Cou	100	1	Yes	1056
Washington Cou	25	5	No	359
Washington Cou	200	1,2,3,4,5	Yes	1195
Washington Cou	60	3,4,5	No	1078
Washington Cou	39	3	Yes	1188
Washington Cou	50	3,4,5	Yes	1200
Washington Cou	170	8	Yes	483
Washington Cou	75	2	Yes	344
Washington Cou	584	K,1,2,3,4,5	Yes	1263
Washington Scho	105	2	Yes	925

Weber School Di	96	6	Yes	960
Weber School Di	50	K , 2	No	568

Name of School	District or Charter	**Level Awarded**	Year Awarded	Year Expires	~# of students
Foothill Elementary	Alpine School District	Platinum	2016-2017	Summer 2020	688
Manila Elementary School	Alpine School District	Silver	2015-2016	Summer 2020	775
Draper Park Middle School	Canyons School District	Bronze	2015-2016	Summer 2020	1516
Union Middle School	Canyons School District	Bronze	2015-2016	Summer 2020	895
Mount Jordan Middle School	Canyons School District	Bronze	2015-2016	Summer 2020	910
Beehive Science and Technology Academy	Charter	Platinum	2015-2016	Summer 2020	140
DaVinci Academy	Charter	Gold	2015-2016	Summer 2020	1164
Mountainville Academy	Charter	Silver	2015-2016	Summer 2020	759
Quest Academy	Charter	Silver	2015-2016	Summer 2020	946
Itnieris Early College High School	Charter	Bronze	2015-2016	Summer 2020	384
Utah County Academy of Sciences (UCAS)	Charter	Bronze	2015-2016	Summer 2020	396
West Point Elementary	Davis School District	Silver	2015-2016	Summer 2020	815
Neil Armstrong Academy	Granite School District	Gold	2015-2016	Summer 2020	882
Woodruff Elementary	Logan City School District	Gold	2015-2016	Summer 2020	669
Overlake Elementary	Tooele School District	Silver	2015-2016	Summer 2020	572
Crimson VIew Elementary	Washington County School District	Platinum	2015-2016	Summer 2020	650
Hurricane Elementary	Washington County School District	Gold	2015-2016	Summer 2020	671
Creekview Elementary	Carbon School District	Gold	2016-2017	Summer 2021	486
Utah Virtual Academy	Charter	Silver	2016-2017	Summer 2021	1989
George Washington Academy	Charter	Bronze	2016-2017	Summer 2021	1000
Endeavour Elementary	Davis School District	Platinum	2016-2017	Summer 2021	908
New Bridge School	Ogden School District	Platinum	2016-2017	Summer 2021	648
Westridge Elementary	Provo City School District	Platinum	2016-2017	Summer 2021	806
Willow Elementary	Tooele School District	Platinum	2016-2017	Summer 2021	706
Nothern Utah Academy of Math, Engineering, and Science (NUAMES)	Charter	Platinum	2017-2018	Summer 2022	888
Cedar North Elementary	Iron County School District	Platinum	2017-2018	Summer 2022	383
Hillcrest Elementary	Logan City School District	Silver	2017-2018	Summer 2022	528
Sunset Elementary	Washington County School District	Silver	2017-2018	Summer 2022	541
Arrowhead Elementary	Washington County School District	Bronze	2017-2018	Summer 2022	659
Coral Canyon Elementary	Washington County School District	Bronze	2017-2018	Summer 2022	568
Diamond Valley Elementary	Washington County School District	Gold	2017-2018	Summer 2022	302
Bonneville Academy	Charter	Gold	2018-2019	Summer 2023	702
Vanguard Academy	Charter	Bronze	2018-2019	Summer 2023	381
Jennie P. Stewart Elementary	Davis School District	Platinum	2018-2019	Summer 2023	745
Vae View Elementary	Davis School District	Platinum	2018-2019	Summer 2023	411
Valley View Elementary	Davis School District	SIlver	2018-2019	Summer 2023	454
Eastwood Elementary	Granite School District	Bronze	2018-2019	Summer 2023	384
Horizon Elementary	Washington County School District	Bronze	2018-2019	Summer 2023	661
Canyon Creek Elementary	Davis School District	Platinum	2018-2019	Summer 2023	850
Boutiful Junior High	Davis School District	Platinum	2019-2020	Summer 2024	650
Gearld Wright Elementary	Granite School District	Bronze	2019-2020	Summer 2024	690
Green Acres Elementary	Weber School District	SIlver	2019-2020	Summer 2024	520
Odyssey Elementary	Davis School District	Platinum	2019-2020	Summer 2024	600
Shadow Valley Elementary	Ogden City School District	Platinum	2019-2020	Summer 2024	654
Sunrise Ridge Intermediate School	Washington County School District	Silver	2019-2020	Summer 2024	673
West Bountiful Elementary	Davis School District	Platinum	2019-2020	Summer 2024	660
Windridge Elementary	Davis School District	Platinum	2019-2020	Summer 2024	615
Paradise Canyon Elementary	Washington County School District	Bronze	2019-2020	Summer 2024	550

K-16 Computing Partnership Summary

Grantee	Round	Project Title	School District	Schools	Scope	Summary
Bryant Middle School	First	Bryant Computing Inititiative	Salt Lake City SD	Bryant Middle School	Middle	Implement afterschool coding and robotics clubs with mentors from nearby high school and summer GREAT camps run by U of U. Professional development for coding and teaching Computer Science Discoveries. Expand extracurricular classes to include Computer Science Discoveries.
Coral Canyon Elementary	First	Establishing a Computer Science Pathway for Underserved Students at Coral Canyon Elementary School	Washington County	Coral Canyon Elementary	Elementary	Afterschool CS and robotics club through 4-H and summer CS day camps. Professional development through Utah State University.
Davis SD	First	Computer Science for All Davis School District Elementary Students	Davis SD	All Elementary Schools	Elementary	CS professional learning for Lab Managers, provided by BootUp PD. Lab Managers will offer CS classes in half of elementary schools during initial roll out, with second half in year following.
Entheos Academy	First	Entheos Academy Kearns Computing Pipeline Project	Charter	Entheos Academy	Elementary Middle	Purchase software to increase keyboarding classes in elementary schools. Professional development to increase teacher knowledge and integrate CS into classrooms. Offer Computer Science Discoveries and Computer Technology classes, as well as afterschool clubs, to middle school students.
Iron County SD	First	Cool 2 Code	Iron County	Canyonview High School, Cedar Middle, Enoch Elementary, South Elementary	Middle High	Increase high school CS class offerings in Programming I. Add Creative Coding to middle school and partner with SWTEC for certification program in Computer Programming for high school students. Add keyboarding classes and hands on coding exercises for all grades of elementary. Partner with CodeChangers to bring coding to elementary classrooms and afterschool coding programs.
Juab/South Sanpete/North Sanpete	First	Tri-District Kindergarten to College CS Pathway Initiative, Supported by Juab, South Sanpete and North Sanpete School Districts to align with Snow College CS programs.	Juab South Sanpete North Sanpete	All Elementary and Middle Schools	Elementary Middle	Create CS pathway from elementary to high school. Add classes for basic coding in elementary and afterschool coding clubs and summer camps. Offer girls coding club in middle school and increase class offerings, including Creative Coding.
Kearns	First	Future Leaders in Tech	Granite SD	South Kearns Elementary Kearns Jr. High	Elementary Middle	Establish new program, Future Leaders in Tech, to introduce low income students to CS through robotics and coding. Create pathway between schools to recruit students in elementary school and keep them involved through middle school. Intensive summer coding program and afterschool clubs for elementary students. Creative Coding for middle school.
Provo City SD	First	Provo Computational Thinking/Computer Science Program	Provo City	All Elementary Schools	Elementary	Develop and implement K-6 CS pilot program in elementary schools: keyboarding, CS Professional Development, curriculum.

Success Academy	First	Polytechnic Magnet Achievement in Computer Science (PMACS)	Charter	Success Academy	Middle High	Academy for Computers and Engineering (ACE) -Recruit students for CS “fast track” advanced collegiate pathway. Retain students in pathways with CS tutors, college mentors and industry speakers. Prepare students for degree in CS with intensive summer programs, focusing on critical thinking, study skills and beginning coding.
Three Falls Elementary School	First	Three Falls Elementary Computer Science Pilot Program	Washington County	Three Falls Elementary	Elementary	Afterschool CS, robotics club, and summer CS programs using 4-H curriculum. Professional development for teachers by partnering with Utah State University, to integrate CS into future curriculum.
Alpine SD	Second	Alpine School District Computing Initiative	Alpine	All Elementary Schools	Elementary	Write CS standards for elementary schools, with coding central to the curriculum. Professional learning provided by BootUp. K-2 to use blockly programming. Introduce grades 3-6 to creative coding with Scratch.
Cache County SD	Second	Cache Computing Collaborative	Cache County	All Schools	Elementary Middle High	Increase course offerings starting in elementary school. Provide elementary teachers professional learning through BootUp. Develop afterschool coding clubs in elementary schools, through partnership with Cache Makers. Lead 8-school consortium of high school IT internships. Students earn at least one industry certification.
Davis SD	Second	K-12 Computing Pathway Enhancement	Davis	All Schools	Elementary Middle High	Add coding classes to elementary keyboarding classes, expanding offerings in middle school (switch from ECS to CSD) and expand HS coding classes. Offer distance learning for students unable to participate in their school.
Delta Middle	Second	Delta Middle School Technology Innovations	Millard	Delta Middle	Middle	Create coding classes with CSD curriculum. Add summer camps and afterschool coding clubs such as Girls Who Code. Sponsor student showcase of created projects. Junior high students to mentor elementary kids through science projects with infrared cameras.
Duchesne Elementary	Second	Establishing a Computer Science Pathway for Underserved Students in Rural Duchesne County Elementary Schools	Duchesne	Duchesne	Elementary	Develop afterschool 4-H CS clubs, FIRST Lego Leagues, and summer camps.
Garfield County SD	Second	21st Century Computing in Utah's Frontier	Garfield	All Schools	Elementary Middle High	Incorporate STEM/coding into classroom through professional learning for all teachers. Expand course offerings in middle and high school. Pay for endorsement of high school CS teacher. Deliver career fair for high school students, including local partners.
InTech Collegiate High SChool	Second	Expanding Computing Courses and Credentials	Charter	InTech Collegiate High School	High	Increase CS course offerings and teacher professional learning to offer wide range of courses. Purchase IT industry certification tests and test prep for students.

Itineris Early College High School	Second	Itineris FIND IT and Computer Science Pathways	Charter	Itineris Early College High School	High	Develop FIND young adult career readiness program for students. Target CS training and access to industry partners.
Juab SD	Second	Juab Elementary Coding Initiative	Juab	Mona, Nebo View and Red Cliffs Elementary Schools	Elementary	Deliver professional learning for all elementary teachers in partnership with BootUp. Integrate computer science into 4-6 grade classes, with expansion to 3rd grade. Coding to be taught using Scratch.
Kane County	Second	Pathway for Students in the	Kane	All Schools	Middle	camps.
Lindon Elementary	Second	Expanding with Tech Trep Academy	Alpine	Lindon	Elementary	Establish The Garage, a makerspace for co-teaching with teachers and delivery of teacher professional learning for CS integration into the classroom. Provide 4th-6th grade students with online CS classes through Tech Trep Academy to gain new skills to apply to their year-long passion project.
Nebo SD	Second	6th Grade Digital Innovators	Nebo	9 Elementary Schools and 1 Advanced Learning Center	Elementary Middle High	Develop afterschool program using WozU with the intent of creating a statewide 6th grade curriculum. Offer afterschool digitial design labs, open to all students in middle school.Deliver WozU certified training program for teachers.
Ogden City SD	Second	Ogden School District Computer Science Pilot and Expansion	Ogden City	All Elementary Schools	Elementary	Expand CS in elementary schools, starting with New Bridge. Lab Monitors trained to teach CS in all grades. BootUp to provide professional learning and incentives to teachers.
Pinnacle Canyon Academy	Second	Chartering New Computing Pathways	Charter	Pinnacle Canyon Academy	Elementary Middle High	Add keyboarding classes to K-8 and increase offerings of CS classes in 8-12th grades, including Programming. Access higher level classes through USU and develop high school internships with local businesses.
San Juan SD	Second	Code to Success	San Juan	High, Whitehorse	High	mentors and weekly guest speakers.
Elementary	Second	Pathway for Underserved	Duchesne	Tabiona	Elementary	summer coding camps.
Tooele County SD	Second	High School IT Industry Certification and STEM Projects	Tooele	All High Schools	High	Provide high school students with industry CS/IT certifications and increase course offerings at community learning center.
County SD	Second	for Computer Science	County	Elementary, Lava	Middle	FIRST Lego leagues for all grades. Offer weeklong summer coding

THE UNIVERSITY OF UTAH
UTAH EDUCATION POLICY CENTER

FOR RELEASE JULY 30, 2020

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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Bridging Research, Policy, and Practice

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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

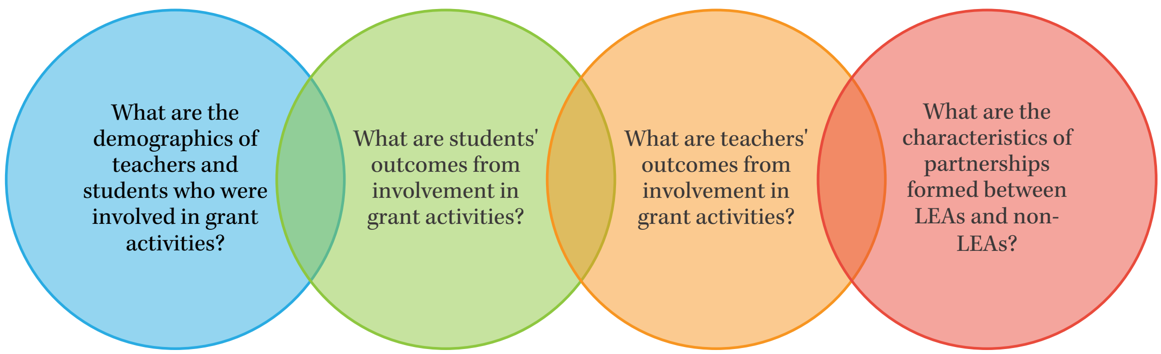
The current evaluation seeks to understand the outcomes of students and teachers involved in grant activities as well as the quality and effectiveness of computing partnerships forged between LEAs and post-secondary institutions, industry, and community organizations. This evaluation is being performed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

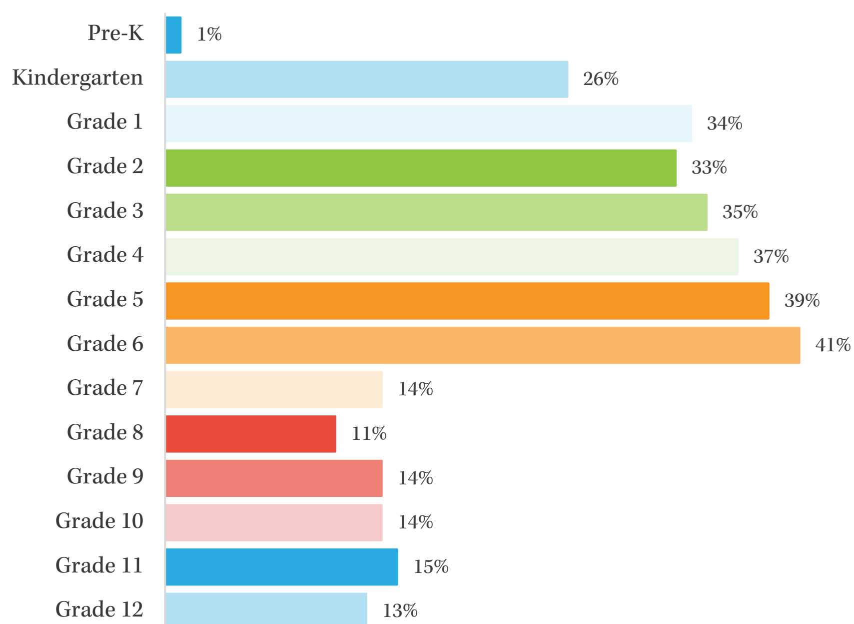
Table 1. Local Education Agencies and Number of Participants

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%).

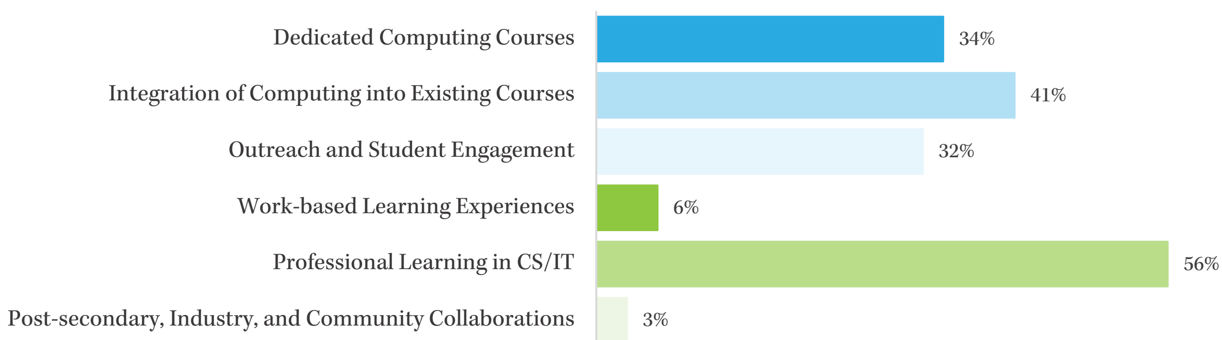
Figure 3. Grade Levels Taught by Teachers



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

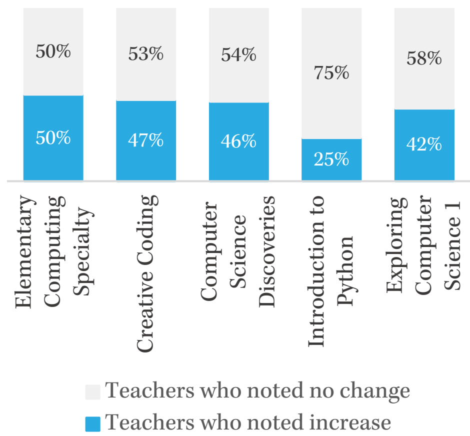


Figure 6. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Interest

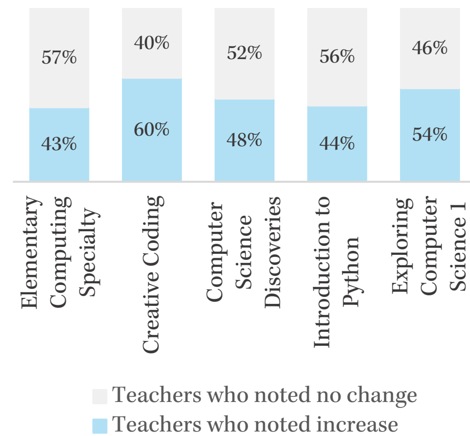


Figure 7. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Engagement

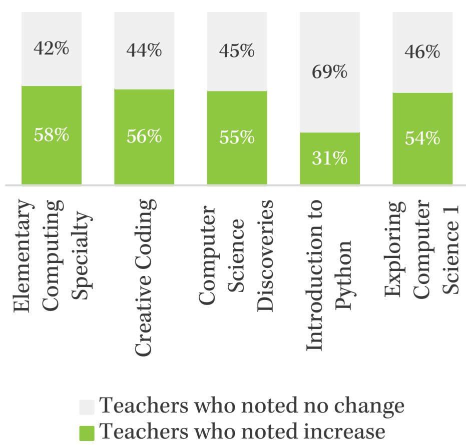


Figure 8. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Skills

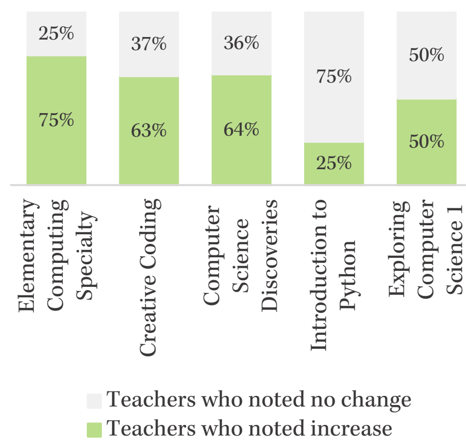
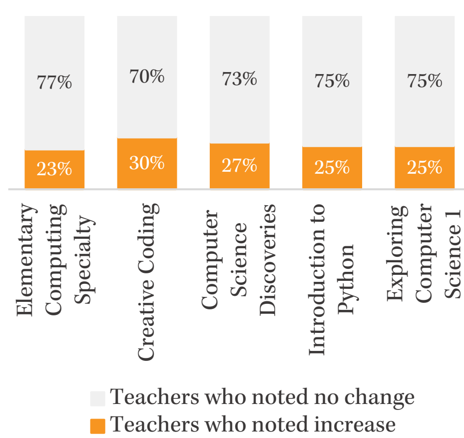


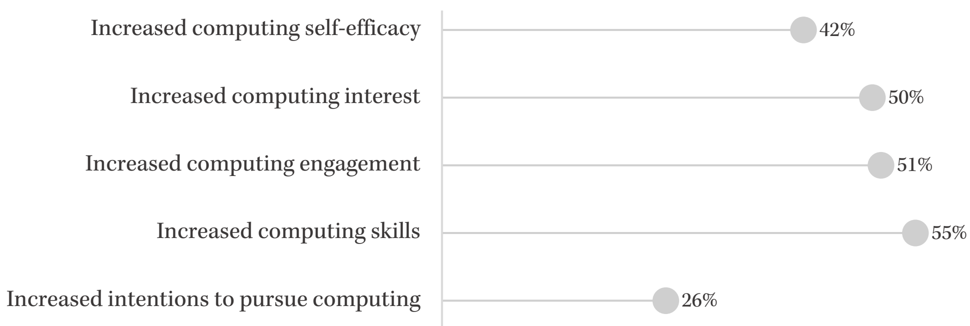
Figure 9. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Intentions to Pursue Computing



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

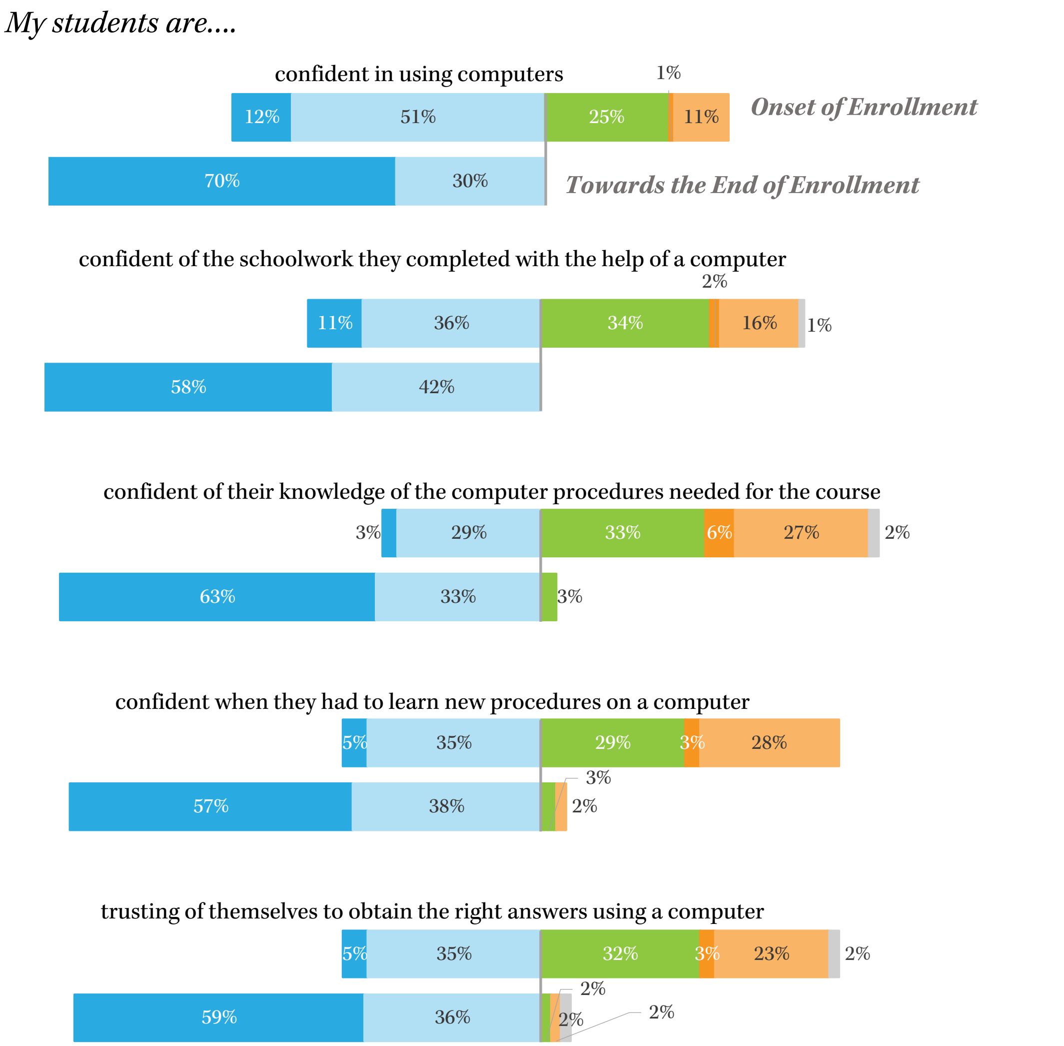


Figure 12. Teachers' Perceptions of Students' Computing Interest at the Start and End of Enrollment

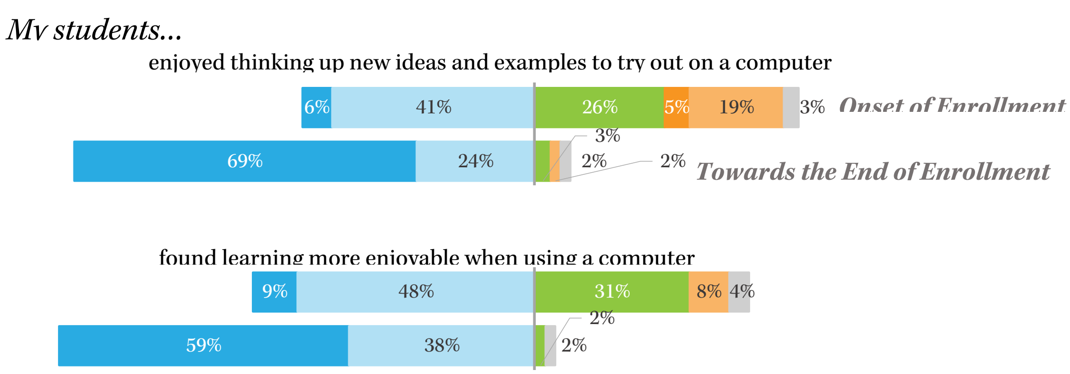


Figure 13. Teachers' Perceptions of Students' Computing Engagement at the Start and End of Enrollment

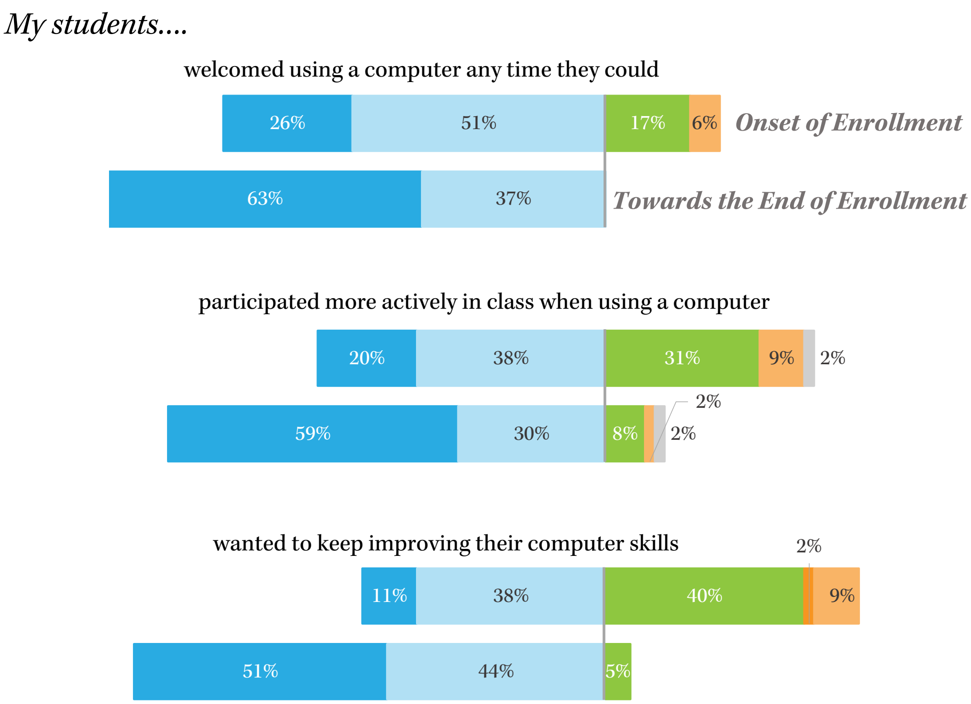


Figure 14. Teachers' Perceptions of Students' Cognitive Skills in Computing at the Start and End of Enrollment

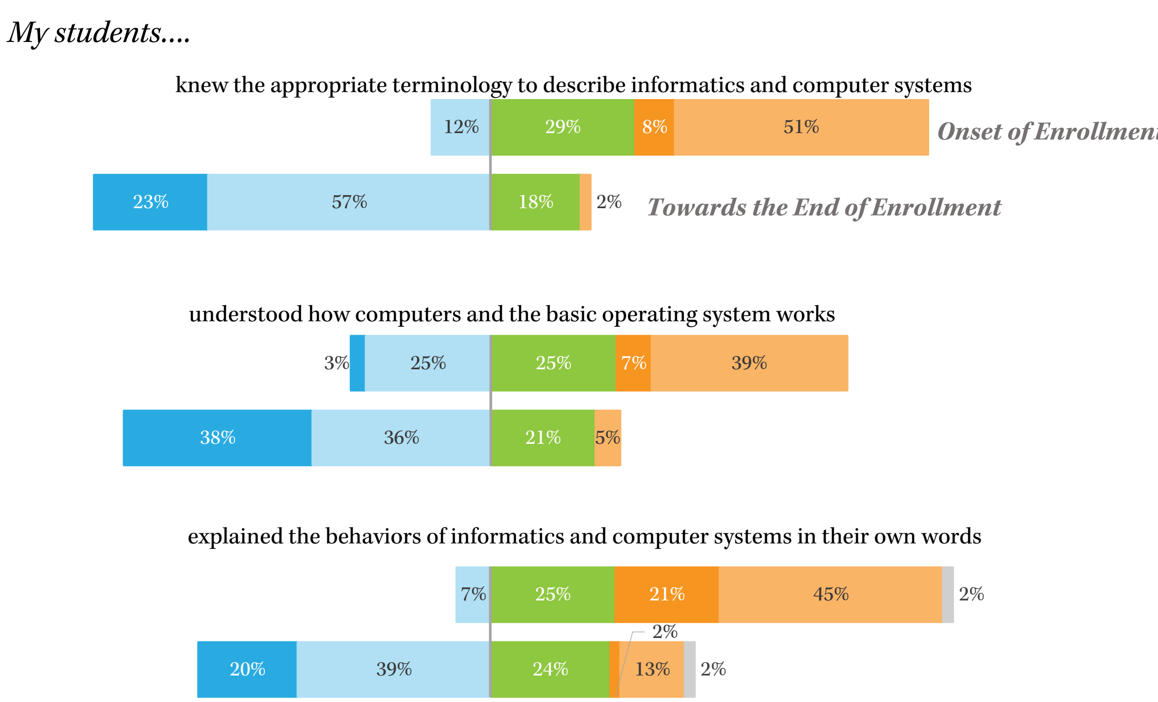


Figure 15. Teachers' Perceptions of Students' Technical Skills in Computing at the Start and End of Enrollment

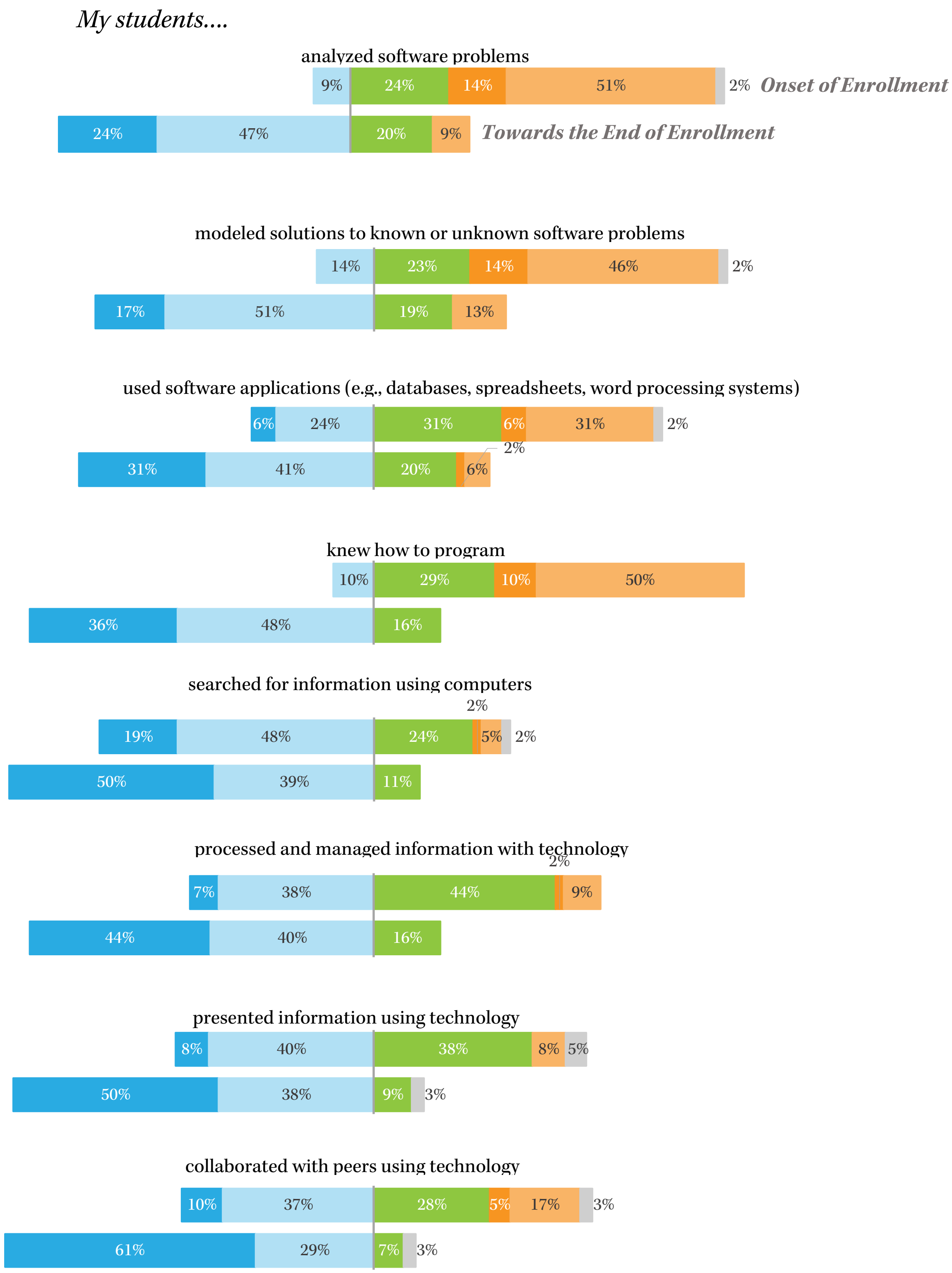
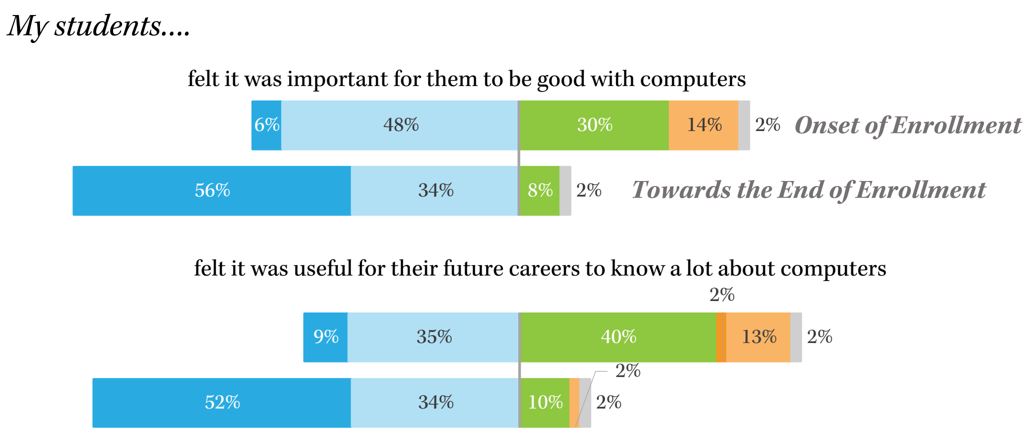


Figure 16. Teachers' Perceptions of Students' Intentions to Pursue Computing at the Start and End of Enrollment



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

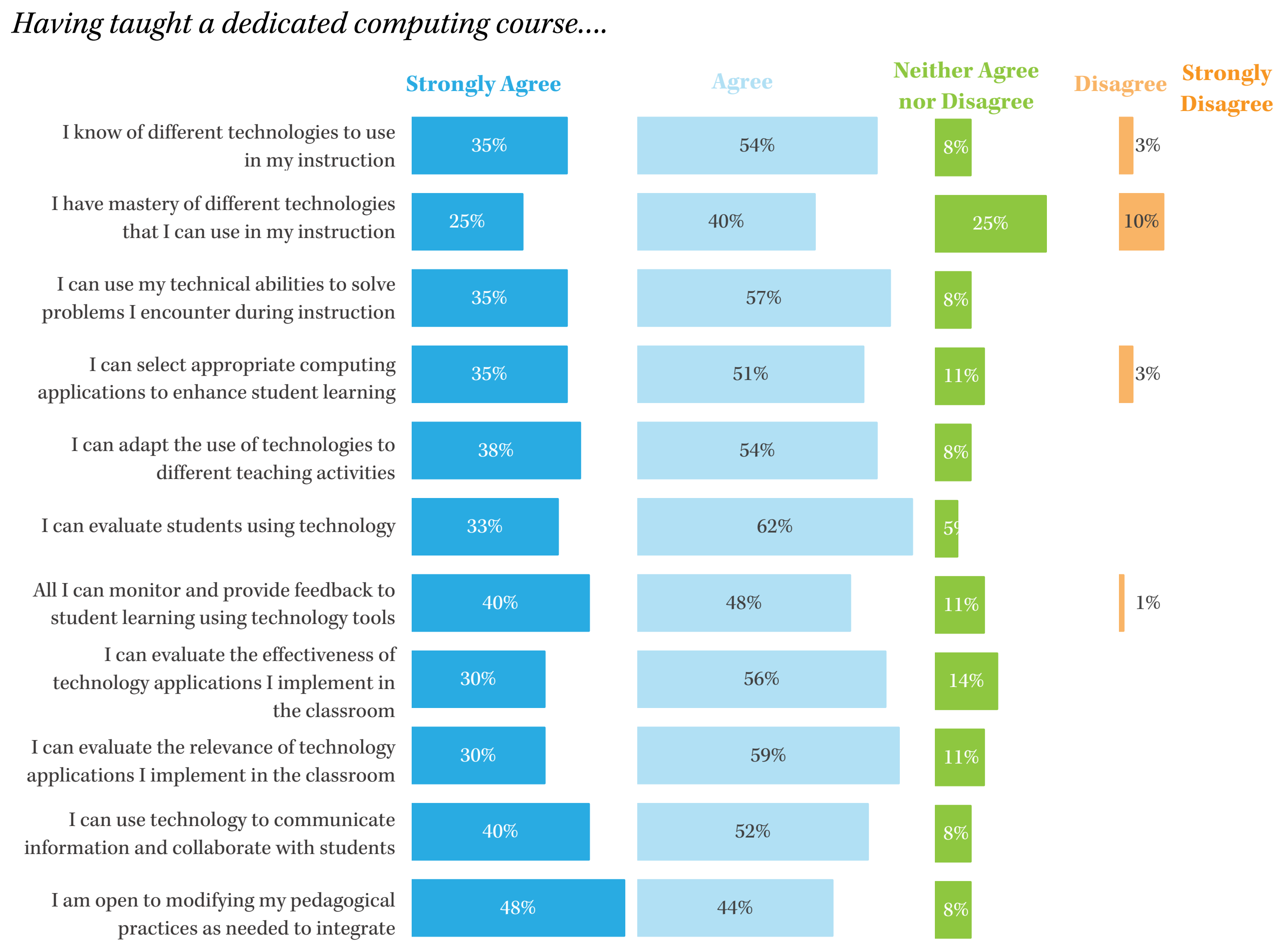


Figure 18. Teachers' Perceptions of the Impact of Dedicated Computing Courses on their Views about Equity and Access in Computing

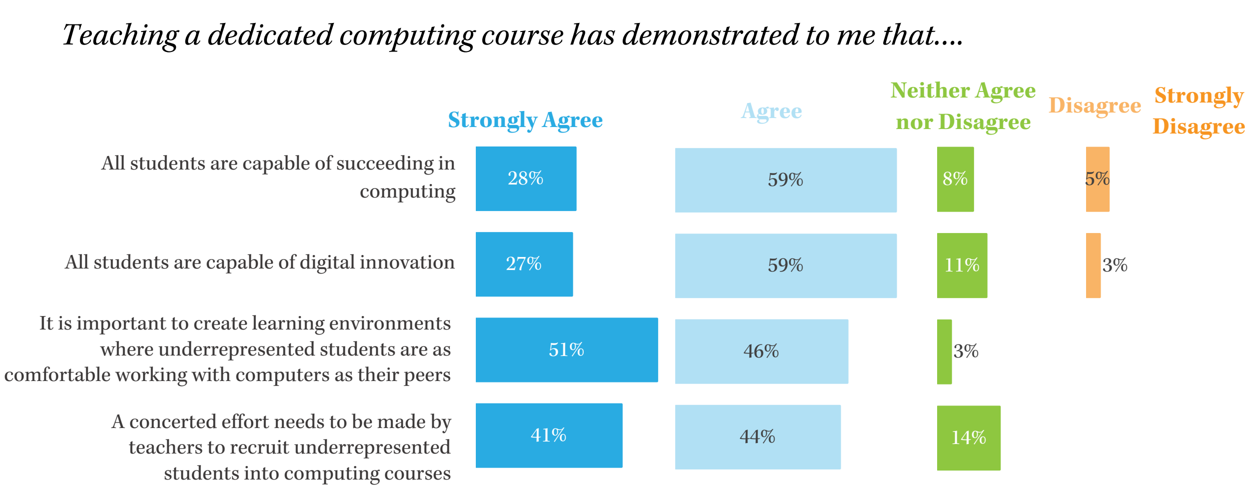


Figure 19. Teachers' Perceptions of the Impact of Dedicated Computing Courses on their Views About Teaching That Integrates Computing

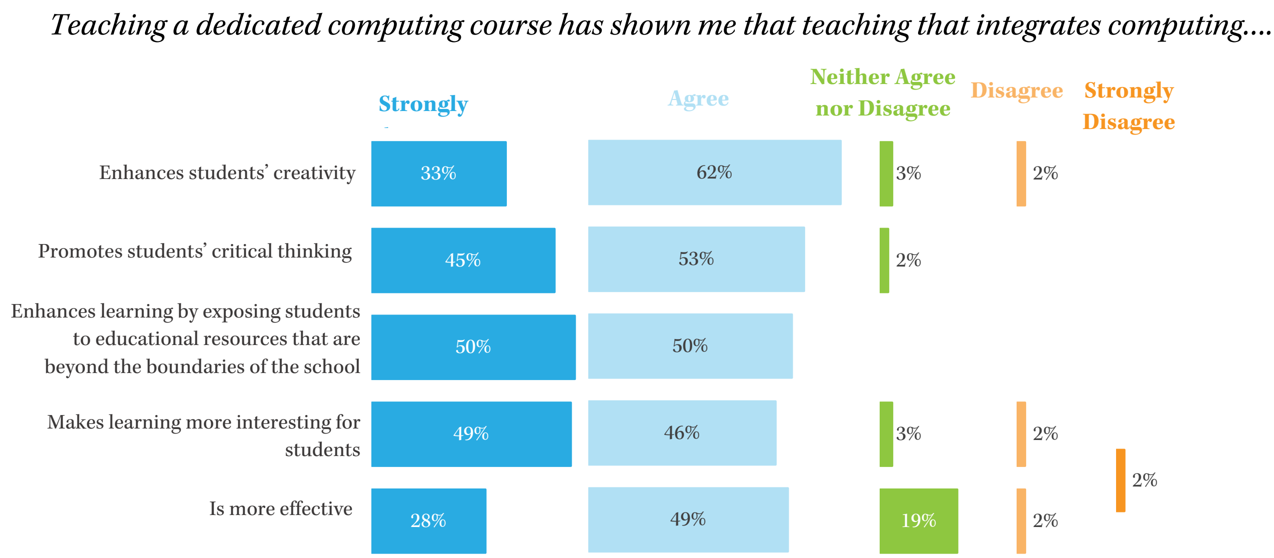


Figure 20. Teachers' Perceptions of the Impact of Dedicated Computing Courses on their Use of Project-Based and Experiential Pedagogy

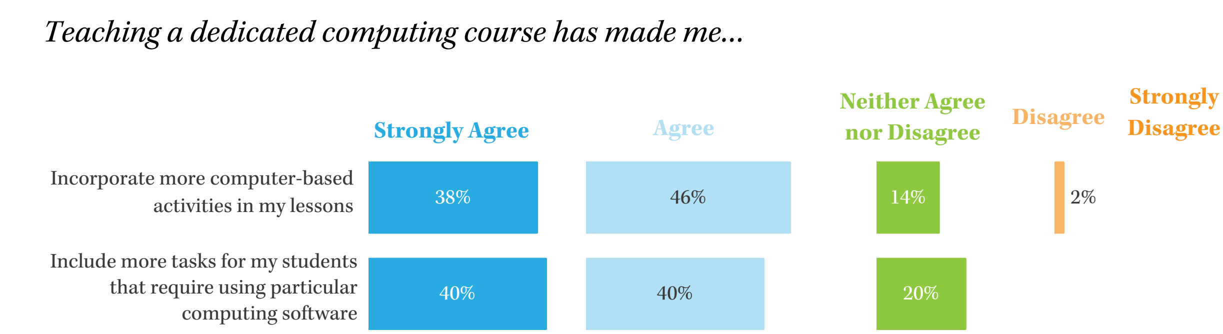
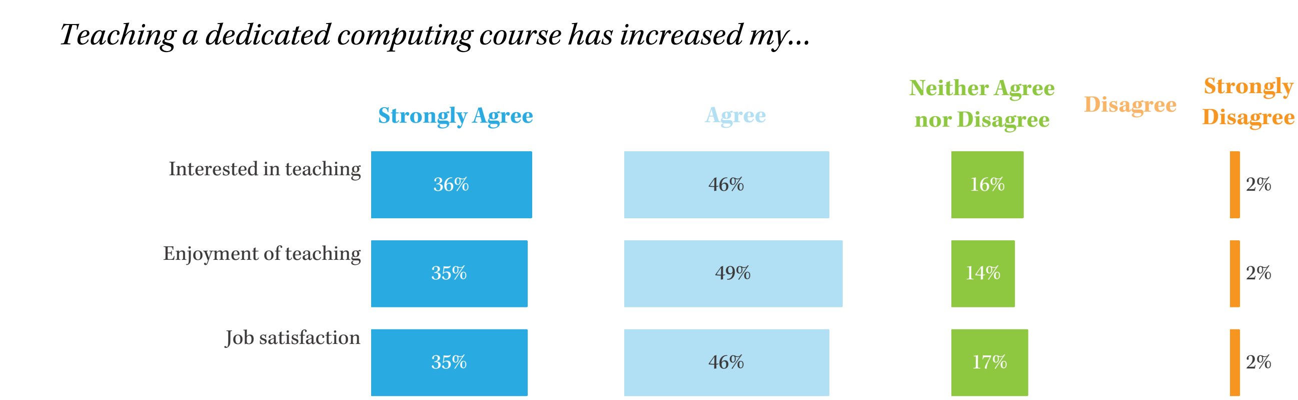


Figure 21. Teachers' Perceptions of the Impact of Dedicated Computing Courses on Their Teaching Attitudes



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

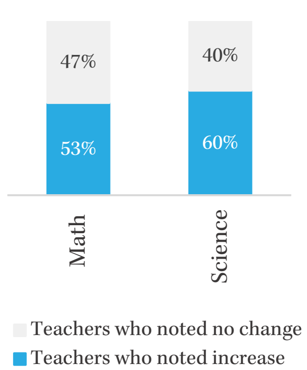


Figure 23. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Interest

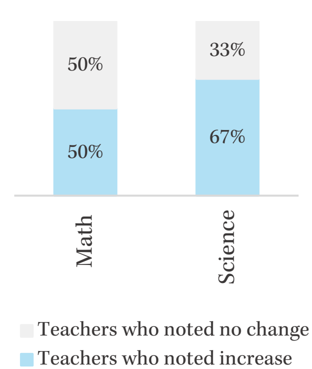


Figure 24. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Engagement

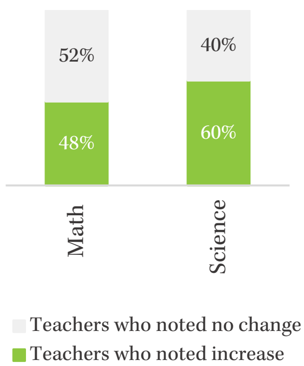


Figure 25. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Skills

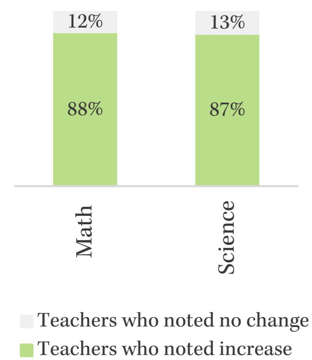
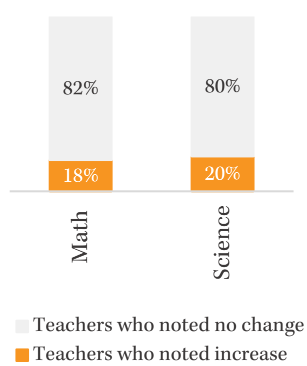


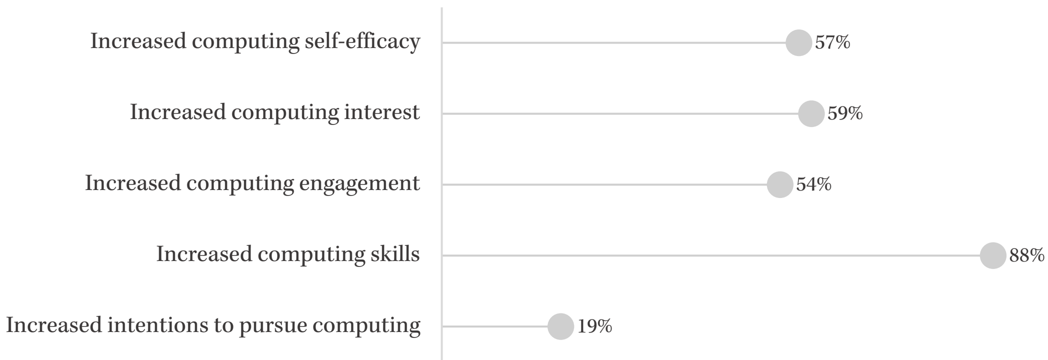
Figure 26. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Intentions to Pursue Computing



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

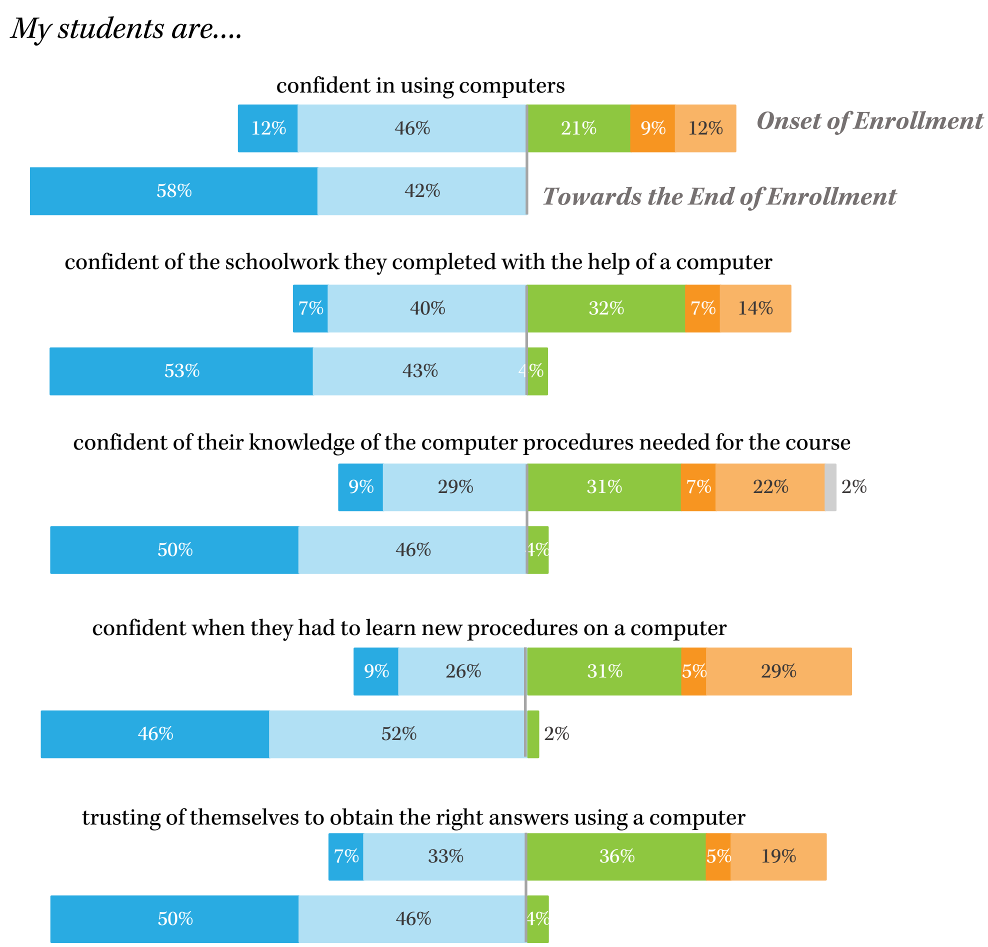


Figure 29. Teachers' Perceptions of Students' Computing Interest at the Start and End of Enrollment

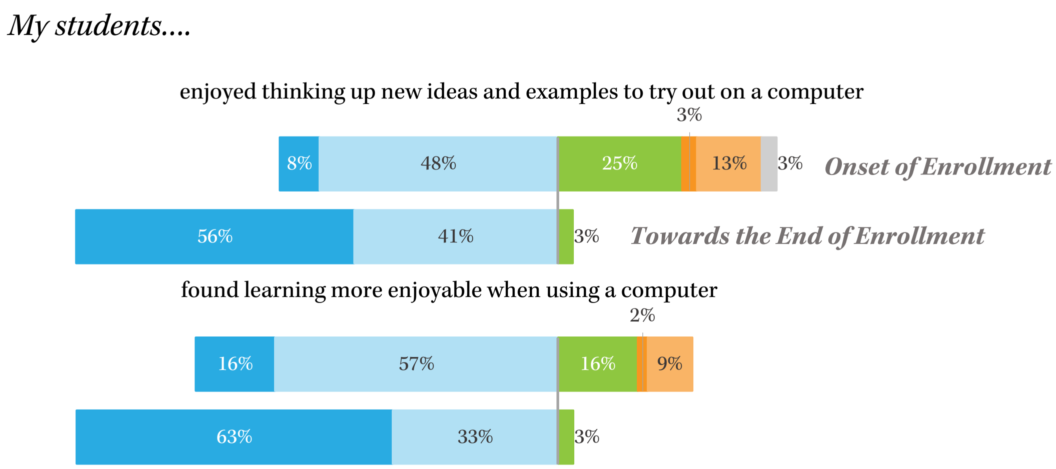


Figure 30. Teachers' Perceptions of Students' Computing Engagement at the Start and End of Enrollment

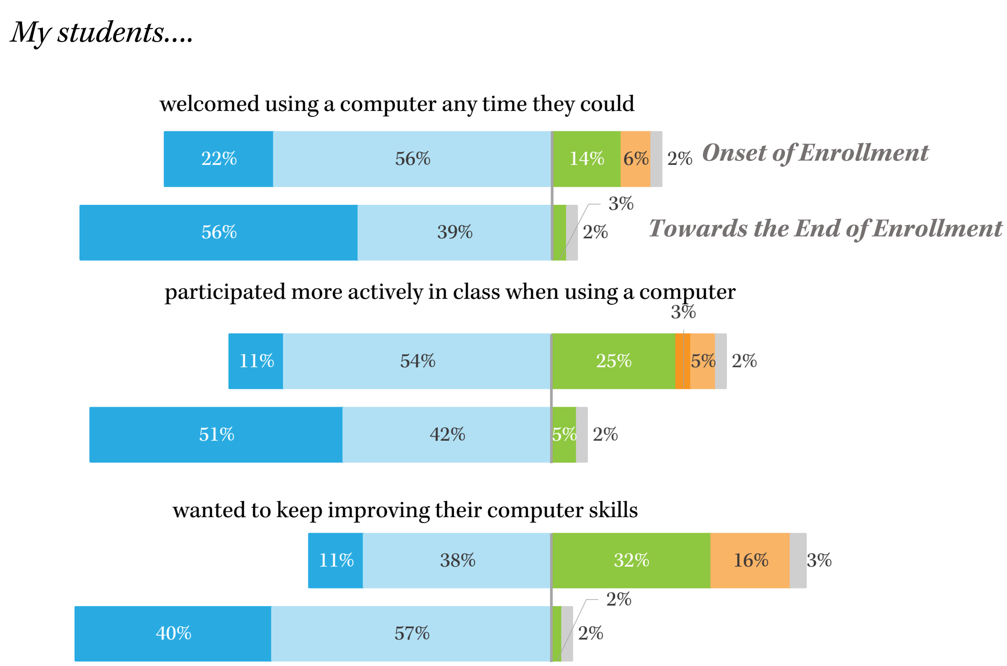


Figure 31. Teachers' Perceptions of Students' Cognitive Skills in Computing at the Start and End of Enrollment

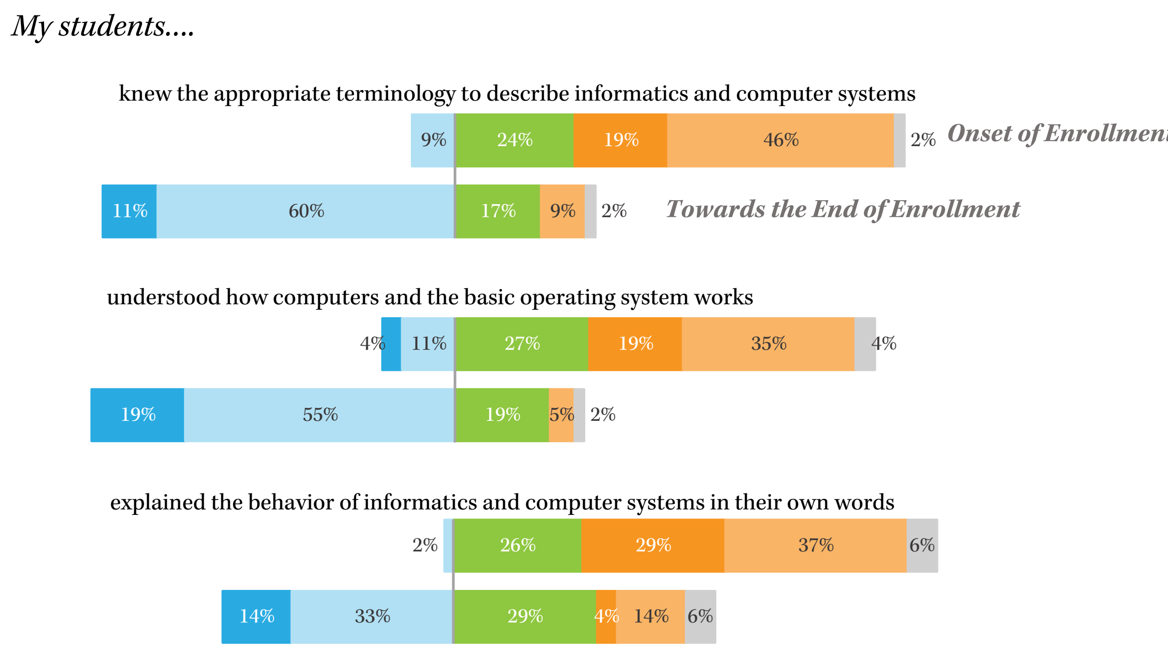


Figure 32. Teachers' Perceptions of Students' Intentions to Pursue Computing at the Start and End of Enrollment

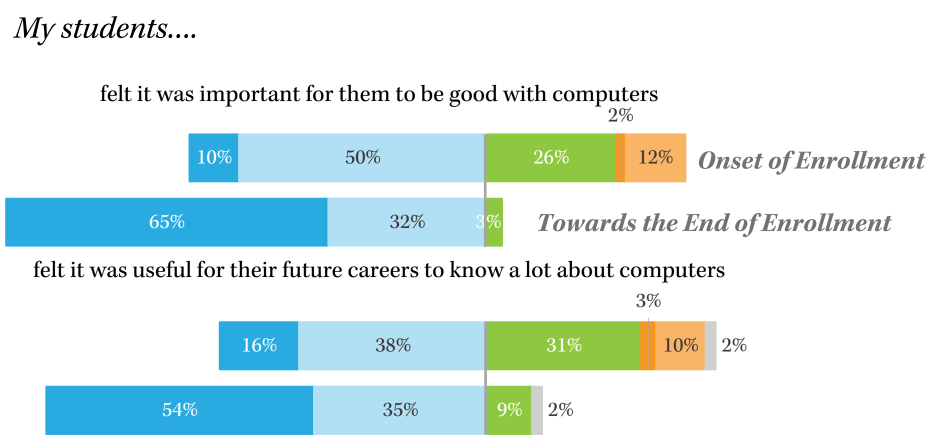
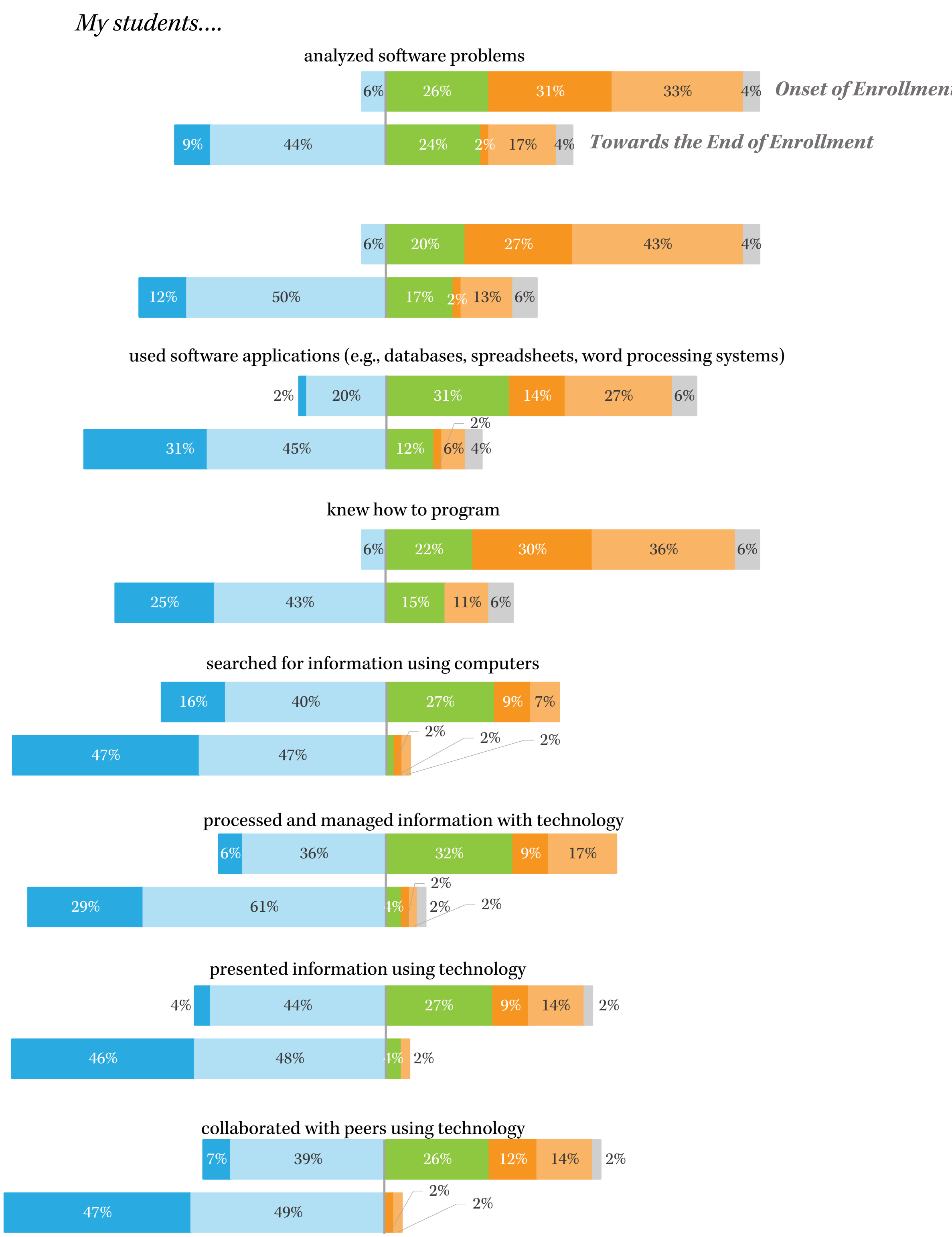


Figure 33. Teachers' Perceptions of Students' Technical Skills in Computing at the Start and End of Enrollment



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

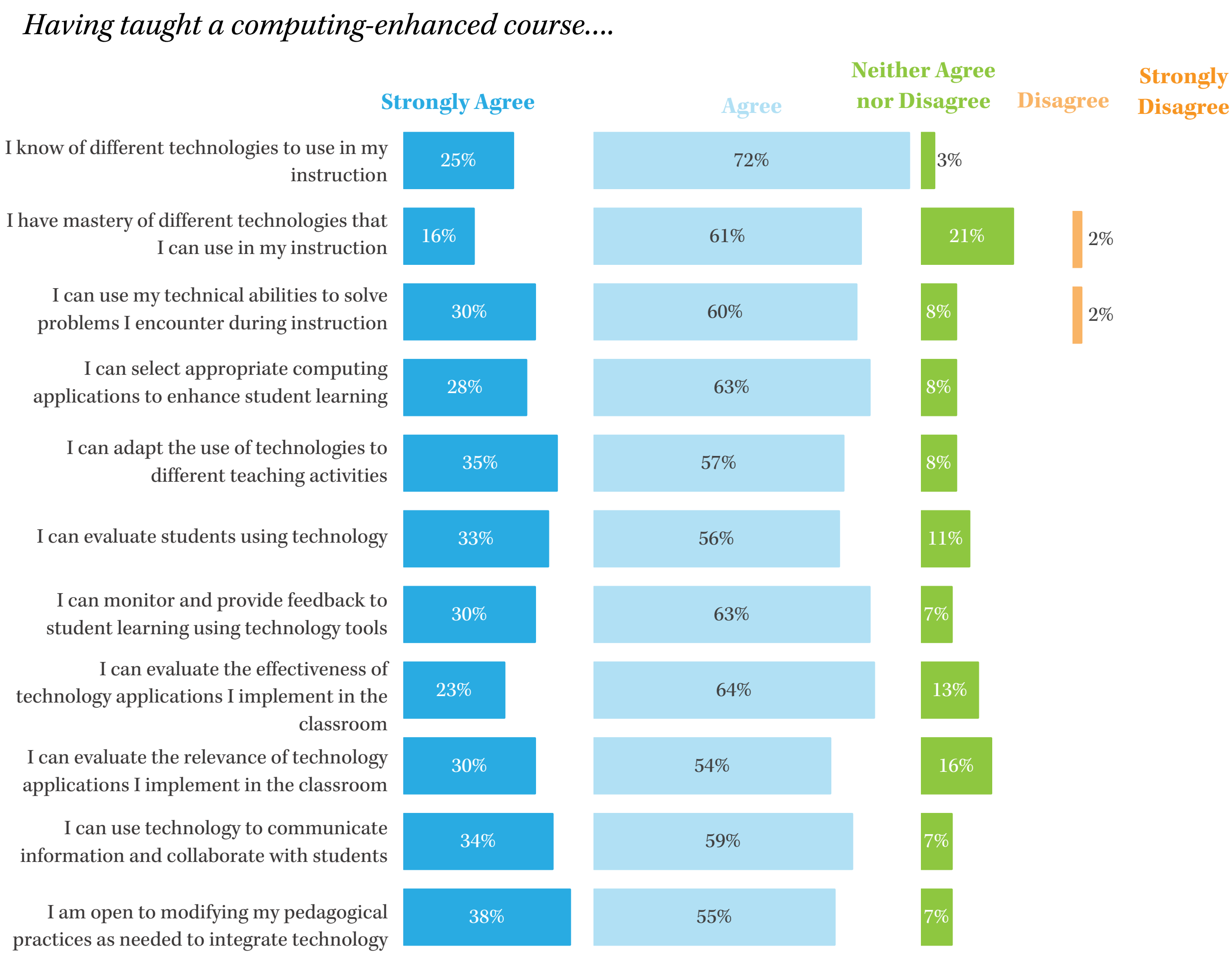


Figure 35. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on their Computing Confidence

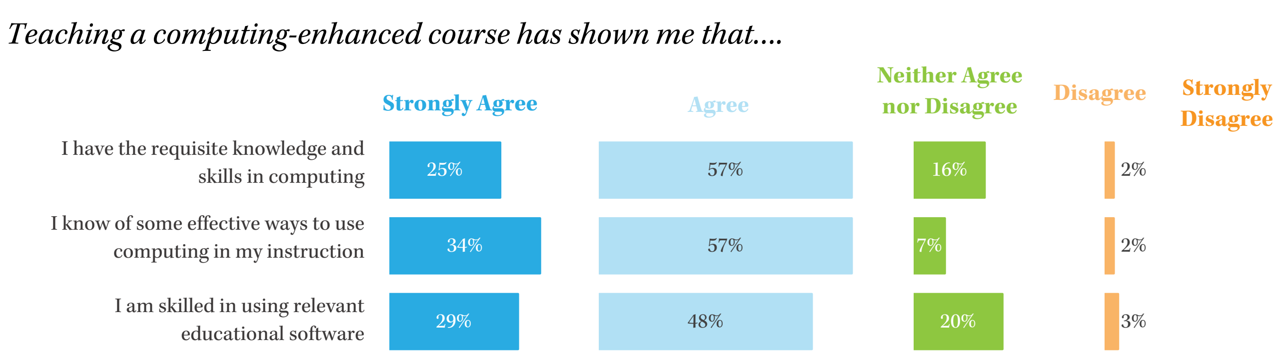


Figure 36. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on their Views about Equity and Access in Computing

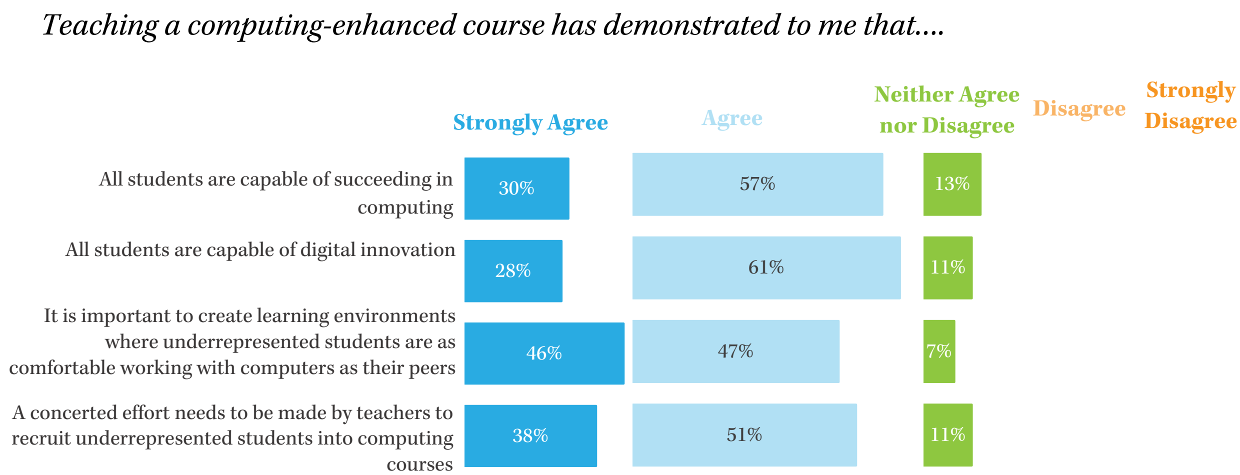


Figure 37. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on their Views About Teaching That Integrates Computing

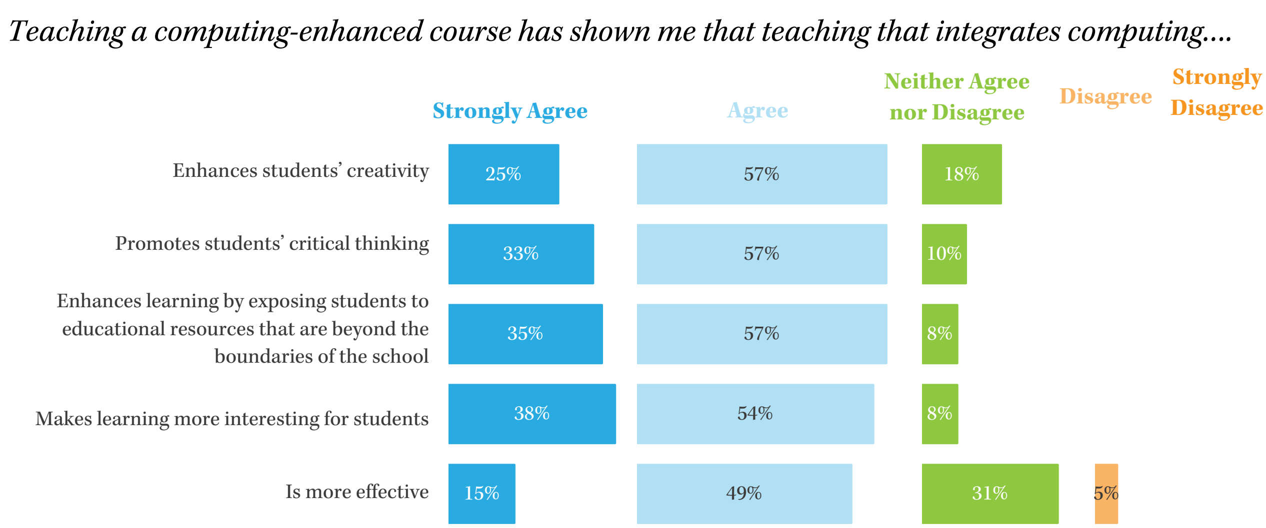


Figure 38. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on their Use of Project-Based and Experiential Pedagogy

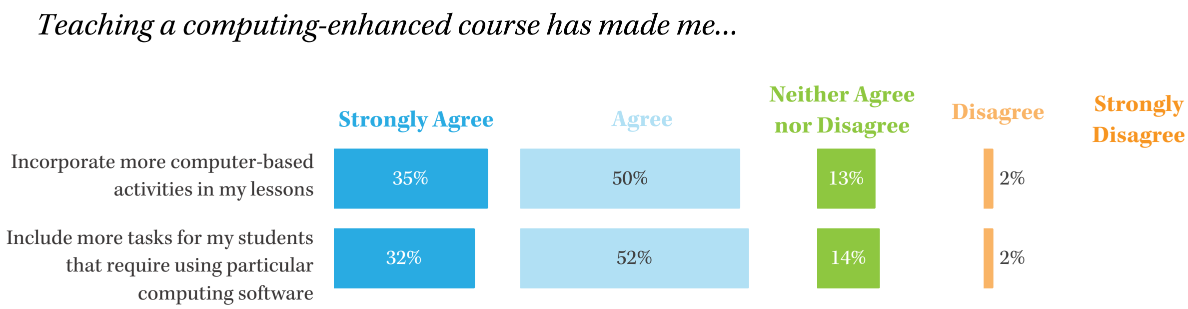
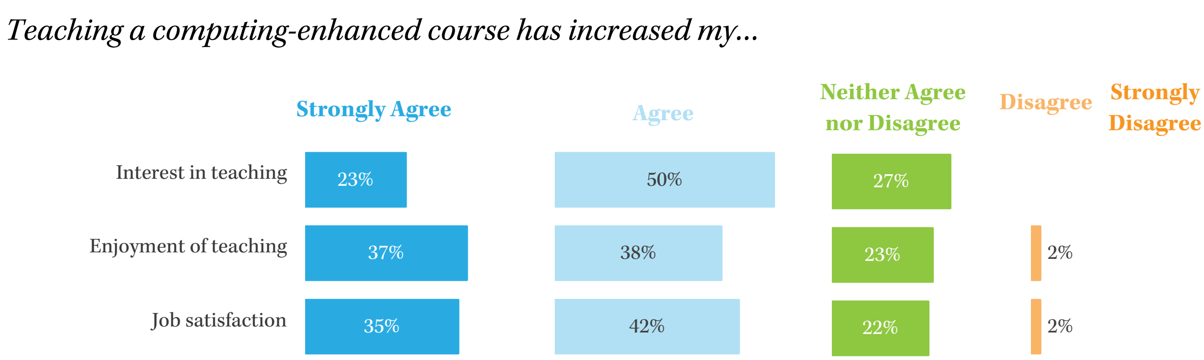


Figure 39. Teachers' Perceptions of the Impact of Computing-Enhanced Courses on Their Teaching Attitudes



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

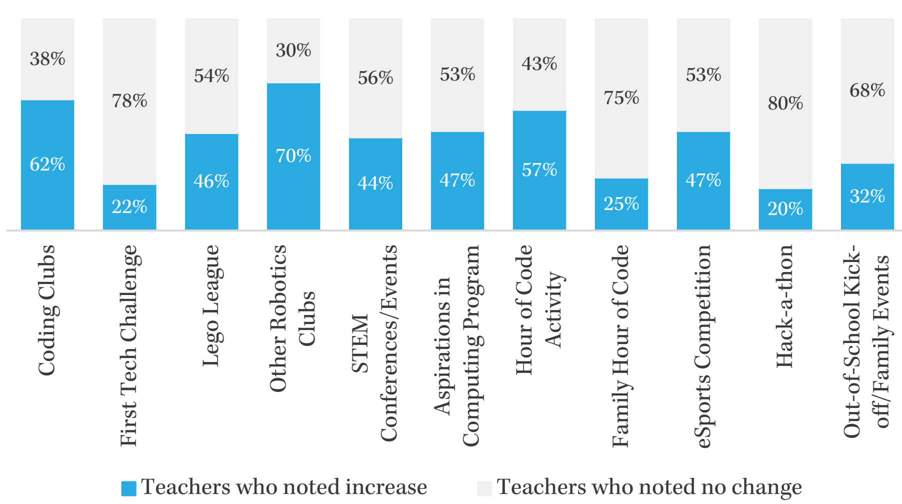


Figure 41. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Interest

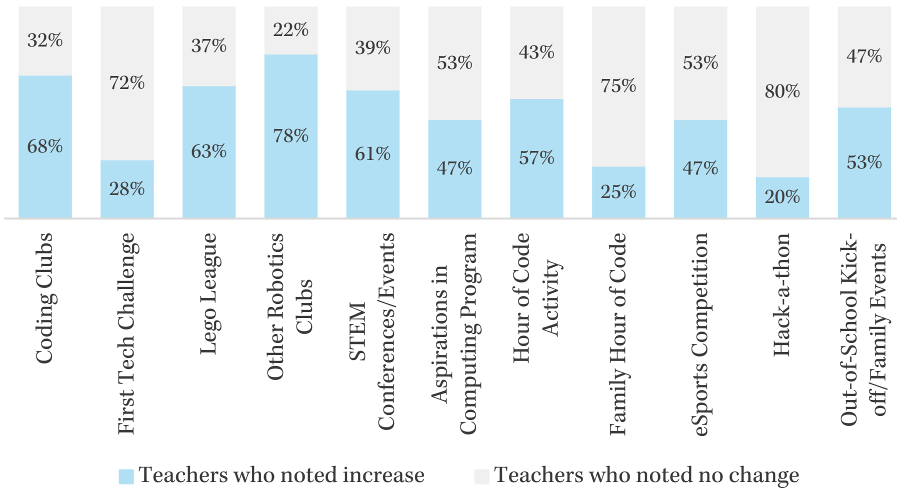


Figure 42. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Engagement

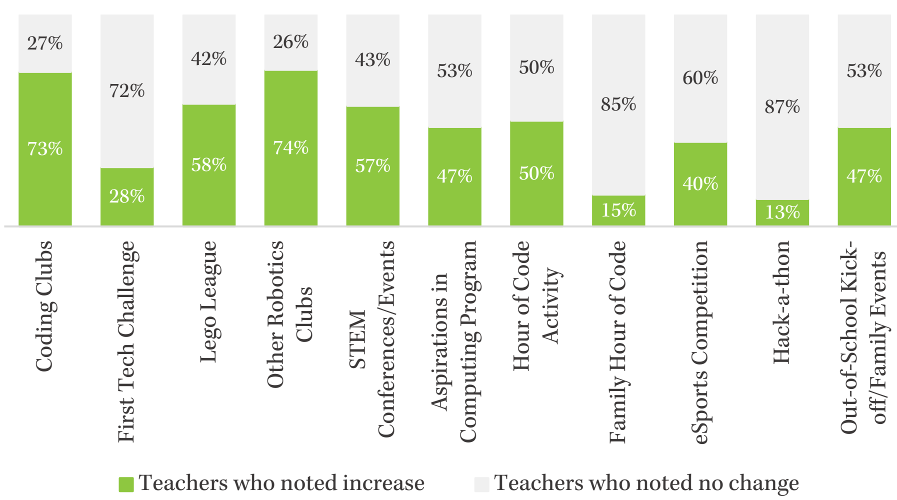


Figure 43. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Computing Skills

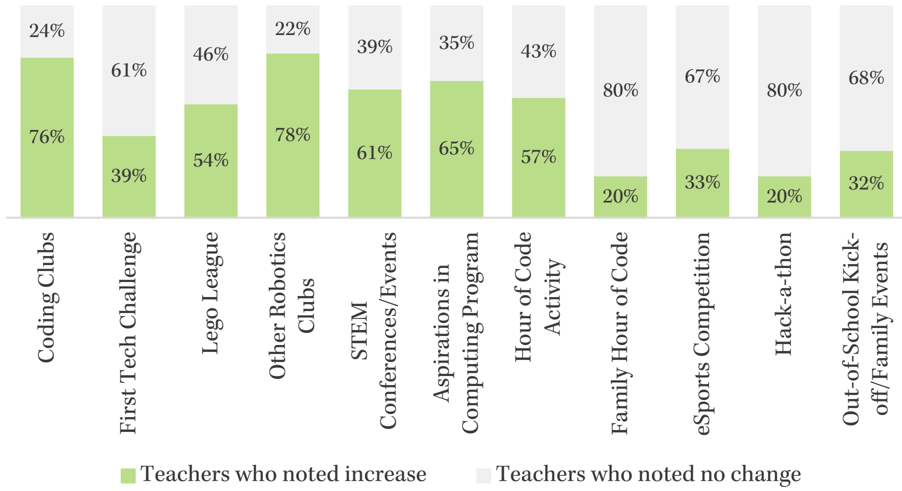
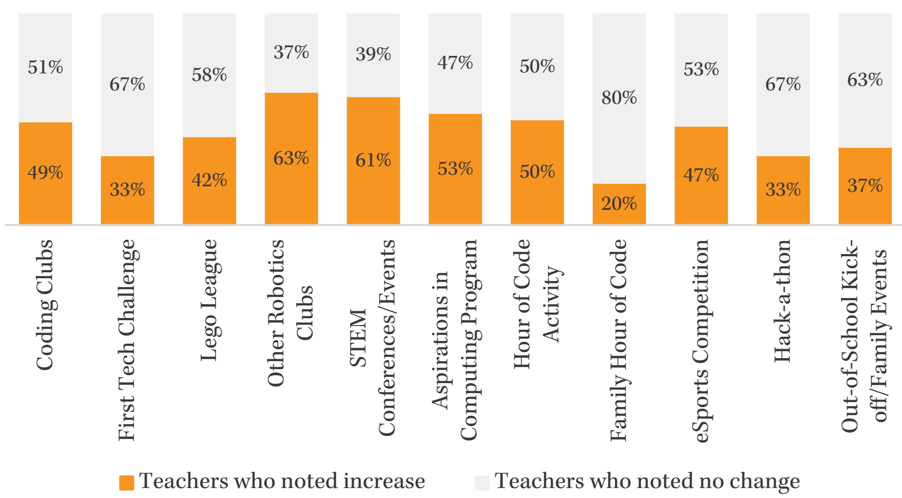


Figure 44. Percent of Teachers Who Did or Did Not Observe an Increase in Students' Intentions to Pursue Computing



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

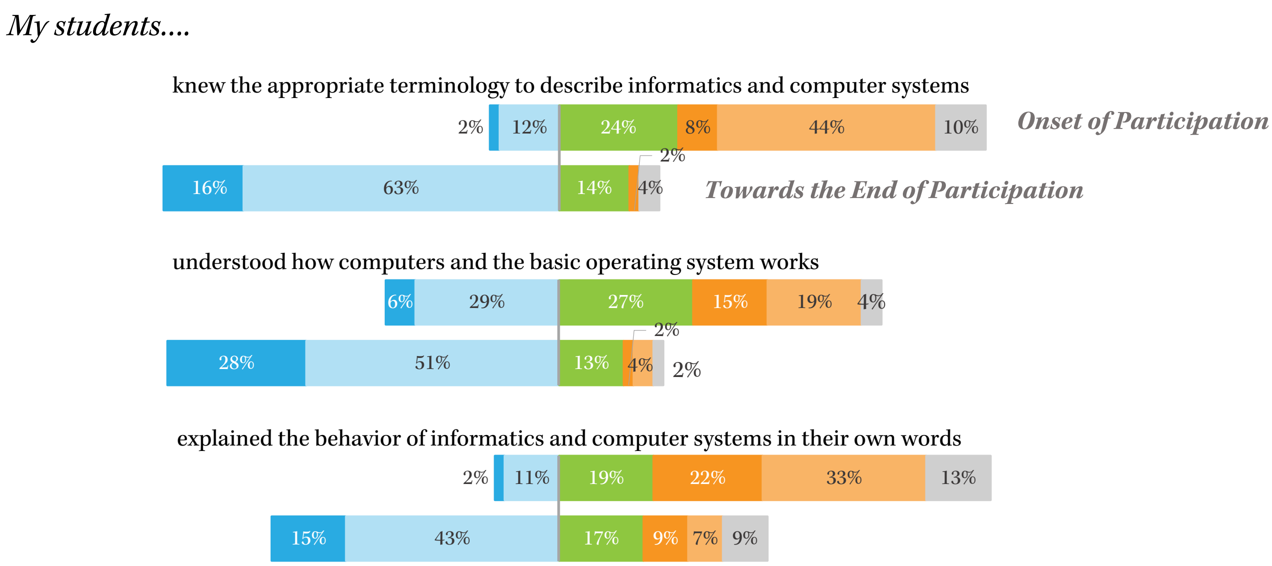


Figure 47. Teachers' Perceptions of Students' Intentions to Pursue Computing at the Start and End of Participation

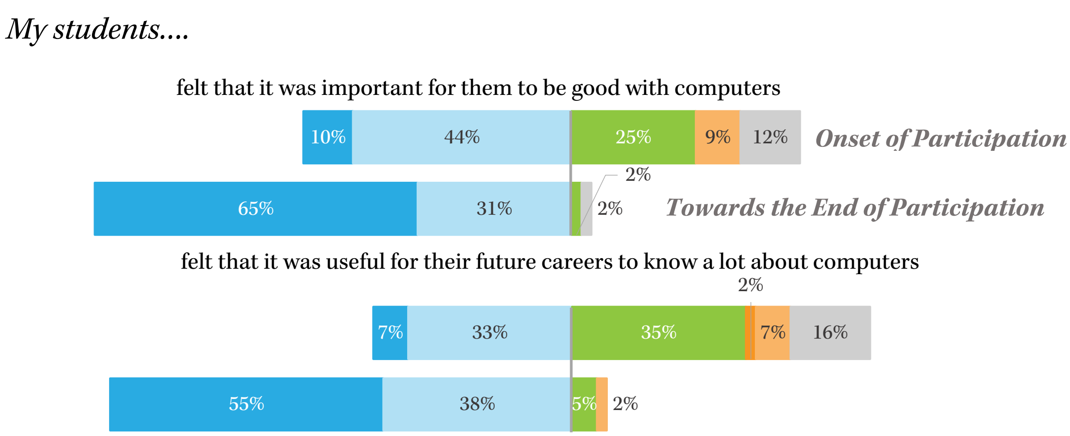
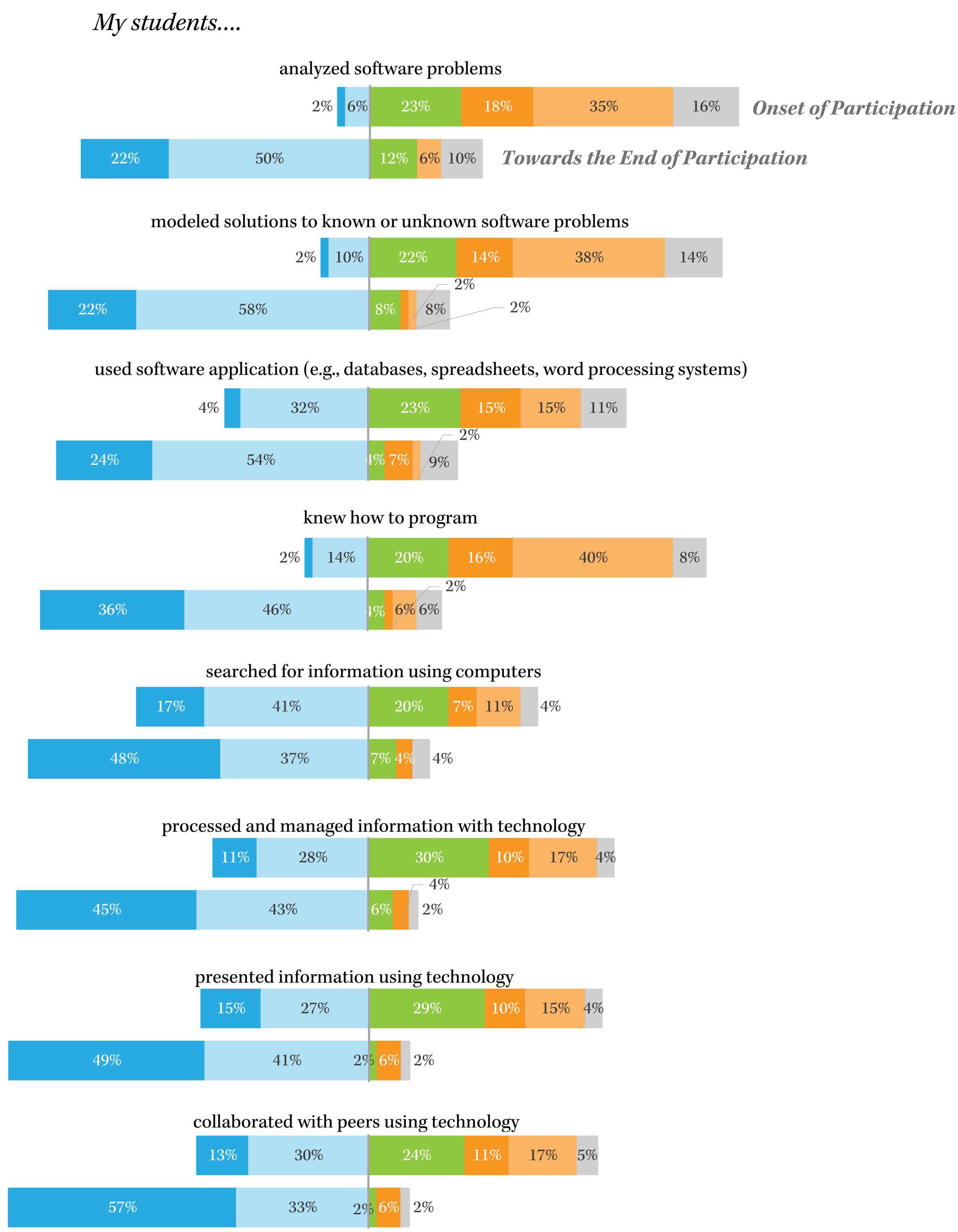


Figure 48. Teachers' Perceptions of Students' Technical Skills in Computing at the Start and End of Participation

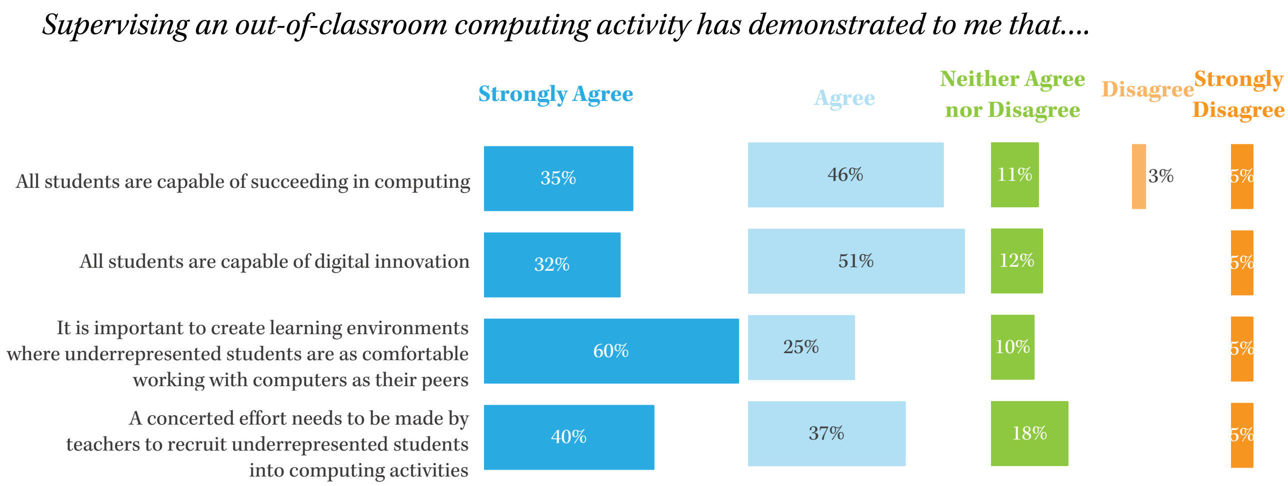


Key Findings on Teacher Outcomes

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

Theme	Teacher Responses
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

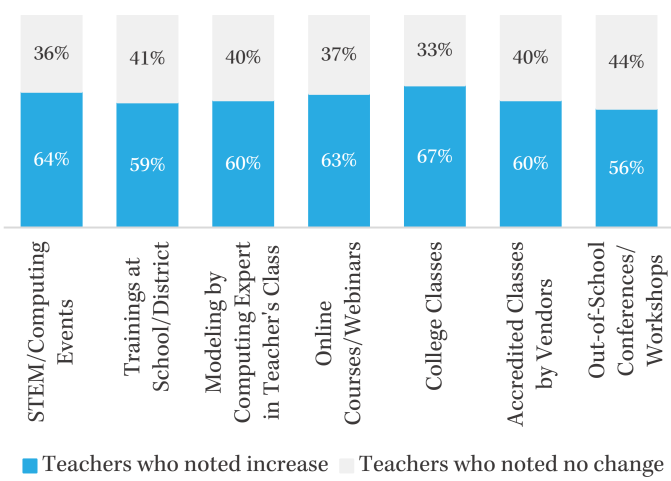


Figure 51. Percent of Teachers Who Did or Did Not Observe an Increase in Their Awareness About the Importance of Teaching Computing

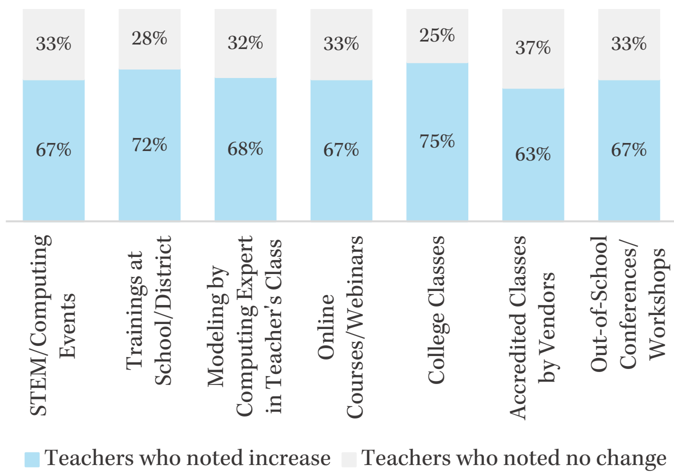


Figure 52. Percent of Teachers Who Did or Did Not Observe an Increase in Their Confidence to Teach Computing

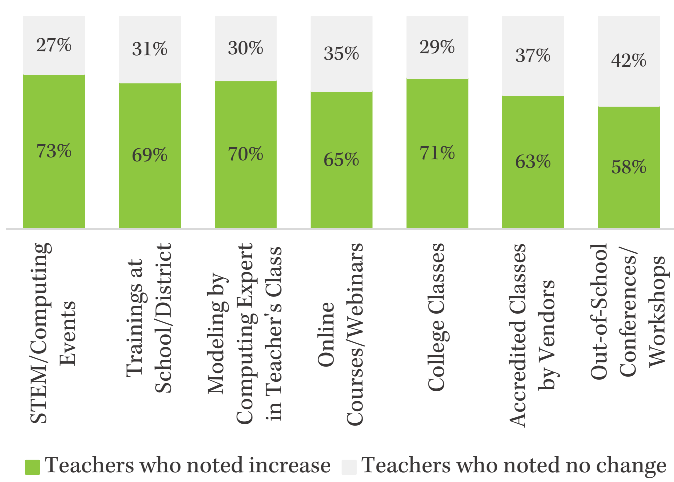


Figure 53. Percent of Teachers Who Did or Did Not Observe an Increase in Their Use of Project-Based and Experiential Pedagogies

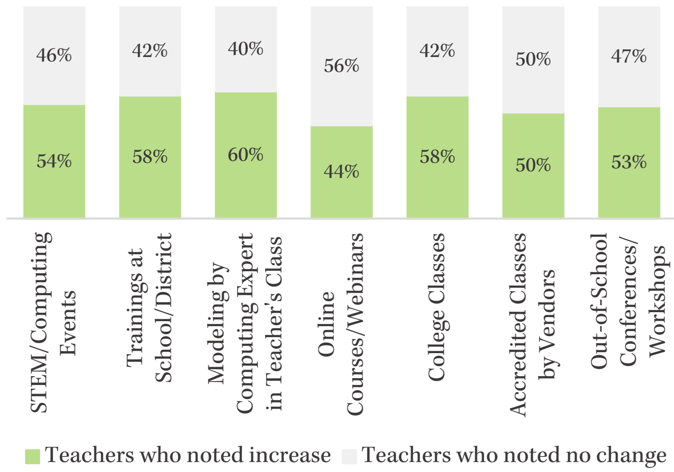


Figure 54. Percent of Teachers Who Did or Did Not Observe an Increase in Their Integration of Computing in Non-Computing Courses

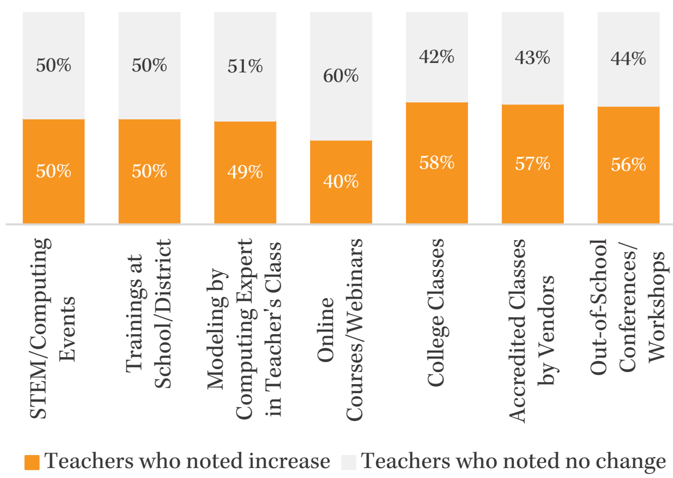
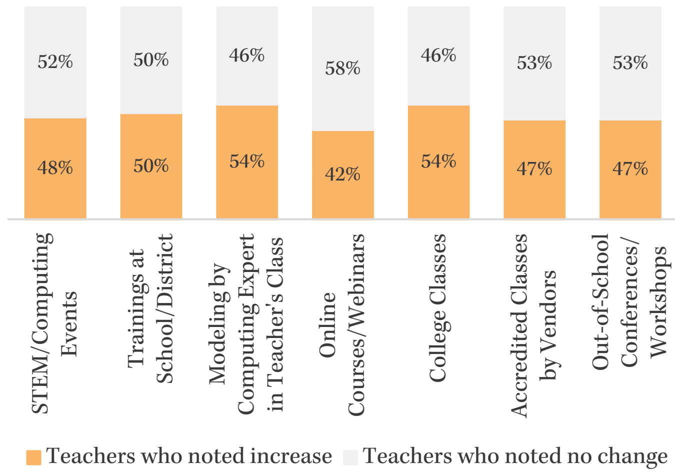


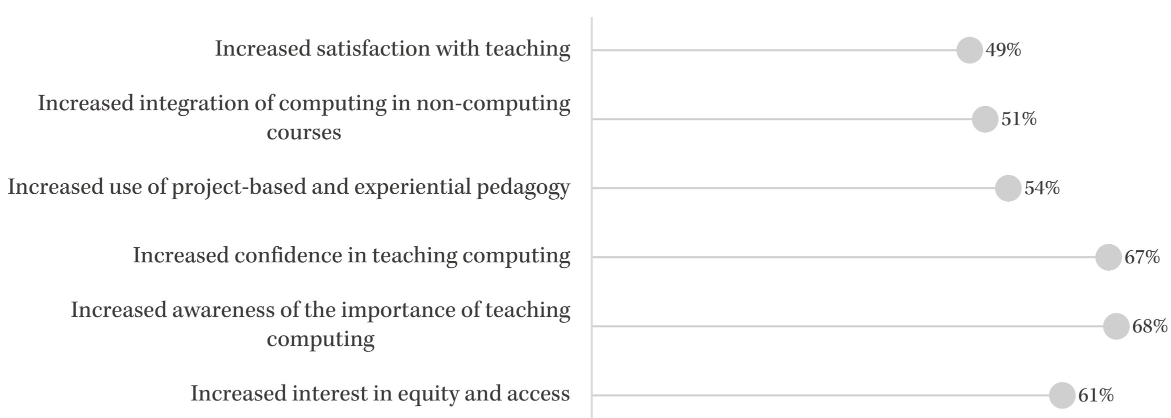
Figure 55. Percent of Teachers Who Did or Did Not Observe an Increase in Their Satisfaction with Teaching



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

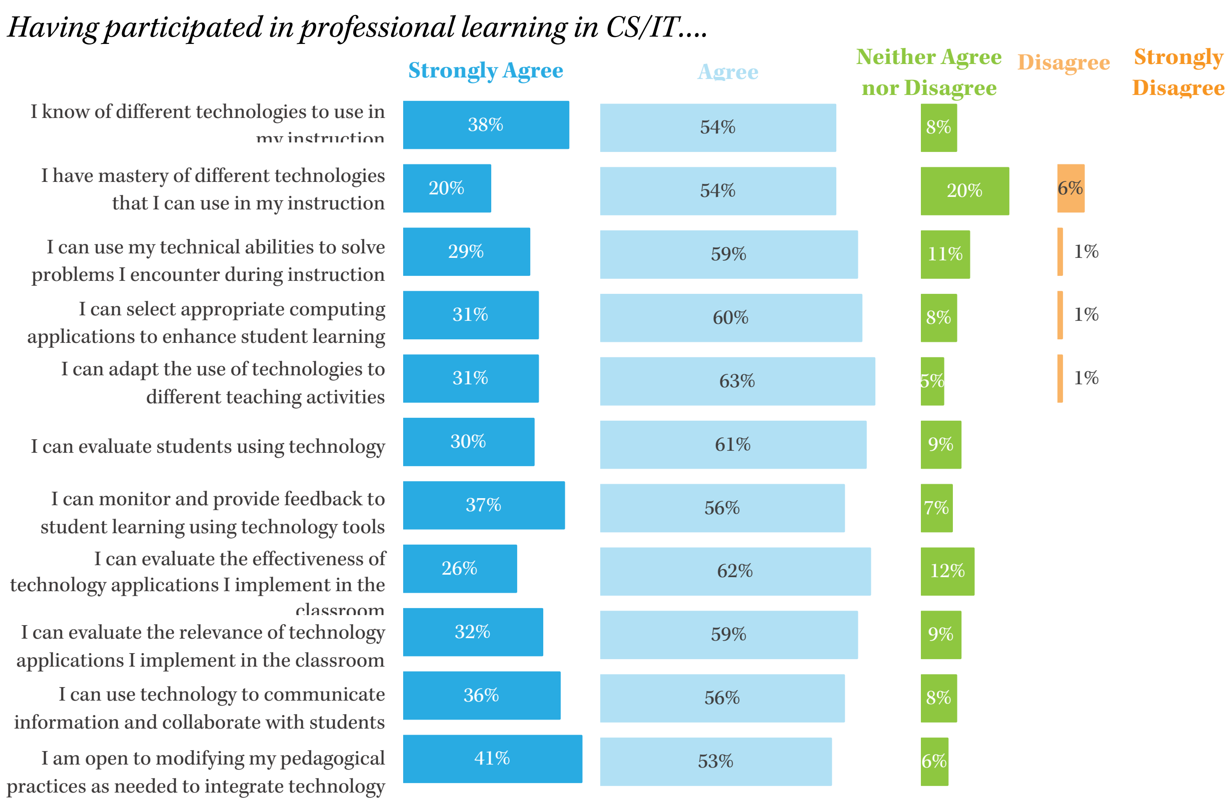


Figure 58. Teachers' Perceptions of the Impact of Professional Learning on their Views about Equity and Access in Computing

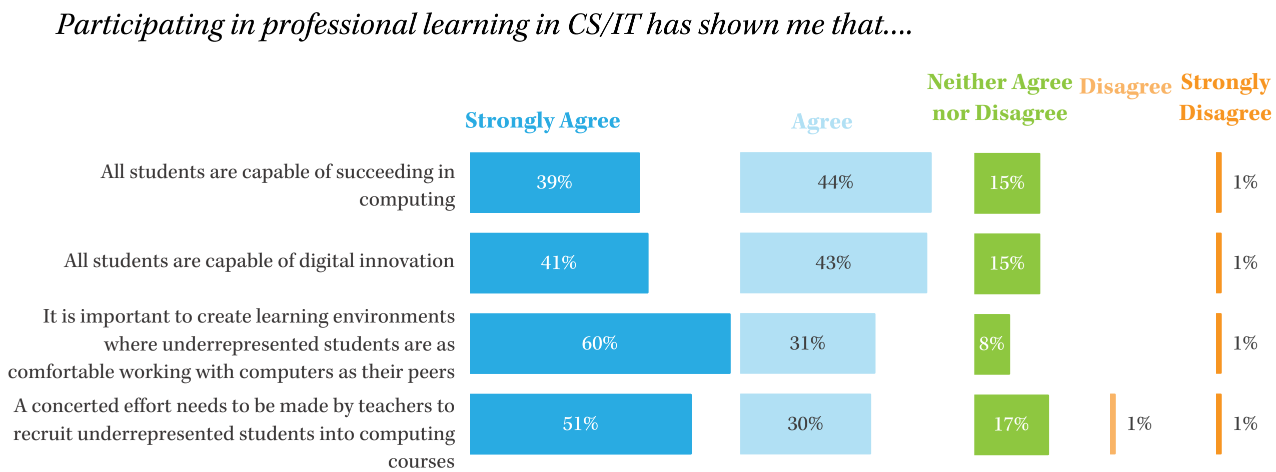


Figure 59. Teachers' Perceptions of the Impact of Professional Learning on their Views About Teaching That Integrates Computing

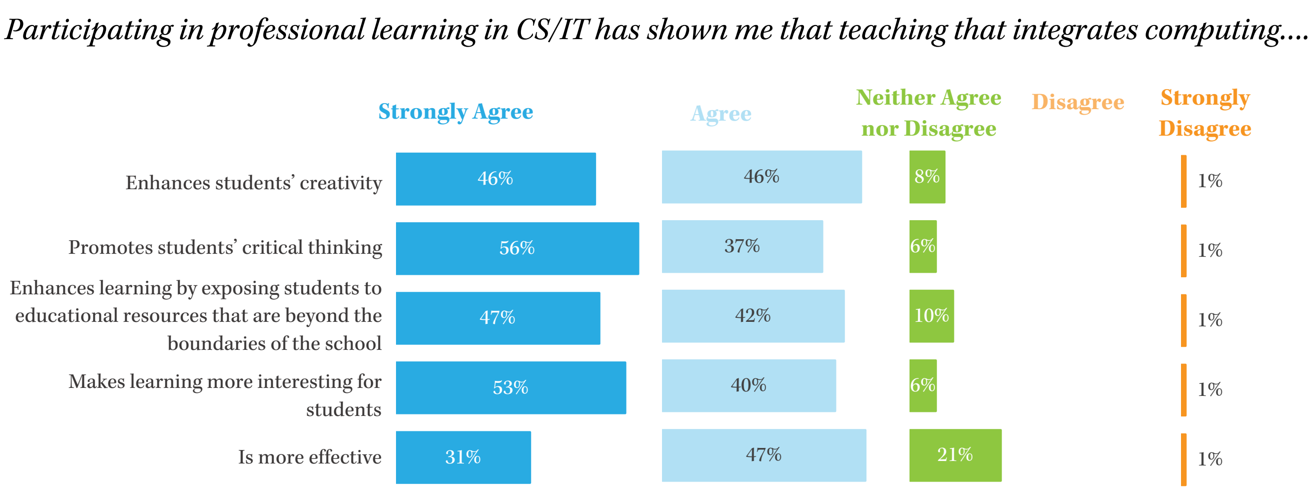


Figure 60. Teachers' Perceptions of the Impact of Professional Learning on their Use of Project-Based and Experiential Pedagogy

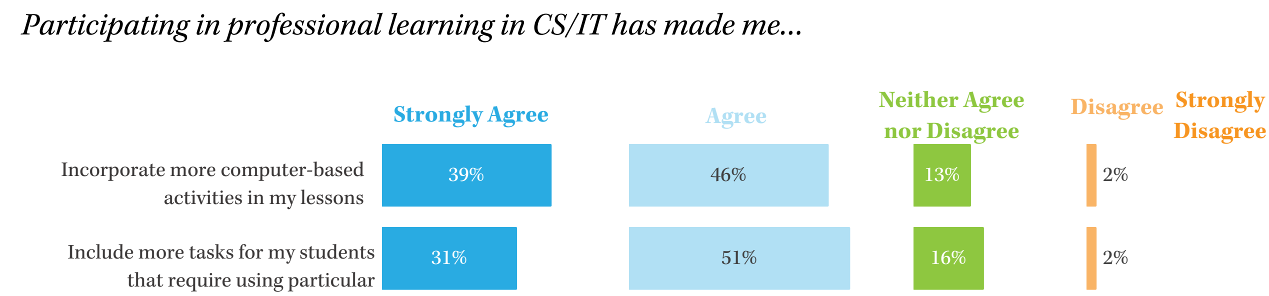


Figure 61. Teachers' Perceptions of the Impact of Professional Learning on Their Teaching Practice

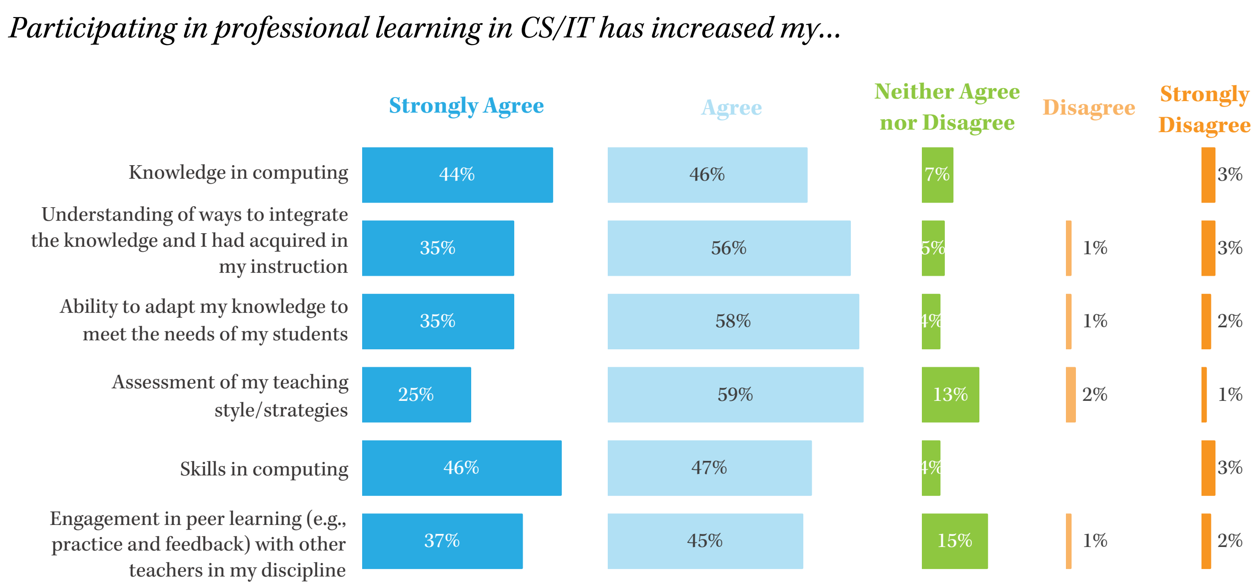
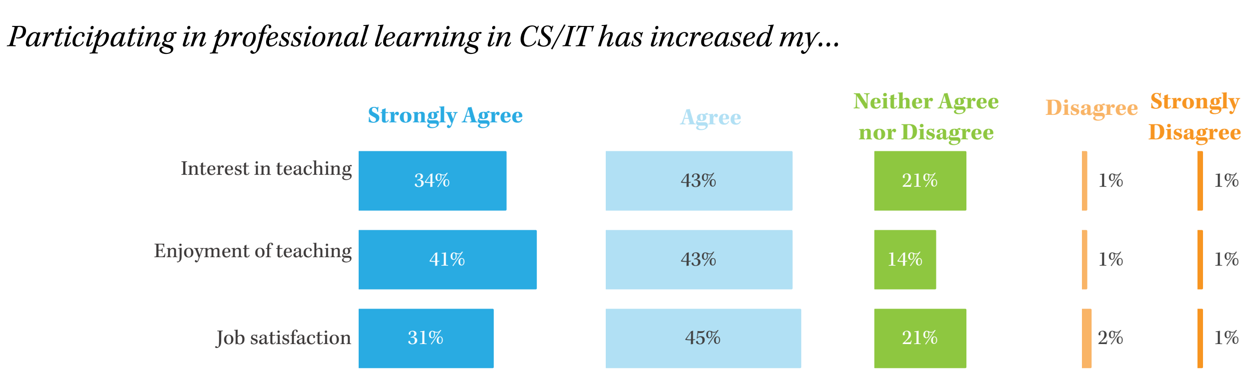


Figure 62. Teachers' Perceptions of the Impact of Professional Learning on Their Teaching Attitudes



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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THE UNIVERSITY OF UTAH
UTAH EDUCATION POLICY CENTER

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BROADENING PARTICIPATION IN COMPUTING IN UTAH

A Progress Report on the Computing Partnerships Grants Program

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

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Bridging Research, Policy, and Practice

The Utah Education Policy Center (UEPC) is an independent, non-partisan, not-for-profit research-based center at the University of Utah founded in the Department of Educational Leadership and Policy in 1990 and administered through the College of Education since 2007. The UEPC mission is to bridge research, policy, and practice in public schools and higher education to increase educational equity, excellence, access, and opportunities for all children and adults.

The UEPC informs, influences, and improves the quality of educational policies, practices, and leadership through research, evaluation, and technical assistance. Through our research, evaluation, and technical assistance, we are committed to supporting the understanding of whether educational policies, programs, and practices are being implemented as intended, whether they are effective and impactful, and how they may be improved and scaled-up, and become sustainable.

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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. Part One also provides an overview of the Computing Partnerships Grants Program and the progress report's methods and 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 irrespective 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 a similar 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

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

design and implementation of comprehensive K-16 computing partnerships" (see 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, schools, and educational consortia are encouraged to partner with industry, higher education, community/cultural organizations or other local education agencies (LEAs; i.e., school districts and schools).

Purpose of Progress Report

This report provides data on the implementation of the Computing Partnerships Grants Program in Summer 2019, Fall 2019, and Spring 2020.

Methods

Data Source and Survey Design

Implementation data for the Computing Partnerships Grants Program from Summer 2019, Fall 2019, and Spring 2020 were collected through surveys of LEAs that received funding from the grant. The Grant Activities Surveys used for data collection were designed by the Utah Education Policy Center (UEPC) to comprehensively assess the Computing Partnerships Grants Program. As Figure 1 illustrates, the surveys were organized around seven key topics that, together, provide a full and nuanced picture of the nature, contributions, and impediments to grant activities. The seven topics include:

1. Demographics of LEAs that received grant funding.
2. Objectives of LEAs that motivated their involvement in grant activities.
3. Grant activities pursued by LEAs, priority areas, and key contributions.
4. Teacher and student outcomes from participation in grant activities.
5. Experiences with increasing the participation of underrepresented students.
6. Challenges faced by LEAs with implementing grant activities, including any posed by the novel coronavirus (COVID-19) pandemic.
7. Feedback for the STEM Action Center.

Survey Administration

The UEPC administered the Grant Activities Surveys to grantees at the end of each grant implementation period. The survey used in collecting Summer 2019 implementation data was disseminated in September 2019, and surveys designed to collect Fall 2019 and Spring 2020 were administered in January 2020 and June 2020 respectively. In advance of each survey administration, 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. Grantee primary contacts were also notified by the STEM Action Center about this information exchange and their expected participation in the survey to be sent by the UEPC at the close of the implementation period. On the respective days of survey launch in September 2019, January 2020, and June 2020, the UEPC sent an email, embedded with the survey link, to the designated primary contact person(s) at LEAs that received grant funding. As the oversight designee for LEA grant activities, primary contacts were the expected survey participants. Surveys were open for four to five weeks during each cycle.

Data Analysis

Survey questions were structured in one of three formats: a close-ended format, an open-ended format that permitted only numerical value answers, and an open-ended format that solicited text responses. Responses to the first two question formats were analyzed using descriptive statistics (e.g., frequencies and percentages). Responses to the third question format were analyzed using inductive coding, which is a process of aggregating responses using themes that emerge directly from the data (Merriam, 2009). Where possible, findings covered in this report were compared to those discussed in the report from the previous year. Such comparisons, to be sure, were not possible for the vast majority of findings debuted in this report as the survey administered in 2019-2020 was vastly different in content and design from that disseminated in 2018-2019. Additionally, although this report features data from Summer 2019, Fall 2019, and Spring 2020, the prior year's report covered data from Fall 2018 and Spring 2019, but not Summer 2018, and in some instances, highlighted aggregated data from 2017-2018. As a result, comparisons in this report, when provided, were made between Fall and Spring data from 2018-2019 and Fall and Spring data from 2019-2020. Consistent with the American Psychological Association (APA) manual, this report uses the terms "boys" and "girls" as nouns, as opposed to "males" and "females."[2]

Report Organization

This introduction is the first of eleven sections of this report. The second section of the report, *Terminology and Definitions*, provides definitions for the grant activities that are covered in the report. *Demographics and Objectives,* the report's third section, highlights the demographics and objectives of LEAs that received funding during each of the implementation periods. 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—and report on the collective contributions of LEAs to the priority areas outlined in

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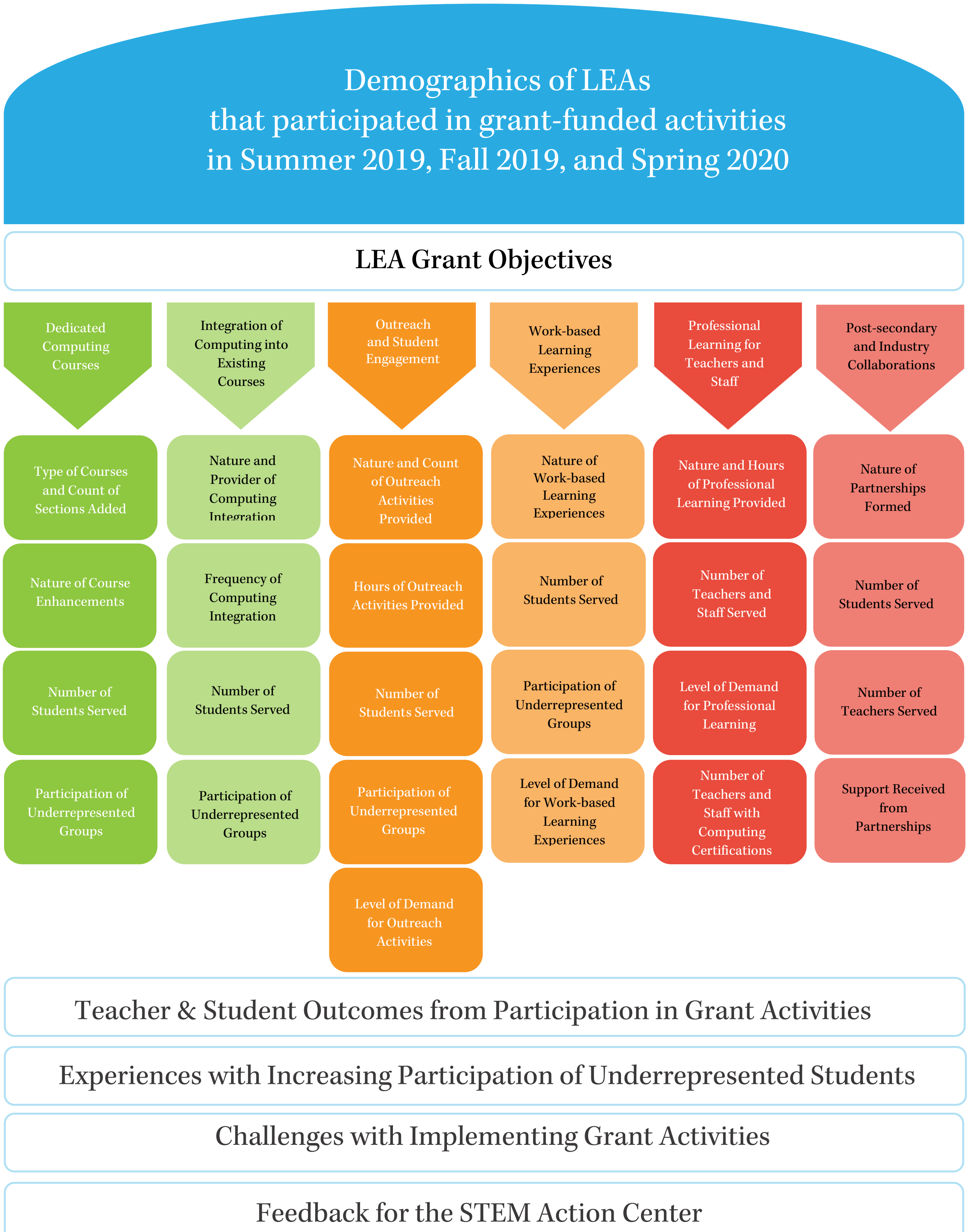
[2] https://apastyle.apa.org/style-grammar-guidelines/bias-free-language/gender

Figure 1. The tenth section of this report, *General Experiences,* highlights themes gathered from text responses about teacher and student outcomes, LEA experiences with increasing the participation of underrepresented experiences, challenges faced with implementing grant activities, and feedback for the STEM Action Center. Finally, the eleventh 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.

Figure 1. Survey Foci



PART TWO:

TERMINOLOGY & DEFINITIONS

This section provides definitions for terms used in the report to refer to the types of grant activities in which LEAs were involved. The grant activities of interest in the current report include Dedicated Computing Courses, Integration of Computing into Existing Courses, Outreach and Student Engagement Activities, Work-Based Learning Experiences, Professional Learning in Computer Science and Information Technology (CS/IT), and Post-Secondary, Industry, and Community Collaborations.

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.

PART THREE:

DEMOGRAPHICS AND OBJECTIVES

This section identifies the school districts, educational consortia, and schools that received funding from the Computing Partnerships Grants Program in Summer 2019, Fall 2019, and Spring 2020. It also addresses the types of grant activities in which LEAs were involved during the three implementation periods, the grade levels served through grant activities, and the objectives pursued by LEAs in choosing to participate in the grant program.

Key Findings

A Wide Variety of LEAs Participated in Grant Activities During the Three Implementation Periods

As Table 1 indicates, a sizeable number and diverse range of LEAs participated in grant activities in Summer 2019, Fall 2019, and Spring 2020. In Summer 2019, 30 LEAs (i.e., 10 school districts, one tri-district consortium, and 19 schools) participated in Computing Partnerships grant activities. In Fall 2019 and Spring 2020, 33 LEAs (i.e., 11 school districts, one tri-district consortium, one education consortium, and 20 schools) and 29 LEAs (i.e., 11 school districts, one tri-district consortium, and 17 schools), respectively, were involved in grant activities. Equally importantly, the vast majority of LEAs participated in grant activities over the course of the entire school year.

Table 1. Local Education Agencies Involved in Computing Partnerships Grant Activities

LEA	Summer 2019	Fall 2019	Spring 2020
Alpine District	x	x	x
Antimony Elementary		x	
Beaver High School	x	x	
Blanding Elementary	x	x	x
Bryant Middle School	x	x	x
Cache District	x	x	x
Cache District (Green Canyon, Sky View, Ridgeline, & Mountain Crest High Schools)			x
Coral Canyon School	x	x	x
Davis District	x	x	x
Davis District (All Elementary Schools)	x	x	
Duchesne Elementary	x	x	x
Emery High School		x	
Entheos Academy (Kearns Campus)	x	x	x
Garfield District	x		x
InTech Collegiate High School	x	x	x
Itineris Early College High School	x	x	x
Iron District	x	x	x
Juab District	x	x	x
Juab-North-Sanpete-South Sanpete Districts	x	x	x
Kane District	x	x	x
Kearns Junior High School	x	x	x
Lindon Elementary	x	x	x
Nebo After School Programs	x	x	x
Ogden City District	x	x	x
Pinnacle Canyon Academy	x	x	x
Provo District	x	x	x
Red Mountain Elementary	x	x	x
Richfield High School		x	
San Juan District (Multiple Schools)	x	x	x
Southwest Educational Development Center		x	
South Kearns Elementary	x	x	x
SUCCESS Academy	x	x	x
Tabiona Elementary	x	x	x
Three Falls Elementary	x	x	x

LEA	Summer 2019	Fall 2019	Spring 2020
Toole Community Learning Center	x		x
Toole District		x	
Total Count	30	33	29

Participating LEAs Were Involved in Various Types of Grant Activities

LEAs were asked in the surveys to identify the types of grant activities they provided from a list of options. Those who participated in Summer 2019 were provided four options: *Outreach and Student Engagement*, *Work-Based Learning Experiences*, *Professional Learning in Computer Science/Information Technology*, and *Post-Secondary, Industry, and Community Collaborations*. They were also permitted to indicate that they did not provide any activities in the Summer if that was more applicable. LEAs that received grant funding for the Fall or Spring semesters were given six grant activities from which to select: *Dedicated Computing Courses*, *Integration of Computing into Existing Courses*, *Outreach and Student Engagement*, *Work-Based Learning Experiences*, *Professional Learning in Computer Science/Information Technology (CS/IT), and Post-Secondary, Industry, and Community Collaborations*. Again, LEAs were also permitted to indicate that they did not provide any grant activities during these semesters. As Figures 2-4 illustrate, all grant activities that were possible during each implementation period received some participation from LEAs, although some received more involvement than others. In Summer 2019, *Outreach and Student Engagement* garnered the most participation from LEAs, with 32% indicating that they provided this grant activity (Figure 2). Thirty-two percent of LEAs also noted that they did not provide any activities in the Summer. In Fall 2019, LEAs were more likely to indicate that they provided *Professional Learning in CS/IT* (59%) and *Outreach and Student Engagement* (56%) (Figure 3). And in Spring 2020, participating LEAs more often provided *Outreach and Student Engagement* (70%), followed by *Professional Learning in CS/IT* (53%) (Figure 4).

Figure 2. LEA Grant Activities in Summer 2019

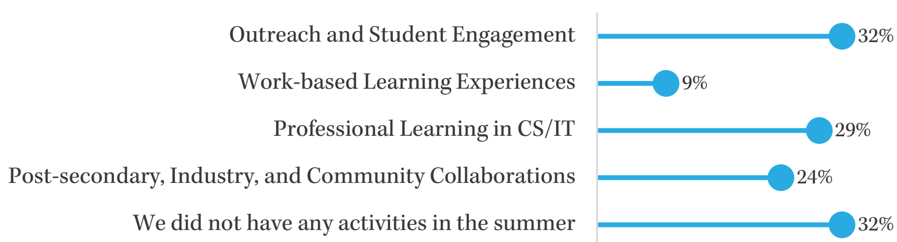


Figure 3. LEA Grant Activities in Fall 2019

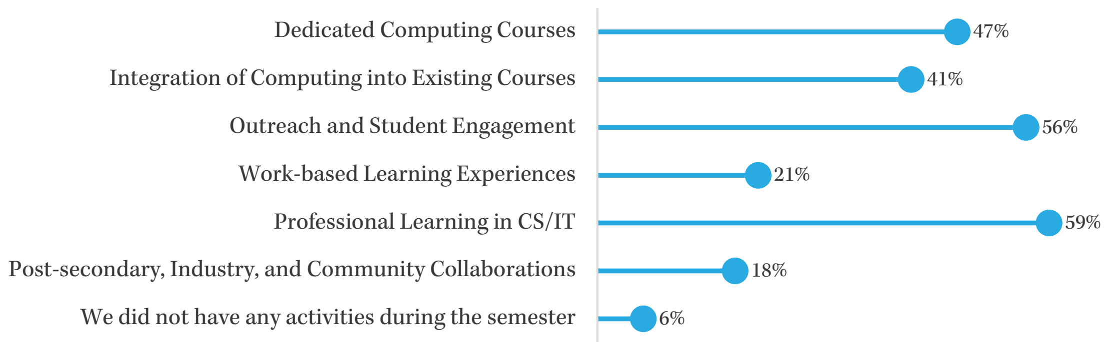
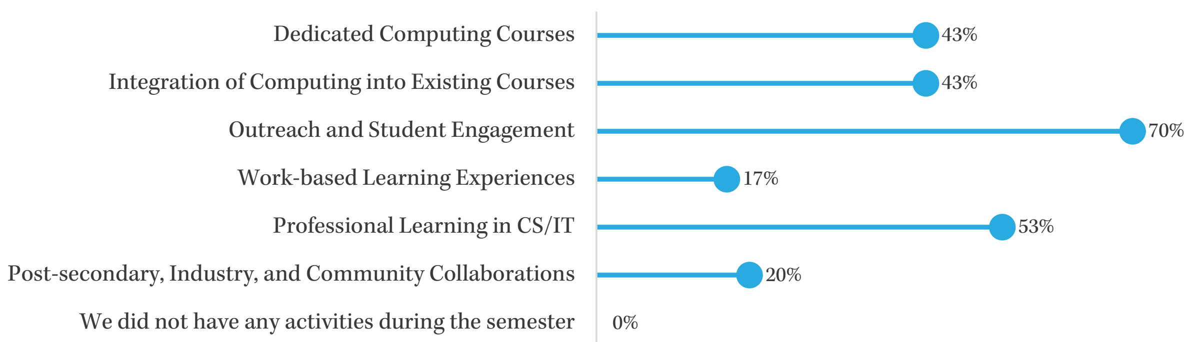


Figure 4. LEA Grant Activities in Spring 2020



All Grade Levels Were Impacted through Grant Activities, although Elementary Grades Seem to Be the Most Impacted

As Figure 5 and Table 2 indicate, grant activities provided in Summer 2019, Fall 2019, and Spring 2020 impacted students across the K-12 continuum. In Summer 2019, LEAs were asked to indicate the grade levels for which activities were provided through grant funding. As Figure 5 illustrates, a notable percent of LEAs provided activities in the Summer for each grade level, although a significantly high fraction (70%) indicated providing activities for elementary grades (K-6). In Fall 2019 and Spring 2020, LEAs were asked to specify the number of elementary, middle/junior high, and high schools that were impacted through the grant funding they received. As Table 2 indicates, all grade schools were impacted by grant funding during both semesters, although elementary schools were most represented among the schools impacted (228 out of 300 schools in Fall 2019 and 252 out of 335 schools in Spring 2020).

Figure 5. Grade Levels Served by LEAs in Summer 2019

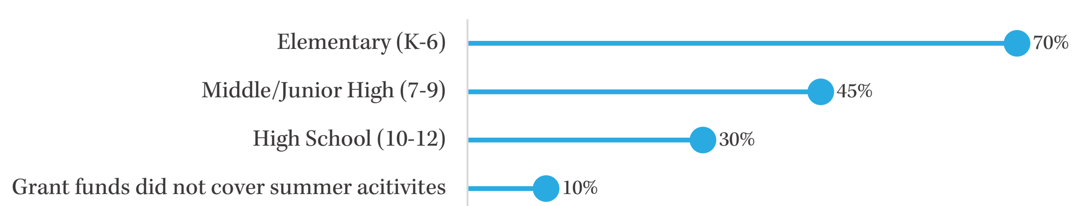


Table 2. Type and Count of Schools Involved in Grant Activities in Fall 2019 and Spring 2020

	Fall 2019	Spring 2020
Elementary Schools	228	252
Middle/Junior High Schools	31	38
High Schools	41	45
Total No. of Schools	300	335

Participating LEAs Had Multiple and Varied Objectives That They Sought to Accomplish through Grant Activities

As Tables 3-5 indicate, LEAs that received grant funding in Summer 2019, Fall 2019, and Spring 2020 set out to achieve multiple and varied objectives including, but not limited to, implementing or augmenting computer science curricula; hiring content experts to teach particular computing courses; increasing the participation of students in work-based learning experiences; integrating new educational software and web programs into existing courses; creating more after-school activities focused on computer science; increasing the participation of traditionally underrepresented groups; providing subject-specific professional development to teachers often in collaboration with higher education faculty; designing computer science programs that involved parents and families; and increasing student involvement in local and state-wide computer science competitions. As these tables also indicate, most LEAs made important progress towards accomplishing their objectives.

Table 3. Participating LEAs, Grant Objectives, and Contributions, Summer 2019

LEA	Objectives & Contributions
Alpine District	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Beaver High School	**Objectives:** Help students develop their higher-order thinking skills, troubleshooting and technology expertise; have intern students complete or continue on an IT pathway. **Reported Progress, Deliverables, or Other Successes:** Hired interns currently working on Apple Repair Certifications.
Blanding Elementary	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Bryant Middle School	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Cache District	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Coral Canyon School	**Objectives:** Engage students in computer science through hands-on, educational activities. **Reported Progress, Deliverables, or Other Successes:** Held a coding science camp for fourth and fifth grade students. They had the opportunity to code, work on Lego robotic projects, and create interactive software through Code.org.
Davis District	**Objectives:** Develop a K-12 Framework aligned to CS Standards. **Reported Progress, Deliverables, or Other Successes:** Developed framework for K-6; currently addressing the framework alignment to grades 7-12.
Davis District (All Elementary Schools)	**Objectives:** Create infrastructure for all elementary CS teachers to gain content knowledge to teach elementary coding; ensure 100% student participation in elementary CS for a minimum of 30 minutes a week.

LEA	Objectives & Contributions
	Reported Progress, Deliverables, or Other Successes: Provided elementary CS teachers with CS training; developed 31 computer science lessons for elementary students; identified websites and links for use in elementary CS curriculum.
Duchesne Elementary	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Entheos Academy (Kearns Campus)	**Objectives:** Implement keyboarding in elementary; implement out of school time enrichment in coding activities; introduce coding in expeditions. **Reported Progress, Deliverables, or Other Successes:** Held three summer camps; developed a "Young engineers" curriculum that is appropriate for computational thinking for grades K-2; New American club was an unprecedented success. Some of our youth who had rarely interacted with older students of color and STEM were very inspired to see the successes of these older peers.
Garfield District	**Objectives:** Hire a part time STEM/Computing teacher at each elementary school; provide professional development for teachers; provide necessary resources, tools and supplies; increase student interest in STEM and computing; create and advisory committee that would work on strategic plan and coordinating with partners. **Reported Progress, Deliverables, or Other Successes:** Expanded our teacher pool with well qualified teachers with training in STEM and computing; shared curriculum and resources with the two new STEM teachers that were hired; held our first community event in partnership with a local nonprofit (This included a rocket making and launching workshop during the day and a presentation about the distance of objects in space at the end).
InTech Collegiate High School	**Objectives:** Expand the number of complete CTE pathways offered by InTech; expand the number of CTE courses offered by InTech; expand the number of InTech CTSOs; expand opportunities for students to earn both achievement and professional certificates in computing-related areas. **Reported Progress, Deliverables, or Other Successes:** Completed three objectives; other objectives are effective and ongoing; developed/polished additional computer science course lesson plans.
Itineris Early College High School	**Objectives:** Provide a second AP Computer Science Principles course; provide a Computer Science supplement one day a week; add two Network Engineering and Network Administration classes to the Itineris school day taught by FIND's Executech partners; add a Foundations of IT course to the Itineris-FIND Young Adult Career Readiness program, in partnership with Executech. **Reported Progress, Deliverables, or Other Successes:** Offered two sections of AP CSP for Sophomores; successfully implemented both the junior and senior after-school coding program; created a specific track for the Itineris-FIND program with the help of the School of Applied Technology; planning for the 2019-2020 school year to implement the Foundations of IT course.
Iron District	**Objectives:** Build up awareness and excitement for Coding opportunities and events; provide professional development and educator supports; increase equity and access for all students; increase involvement in computing pathways. **Reported Progress, Deliverables, or Other Successes:** Held our CodeCamp at SUU with CodeChangers this summer to drive up excitement and awareness of opportunities in CS; offered teachers the opportunity to go and attend Code.org's 4 day training and certification as they prepare to teach CS Discoveries and CS Principles; continuing to reach out to underrepresented students offering scholarships to CodeCamp and opportunities for free summer coding courses; provided new offerings in CS Discoveries this year anticipate new offerings in CS Principles next year.
Juab District	**Objectives:** Integrate computer science into upper elementary grades and impact all 4th-6th graders. **Reported Progress, Deliverables, or Other Successes:** Provided weekly computer science instruction to students in grades 4-; students are accelerated beyond our

LEA	Objectives & Contributions
	perceived planning. Students have entered 6th grade with the ability to take more advanced coding courses, rather than introductory Scratch work as has been in the past.
Juab-North-Sanpete-South Sanpete Districts	**Objectives:** Recruit teachers and students; standardize computer science curriculum offered across all high schools including classes for Exploring Computer Science, Computer Science Principles, and Programming I; purchase curriculum to support teachers with various knowledge levels participating in Code.org. **Reported Progress, Deliverables, or Other Successes:** Added more courses to spring and fall schedules to draw interest including Gaming, Mobile App 3D Printing; provided kits in all four high schools; provided training and professional development through Code.org; provided training to district and elementary IT specialists on recently purchased elementary computer science kits.
Kane District	**Objectives:** Host weekly CS activities; engage community and partners; support teachers in implementing new technology in their classrooms. **Reported Progress, Deliverables, or Other Successes:** Completed a 6 week after school coding class with 36 participants; hosted summer time STEM activities; hosted two teacher training days with information on Augmented and virtual reality, Spheros, and coding (37 teachers received this training).
Kearns Junior High School	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Lindon Elementary	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Nebo After School Programs	**Objectives:** Impact students by providing a project-based, technology-driven course introducing students to the digital world; increase student engagement; provide teacher professional development in Summer 2020 to encourage project-based learning and utilizing technology in innovative ways. **Reported Progress, Deliverables, or Other Successes:** Offered a summer program that was 4 weeks for 4 hours/day and students attended courses in Aviation, 3D Design and Production, Coding and Robotics, and STEM projects. The courses were project-based and technology driven; participating students were engaged, excited, and developed confidence in their ability to succeed in the basics of computing.
Ogden City District	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Pinnacle Canyon Academy	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Provo District	**Objectives:** Implement universal keyboarding program; develop and implement a K-6 CT/CS Curriculum; expand CT/CS professional development; expand equity and access for underrepresented group in CT/CS experiences; increase participation of industry partners in K-6 experiences. **Reported Progress, Deliverables, or Other Successes:** Implemented a keyboarding program in grade 3-6; developed at 1-2 integrated computer science/coding learning units for students in Rock Canyon Elementary and Franklin Elementary; exposed teachers in multiple schools to programmable devices; provided teachers in grade 2-6 with computer science PD options in June.
Red Mountain Elementary	**Objectives:** Eliminate the computer science opportunity gap for all students. **Reported Progress, Deliverables, or Other Successes:** Provided summer camp that gave students from grades 2-8 an opportunity to use technology as it relates to agriculture; partnership with DSU was a huge success (We were able to take our whole camp on all of the Fridays to DSU to learn from the instructors on campus.)
San Juan District (Monument Valley, San Juan, & Whitehorse High Schools)	**Objectives:** Build a sustainable Computer Coding pathway starting in our Elementary schools and continuing throughout our high schools.

LEA	Objectives & Contributions
	Reported Progress, Deliverables, or Other Successes: Observed an increase in interest in computer science, robotics, coding, and virtual reality among students who participated in our 6-week computing coding class “Code to Success.”
South Kearns Elementary	**Objectives:** Have students participate in computer clubs and activities including robotics, coding, and gaming; collaborate with industry partners to support integration of computer skills into school day activities; implement Creative Coding class; provide teachers with training, webinars, and other PD activities. **Reported Progress, Deliverables, or Other Successes:** Had students participate in robotics, coding and game design throughout the summer months; created videos, missions, and curriculum for Scratch, Sphero, Mindstorm, and Meetedison.com Edison Robots; took students on a field trip to Adobe where they learned about career opportunities they did not know about before (many students left the program with a goal to work at Adobe someday).
SUCCESS Academy	**Objectives:** Recruitment, retention, and preparation. **Reported Progress, Deliverables, or Other Successes:** Hired and utilize advanced computer science students as tutors to assist the younger students in an effort to aid retention; SUCCESS Academy is excited about our new formalized partnership with DSU Prep and SUU Prep as this will facilitate the CIT and to a greater degree the STEM pipeline.
Tabiona Elementary	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Three Falls Elementary	**Objectives:** Engage students in CS through the following hands-on, educational activities and events: weekly afterschool 4-H CS club meetings (February-May) and weekly afterschool FIRST LEGO League Jr. Robotics club meetings (August-January); facilitate an "International Scratch Day" family event and a "Words-per-Minute" keyboarding contest; participate in FIRST LEGO League Jr. Robotics program and showcase event; provide 4-H CS & Robotics summer camps. **Reported Progress, Deliverables, or Other Successes:** Held our summer STEM camp where students worked on robotics and CS; did some of the prep work required to start our new robotics teams for the upcoming season; created a schedule of curriculum to provide different areas of CS such as coding, robots, programming drones, and circuits.
Toole Community Learning Center	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.

Table 4. Participating LEAs, Grant Objectives, and Contributions, Fall 2019

LEA	Objectives & Contributions
Alpine District	**Objectives:** Introduce computer science to ALL elementary students; provide onsite professional development for teachers. **Reported Progress, Deliverables, or Other Successes:** Recruited an additional 27 Elementary Computer technology teachers to participate in training representing 28 schools; use the BootUpPD.org website as the primary PD material for teachers.
Antimony Elementary	**Objectives:** Hire part-time STEM/computer teacher; provide professional development to support teachers' integration of computer science into the curriculum; provide necessary resources, tools, and supplies; increase student interest in STEM and computing; create an advisory committee that would work on a strategic plan and coordinate with partners. **Reported Progress, Deliverables, or Other Successes:** Implemented a PD plan for all elementary teachers; currently putting together a district-wide committee to plan the implementation of a master plan for computer science by 2022; provided teachers with access to BootUp resources and lesson plans.
Beaver High School	**Objectives:** Help students develop their higher-order thinking skills, troubleshooting and technology expertise for their school; have intern students complete or continue on an IT pathway. **Reported Progress, Deliverables, or Other Successes:** Working with students in the classroom setting throughout the school year to prepare students for internships in the summer; monitoring industry exam completion as part of our selection process for potential interns this summer; assigned mentors to interns to assist them in achieving their goals on their IT pathway.
Blanding Elementary	**Objectives:** Develop students' computer science skills in terms of coding and computer programming primarily in an after school setting (emphasis on underprivileged students); offer professional development in order to enhance the programs already in place at the school and the overall computer science education of all students. **Reported Progress, Deliverables, or Other Successes:** Had 31 students enrolled in our after school coding program; had UVU professor provide professional development to all teachers in computer science integration; provided lesson plans to teachers and instruction on integrating robotics in their lessons.
Bryant Middle School	**Objectives:** Obtain equipment and materials for after school computing program; make computing part of the regular after school programming; market afterschool programming; coordinate and prepare curriculum. **Reported Progress, Deliverables, or Other Successes:** Purchased robotics equipment for use in the Bryant Middle School library after school; significantly increased the number of students participating in after school computing and robotics; hired a new teacher with great experience in teaching coding; increased number of teachers who integrate computing in their curriculum from 2 to 10.
Cache District	**Objectives:** Provide coding instruction through the implementation of bi-monthly coding instruction in 1st and 2nd grade using BootUp curriculum; increase student exposure to STEM related careers through STEM events with community partners; provide professional learning for teachers in Computer Science. **Reported Progress, Deliverables, or Other Successes:** Expanded our coding instruction to weekly 20 minute sessions for all students grade 1-6 held in the computer lab; held 4 STEM events in this quarter; provided ongoing professional development for our computer lab specialists.
Coral Canyon School	**Objectives:** Engage Students in computer sciences through a Lego League; provide more coding opportunities in the school; provide teacher training through attendance to a science based conference. **Reported Progress, Deliverables, or Other Successes:** Provided three after-school programs (Each program contains 20 students ranging from grade 2-5.); expanded

LEA	Objectives & Contributions
	from one Lego League to two and increased our competition attendance by one; had all 3-5th grade students participate in coding activities throughout the month of December.
Davis District	**Objectives:** Develop K-12 framework aligned with standards. **Reported Progress, Deliverables, or Other Successes:** Developed K-6 framework; continuing work on framework for grades 7-12.
Davis District (All Elementary Schools)	**Objectives:** Create infrastructure for all elementary CS teachers to learn content knowledge to teach elementary coding; involve all elementary students in CS for a minimum of 30 minutes a week. **Reported Progress, Deliverables, or Other Successes:** Provided elementary CS teachers with CS training; developed 31 computer science lessons for elementary students; identified websites and links for use in elementary CS curriculum.
Duchesne Elementary	**Objectives:** Hold weekly after school 4-H and computer science club meetings; attend Southern Utah Code Camp; participate in International Scratch Day event; participate in word-per-minute keyboarding contest. **Reported Progress, Deliverables, or Other Successes:** Increased membership and recruited members to 78 enrollees; continuing to use Code.org to teach block coding and LEGO.org to teach building, sensor use, and block coding of our robots.
Emery High School	**Objectives:** Expose students to technology, and discuss career readiness; facilitate one student's A+ Certification; have interns help with professional development for teachers. **Reported Progress, Deliverables, or Other Successes:** Hired interns to help with a wide range of technology projects; taught and had interns self-study the A+ materials for certification; updated District web content; increased interest in technology pathways; created PD videos.
Entheos Academy	**Objectives:** Provide students with school time opportunities to develop basic computer skills; increase competency in middle school computer classes; provide afterschool enrichment activities to increase computing at all grade levels; integrate CS skills into project-based learning. **Reported Progress, Deliverables, or Other Successes:** Implemented school-wide basic computer skills program with elementary students; integrated computer-based activities into courses included 3D printing and graphic design; continuing to work with teachers to encourage an increase of integration of CS into expedition.
InTech Collegiate High School	**Objectives:** Expand the number of complete CTE pathways offered by InTech; expand the number of CTE courses offered by InTech; expand the number of InTech CTSOs; expand opportunities for students to earn both achievement and professional certificates in computing-related areas. **Reported Progress, Deliverables, or Other Successes:** Completed three objectives; other objectives are effective and ongoing; developed/polished additional computer science course lesson plans.
Itineris Early College High School	**Objectives:** Continue to offer and extend computer science courses that were added during year 2 in the grant; offer computer science supplement one day a week; offer MTA course to Itineris juniors and seniors. **Reported Progress, Deliverables, or Other Successes:** Offered two sections of AP Computer Science Principles, one section of CSIS 1030 (Foundations of Computer Science), and one section of CSIS 1020 (Computer Essentials); successfully implemented both the junior and senior after-school coding program; provided professional development to teachers using Adobe NearPod, and Instructure (Canvas); expanded partnership with Salt Lake Community College School of Applied Technology (SAT).
Iron District	**Objectives:** Build up awareness and excitement for Coding opportunities and events; provide professional development and educator supports; increase equity and access for all students; increase involvement in computing pathways.

LEA	Objectives & Contributions
	Reported Progress, Deliverables, or Other Successes: Held our Cool2Code student kickoff event this fall with roughly 1000 attendees; had all of our nearly 500 educators attend our teacher kickoff event during the intermission of our opening institute; offered after school programs in diverse areas of the county to be accessible to all; expanded Creative Coding to all 6th graders at CVMS.
Juab District	**Objectives:** Successfully integrate computer science into upper elementary grades and impact all 4th-6th graders. **Reported Progress, Deliverables, or Other Successes:** Provided weekly computer science instruction in grades 4-6; created elementary CS framework curriculum to accompany BootUp curriculum.
Juab-North-Sanpete-South Sanpete Districts	**Objectives:** Provide curriculum that high school computer science teachers could implement; provide after school computer science activities, K-12 camps, and clubs; provide training and professional development to teachers and IT specialists; implement computer science in grades K-6 using resource kits. **Reported Progress, Deliverables, or Other Successes:** Created curriculum that supports ECS, Computer Science Principles, Gaming, Web Design, and AP Computer Science; implemented computer science, coding, and robotics clubs in three middle schools, provided PD courses through CodeHS; purchased computer science resource kits that align with the implementation plan of incorporating computer science at the K-6 level.
Kane District	**Objectives:** Host weekly CS activities; engage community partners; support teachers in implementing new technology and CS into their classroom. **Reported Progress, Deliverables, or Other Successes:** Had 2 six-week coding classes (each class had 25 participants); provided additional training and support for 26 volunteer Lego League coaches; provided coding programing in school for the 3,4,5th grades in Kanab elementary school (195 students participated)
Kearns Junior High School	**Objectives:** Increase participation in coding classes (especially among females); increase after school program with Lego League and robotics; increase use of technology by teachers in class and teaching of technology used in classes. **Reported Progress, Deliverables, or Other Successes:** Offered coding classes (70 students enrolled); offered Lego League and Robotics after school; integrated Python into coding classes.
Lindon Elementary	**Objectives:** Increase student performance in the areas of science, math, and Language Arts through lessons that integrate everyday computing skills; provide training and professional development to teachers to help them incorporate everyday computing in their classrooms; have 4th-6th grade students complete two Tech Trep courses to help them learn 2 different digital media forms. **Reported Progress, Deliverables, or Other Successes:** Provided teachers with job-embedded professional development once a week throughout the school year; hosted countless schools throughout our district in the Garage; offered all 4th-6th grade students access to instruction on 6 different digital media forms: programming, web design, stop motion animation, robotics, 3D printing, and sound and audio mixing.
Nebo After School Programs	**Objectives:** Impact students by providing project-based, technology-driven after school clubs introducing students to the digital world; increase student engagement, professional development, and partnerships. **Reported Progress, Deliverables, or Other Successes:** Increased student participation from 116 at this time last year to 331 this year; implemented courses (WOZU materials) in our afterschool program; had students engage with Ollies, Sheros, Ozobots, 3D printers, drones, etc.
Ogden City District	**Objectives:** Provide professional development to teachers and all technology specialists; build program sustainability by training personnel in every building. **Reported Progress, Deliverables, or Other Successes:** Held monthly PDs for 8 educators; 9 out of 12 schools now teach coding.

LEA	Objectives & Contributions
Pinnacle Canyon Academy	**Objectives:** Provide typing classes to students in grades 3-5th grade; hire a STEM teacher and teach programming to students in the secondary school; provide internships and college classes to students in STEM related fields. **Reported Progress, Deliverables, or Other Successes:** 91 students in the elementary completed assignments daily through Edutype; 11 students have taken the programming class in grades 9th-12th; 28 students are taking college classes at Utah State University Eastern.
Provo District	**Objectives:** Implement a universal keyboarding program with student progress shared with parents on our quarterly standards reports; develop & implement a K-6 CT/CS Curriculum; expand CT/CS professional development. **Reported Progress, Deliverables, or Other Successes:** Created keyboarding summary report; invited teachers to participate in coding and computer science training.
Red Mountain Elementary	**Objectives:** Eliminate the CS opportunity gap for all students. **Reported Progress, Deliverables, or Other Successes:** Continuing to provide opportunities for elementary through high school students to learn computer science and to compete in events; our group, from Red Mountain Elementary and Lava Ridge Intermediate School, won all awards from Code Camp.
Richfield High School	**Objectives:** Help students develop their higher-order thinking abilities, troubleshooting skills and technology expertise through hands-on, work-based internships; have students continue on IT pathway. **Reported Progress, Deliverables, or Other Successes:** Provided one paid internship. The internship focused on authentic projects that have allowed the student to be accountable and to show real-world experience. The student has completed an IT certification based on their job role.
San Juan District (Monument Valley, Monticello, San Juan, & Whitehorse High Schools)	**Objectives:** None reported. **Reported Progress, Deliverables, or Other Successes:** None reported.
Southwest Educational Development Center	**Objectives:** Help students develop their higher-order thinking abilities, troubleshooting skills and technology expertise though hands-on, authentic, work-based internship; provide participating schools with quality technology support from student interns to enhance district/school technology program. **Reported Progress, Deliverables, or Other Successes:** Had two student interns working with IT staff to support districts and schools in web design; developed and updated websites in four school districts.
South Kearns Elementary	**Objectives:** Have students participate in computer clubs and activities including robotics, coding, and gaming; collaborate with industry partners to support integration of computer skills into school day activities; implement Creative Coding class; provide teachers with training, webinars, and other PD activities. **Reported Progress, Deliverables, or Other Successes:** Participation increased to 31 students in school STEM activities; requested additional training from our contacts at Spy Hop but they have not committed to a training date; students in Zions Bank Hour of Code and Lego League Robots have created videos in preparation for an upcoming competition.
SUCCESS Academy	**Objectives:** Increase student participation in the Academy for Computers and Engineering by 75 students over three years; develop community, student, and counselor awareness about the available opportunities at the Academy for Computers and Engineering magnet program; increase 6th, 7th, and 8th grade student ability to apply logic and inference in problem solving; provide coaching support for all computer science courses; engage students in authentic CS projects.

LEA	Objectives & Contributions
	Reported Progress, Deliverables, or Other Successes: Increased enrollment substantially over the past three years and now as an enrollment of 150 students; provided academic coaching; provided academic coaching during study halls, lunch time, and after school; observed increase on students inferential logic during SUU and Dixie Prep summer programs.
Tabiona Elementary	**Objectives:** Provide weekly after school 4-H CS club meetings and weekly after school FIRST LEGO League Jr. Robotics club meetings; participate in the Southern Utah Code Camp Event; participate in a Words-Per-Minute Keyboarding Contest and FIRST LEGO League Jr. Robotics Showcase Event; provide 4-H CS summer camps and 4-H Robotics summer camps. **Reported Progress, Deliverables, or Other Successes:** Held weekly meetings on Tuesday after school; plan to participate in a Summer Robotics camp.
Three Falls Elementary	**Objectives:** Have part-time STEM/Computing teacher at each elementary. **Reported Progress, Deliverables, or Other Successes:** Observed increase in student participation from 24 to 36 this year; sent our grade level team leaders from 1st grade through 5th grade to the CS for All conference in SLC.
Toole District	**Objectives:** Increase industry certifications in Computer A+ and Linux by becoming a test facilitator; increase participation of project based learning of students (target non-traditional students specifically girls); increase industry projects in TCSD with IT clubs; increase the awareness and offerings of IT courses in Tooele County School district. **Reported Progress, Deliverables, or Other Successes:** Targeted to get girls involved in project based learning; successfully completed a HARPO launch with IT students; expanded into teaching 4 different programming languages throughout the school district (Java, JavaScript, C# and Python)

Table 5. Participating LEAs, Grant Objectives, and Contributions, Spring 2020

LEA	Objectives & Contributions
Alpine District	**Objectives:** Introduce computer science to ALL elementary students; provide professional development for teachers. **Reported Progress, Deliverables, or Other Successes:** Completed training for 26 Elementary Computer technology teachers in 27 schools; used the BootUpPd.org website as the primary PD materials for teachers; began training all of our ILC coaches (1 of the 5 training sessions have been delivered so far).
Blanding Elementary	**Objectives:** Provide computer science classes after school and expose students to coding and robotics; provide training for our teachers in computer science integration. **Reported Progress, Deliverables, or Other Successes:** Successfully implemented an after school program twice a week and taught students coding and robotics; will have 5 teachers attend the National Computer Science Teachers Association conference; brought in UVU to teach an integrated lesson using robotics at each grade level.
Bryant Middle School	**Objectives:** Obtain equipment and materials for after school computing program; make computing part of the regular after school programming; market after school programming; coordinate and prepare curriculum. **Reported Progress, Deliverables, or Other Successes:** Accomplished primary objective during prior grant years; integrated computing in after school programming; increased student interest in computing; great planning and execution of dedicated computing courses and after school programming.
Cache District	**Objectives:** Implement coding instruction in 1st and 2nd grade students; increase student engagement in STEM related activities by supporting STEM nights at each elementary school with community partners from local STEM related businesses. **Reported Progress, Deliverables, or Other Successes:** Implemented system-wide weekly coding instruction in all grades 1-6; developed a scope and sequence for coding instruction in grades 1-6 using Code.org and Scratch in 3-6; systematic implementation of coding in grades 1-6 ensured that all students participated; held STEM nights at 13 of the 17 elementary schools (3167 students attended district wide).
Cache District (Green Canyon, Sky View, Ridgeline, & Mountain Crest High Schools)	**Objectives:** Provide internship opportunities for IT Academy students. **Reported Progress, Deliverables, or Other Successes:** We had two students participate in internships.
Coral Canyon School	**Objectives:** Increase participation in computer clubs and activities including robotics; increase teacher's ability to use computing skills in the classroom. **Reported Progress, Deliverables, or Other Successes:** Sent 16 teachers to two different technology/coding trainings; increased desire for younger kids to join Lego League when they reach 4th-5th grade; showed some of the LEGO activities through our CCTV weekly newscast; create lesson plans for STEM, Robotics, Code.org, PearDeck.com, and Adobe.com
Davis District	**Objectives:** Develop K-12 framework aligned to standards **Reported Progress, Deliverables, or Other Successes:** Developed, implemented, and revised K-6 framework was as needed; framework for grades 7-12 is in progress.
Davis District (All Elementary Schools)	**Objectives:** Create infrastructure for all elementary CS teachers to learn content knowledge to teach elementary coding; ensure 100% student participation in elementary CS for a minimum of 30 minutes a week. **Reported Progress, Deliverables, or Other Successes:** Provided computer science training to all elementary computer science teachers; offering ongoing training in monthly professional learning communities (PLCs) and online through Canvas; created and reported DESK standards for elementary computer science; created over 250 computer science lessons for grades K-6.
Duchesne Elementary	**Objectives:** Provide weekly after school 4-H and Computer Science club meetings; attend Southern Utah Code Camp; participate in International Scratch Day event; participate in word-per-minute keyboarding contest.

LEA	Objectives & Contributions
	Reported Progress, Deliverables, or Other Successes: Met weekly during school (Increased membership and started preparing for LEGO competition. Average attendance is approximately 45)
Entheos Academy (Kearns Campus)	**Objectives:** Provide elementary students with school time opportunities to develop computer skills; increase competency in computing skills through secondary classes; provide training, materials, and equipment to enhance integration of computer skills into project based learning; provide afterschool enrichment activities that will increase computing skills at all grade levels. **Reported Progress, Deliverables, or Other Successes:** Students worked on 3D printing in 8th grade in early March; implemented computational thinking quilling; computational thinking paper art, STEM goose chase scavenger hunt, playdough circuits kits, and young engineers kits.
Garfield District	**Objectives:** Hire a part-time STEM teacher at each elementary school; provide professional development for teachers; Provide necessary resources, tools and supplies; increase interest in STEM and computing; create an advisory committee that would work on a strategic plan and coordinate with partners. **Reported Progress, Deliverables, or Other Successes:** Continued professional development with BootUp and had the trainer work with students and teachers during a day session and then provide a community computing night in each of the three communities focused on utilizing Scratch Jr.; teachers did extensive individual PD to conduct online school after the soft closure; expanded our advisory committee beyond the three communities to encompass our whole district to begin district strategic planning; the Community Computing Events at Boulder and Antimony were very successful.
InTech Collegiate High School	**Objectives:** Expand the number of complete CTE pathways offered by InTech; expand the number of CTE courses offered by InTech; expand the number of InTech CTSOs; expand opportunities for student to earn both achievement and professional certificates in computing-related areas. **Reported Progress, Deliverables, or Other Successes:** Accomplished all goals; developed/polished additional computer science course lesson plans; students earned additional industry certifications.
Itineris Early College High School	**Objectives:** Continue to offer and extend computer science courses that were added during year 2 in the grant; provide CS supplement one day a week; offer MTA course (industry credential) to juniors and seniors through partnership with Salt Lake Community College School of Applied Technology. **Reported Progress, Deliverables, or Other Successes:** Offered two sections of AP Computer Science Principles, one section of CSIS 1030 (Foundations of Computer Science), and one section of CSIS 1020 (Computer Essentials); training our teacher for CSIS 1400 next fall; trained all teachers in using Adobe, NearPod, and Instructure (Canvas).
Iron District	**Objectives:** Build up awareness and excitement for Coding opportunities and events; provide professional development and educator supports; increase equity and access for all students; increase involvement in computing pathways. **Reported Progress, Deliverables, or Other Successes:** Offered after school programs with CodeChangers, First Lego League and SUU; provided extensive coaching PD for 5 teachers with CodeChangers; continue to expand Creative Coding for sixth graders; created a comprehensive plan to expand offerings at all of our schools including integration in elementary, and expanded offerings in middle and high schools; had wonderful stakeholder and partner engagement during our planning process for our 4 Year plan.
Juab District	**Objectives:** Integrate computer science in upper elementary grades and impact all 4th-6th graders.

LEA	Objectives & Contributions
	Reported Progress, Deliverables, or Other Successes: Provided weekly computer science instruction to students in grades 4-6; created Elementary CS Playbook, Juab SD CS Scope and Sequence, and CS Task Force: Script Workshop.
Juab-North-Sanpete-South Sanpete Districts	**Objectives:** Provide a common curriculum and training to support high school teachers in computer science courses; provide after school computer science activities, K-12 camps, and clubs; provide training and professional development to teachers and IT specialists participating in implementing and enhancing computer science initiative; implement computer science in grades K-6 using resource kits; plan and implement CS courses at the middle grades including Creative Coding, Digital Literacy; and STEM Computer Science. **Reported Progress, Deliverables, or Other Successes:** Created curriculum that supports ECS, Computer Science Principles, Gaming, Web Design, and AP Computer Science; implemented computer science, coding, and robotics clubs in three middle schools, provided PD courses through CodeHS; purchased computer science resource kits that align with the implementation plan of incorporating computer science at the K-6 level.
Kane District	**Objectives:** Host weekly CS activities; engage community partners; support teachers in implementing new technology and CS into their classroom. **Reported Progress, Deliverables, or Other Successes:** Hosted 2 six-week classes-Each class had 25 participants so 50 students received 9 hours of instruction in coding; partnered with the Kane Education Foundation to create, package and distribute take home kits of STEM supplies to 500 elementary school kids; Kane County 4-G YouTube channel to continue to meet objectives during COVID-19.
Kearns Junior High School	**Objectives:** Increase participation in coding classes (specifically females); increase after school programs with Lego league and robotics; increase use of technology by teachers in class and teaching of technology used in classes; increase home visits. **Reported Progress, Deliverables, or Other Successes:** Increased the coding class options offered this year (We had over 70 students enrolled (42% female) 2nd semester of this year); continuing monthly technology training with teachers; observed growth in student engagement during online learning.
Lindon Elementary	**Objectives:** Increase student performance in the areas of science, math, and Language Arts through lessons that integrate everyday computing skills; provide training and professional development to teachers to help them incorporate everyday computing in their classrooms. **Reported Progress, Deliverables, or Other Successes:** Take students to Garage where they have regular access to lessons that integrate content with everyday computing; students and teachers were well prepared to continue to instruct and demonstrate learning online due to their everyday computing skills.
Nebo After School Programs	**Objectives:** Impact students by providing project-based, technology-driven after school programs introducing students to the digital world; increase student engagement; provide professional development to teachers; work with educational and community partners. **Reported Progress, Deliverables, or Other Successes:** Exposed students to different STEM kits as we rotated the WOZU kits between the elementary schools; instructors are becoming more familiar with the process and the lesson plans; improved instruction; exposed to coding; incorporated lesson plans from WOZU STEM kits into after school programs.
Ogden City District	**Objectives:** Increase teacher capacity with ongoing, year-long professional development; Increase opportunities for students in elementary coding in and out of school. **Reported Progress, Deliverables, or Other Successes:** Provided 17 additional class and 3 new after school clubs through grant; modifying PD courses from BootUp PD to work with our future PDs.

LEA	Objectives & Contributions
Pinnacle Canyon Academy	**Objectives:** Provide keyboarding to the elementary students; increase high school course offerings and course content design in the computer fields; recruit of high school students who would like to work in the computer industry; provide paid work-based and mentoring experiences. **Reported Progress, Deliverables, or Other Successes:** 110 students completed keyboarding daily in the elementary until March 13th when the school went out on soft closure; hired STEM teacher who is teaching junior high and high school students; 22 students enrolled in college classes that were related to the computer industry; 17 students completed six work-based learning experiences throughout the year.
Provo District	**Objectives:** Implement a universal keyboarding program at elementary schools; develop & implement a K-6 CT/CS curriculum; expand CT/CS professional development among teachers; expand equity and access for under-represented groups in CT/CS experiences; increase participation of industry partners in K-6 CT/CS experiences. **Reported Progress, Deliverables, or Other Successes:** Possible increase in percentage of students that are proficient in keyboarding (data has not been collected to verify this assumption however); implementation of CT/CS curriculum is continuing; expanded training district wide; created Elementary Technology Leadership Team with 12 teachers from various schools that are implementing and helping their peers; created computer science vocabulary cards related to the new computer science core; created a list of integrated lessons that teachers can do with their students in K-6 grades.
Red Mountain Elementary	**Objectives:** Eliminate the CS opportunity gap for all students. **Reported Progress, Deliverables, or Other Successes:** Provided CS opportunities (aftershock clubs/teams, family nights, summer camps) to kids in our pipeline between the 2nd and 12th grade; teacher team created a guide for future schools to use to create and implement Code Clubs in their schools as well as Hackathons; formed partnerships with agencies in our community who will continue to support our CS efforts in the consortium schools; provided professional development for individual schools as well as to schools throughout the district and state; created lesson plans for summer camps for two successful years; all of our Lego League teams scored in the top 14 at regional and were asked to participate at the state level.
San Juan District (Multiple Schools)	**Objectives:** Provide students with an opportunity to learn how to code through the Code to Success Program; provide coding robots in elementary and middle schools' innovation spaces and district's mobile maker space. **Reported Progress, Deliverables, or Other Successes:** 8 students participated in the Code to Success program and 19 completed the program (13 registered for the online program and 3 completed this version); 19 of 28 students completed a 120-hour course in coding (Code to Success); utilized grant funds to give teachers tools (Computer Coding Robots) to facilitate their professional development and instruction.
SUCCESS Academy	**Objectives:** Increase student participation in the Academy for Computers and Engineering by 50 students over three years; develop community, student, and counselor awareness about the available opportunities at the Academy for Computers and Engineering magnet program; provide tutoring support for all computer science courses; highlight computer science industry opportunities through guest lectures and in school messaging; engage students in authentic CS projects. **Reported Progress, Deliverables, or Other Successes:** Grew ACE program from the 2016-2017 school year (17 students), to the 2017-2018 school year (75 students), to the 2018-2019 school year (89 students) to the 2019-2020 school year (135 students) with a project enrollment of 172 for the 2019-2020 school year; hired content expert tutors to provide tutoring in all computer science courses; hired two adjuncts direct from industry to teach our WEB 1400 courses; 10th grade students created individual websites for their WEB 1400 courses as part of the embedded curriculum; 11th grade students created their computer projects for their science research projects per the requirements of the Technology Student Association.

LEA	Objectives & Contributions
South Kearns Elementary	**Objectives:** Have students participate in computer clubs and activities including robotics, coding, and gaming; collaborate with industry partners to support integration of computer skills into school day activities; implement Creative Coding class; provide teachers with training, webinars, and other PD activities. **Reported Progress, Deliverables, or Other Successes:** Total student participation in our before school and after school programs increased from 31 students to 39 students; planned major training for staff members to discuss ways to integrate on ways to integrate Kibo robots into Pre-K and K, Dash robots for grades 1-4, and Sphero robots for grades 4-6 (program has been rescheduled for the beginning of the upcoming school year because of the soft closure)
Tabiona Elementary	**Objectives:** Provide weekly after school 4-H CS club meetings and weekly after school FIRST LEGO League Jr. Robotics club meetings; participate in the Southern Utah Code Camp Event; participate in a Words-Per-Minute Keyboarding Contest and FIRST LEGO League Jr. Robotics Showcase Event; provide 4-H CS summer camps and 4-H Robotics summer camps. **Reported Progress, Deliverables, or Other Successes:** Held our weekly meetings on Tuesdays after school, for two hours. Total student participation has increased by 2 students; continue to use some of the tools and activities from our weekly meetings in regular classes at school.
Three Falls Elementary	**Objectives:** Engage these students in CS through hands-on, educational activities and events. **Reported Progress, Deliverables, or Other Successes:** Reached 25 students in our before-school computer coding program; met on Google Meets weekly during remote learning to keep students working and learning on projects in CS
Toole Community Learning Center	**Objectives:** Increase industry certifications in computer A+ and Linux; increase participation of project based learning of students (specifically girls); increase awareness of IT offerings in Tooele County School District. **Reported Progress, Deliverables, or Other Successes:** Planned for a drone competition and robotics competition; increased industry projects with IT clubs; held tours for all freshman in the school district, showed them the computer labs, and talked about the different coding languages and courses that are offered; students that take the classes, love them! The student success will bring more students to the program!

PART FOUR:

DEDICATED COMPUTING COURSES

This section identifies the dedicated computing courses provided by LEAs in Fall 2019 and Spring 2020. It also addresses the number of *new* sections provided for each identified course, the nature of enhancements that were made to the courses, the number of students served by each course, and the participation of underrepresented groups. Dedicated computing courses were not offered in the Summer, as such, this section does not provide data from Summer 2019. A description of the grant activity *Dedicated Computing Courses* is provided in the *Terminology and Definitions* section of the report.

Key Findings

A Variety of Dedicated Computing Courses Were Provided in Fall 2019 And Spring 2020. Also, A Higher Number of New Sections Were Provided in the Fall Than Spring

LEAs were asked to identify the dedicated computing courses they provided in Fall 2019 and Spring 2020 from among six options—Elementary Computing Specialty, Creative Coding, Computer Science Discoveries, Introduction to Python, Exploring Computer Science I, and "Other." Additionally, they were asked to indicate the number of new sections, if any, they added in Fall 2019 and Spring 2020 for each course they provided. As Table 6 illustrates, all six course options were provided in Fall 2019 and Spring 2020, although no new sections were provided for Exploring Computer Science I in Fall 2019. In Fall 2019 also, Elementary Computing Specialty accounted for most of the new sections added (322 out of 330) and in Spring 2020, LEAs added more sections for Creative Coding (n = 7) than any other dedicated computing course. Table 6 also shows that more sections of dedicated computing courses were added by LEAs in Fall 2019 (n = 330) than in Spring 2020 (n = 20). Finally, a comparison of 2018-2019 (Fall 2018 and Spring 2019 only) and 2019-2020 (Fall 2019 and Spring 2020 only) data reveals that more sections were added for Elementary Computing Specialty in 2019-2020 (n = 323) than in 2018-2019 (n = 257). "Other" courses provided by LEAs in Fall 2019 and Spring 2020 include Computer Science Principles, Digital Marketing, CSIS 1020 Computer Essentials, and Gaming.

Table 6. Numbers of Sections of Dedicated Computing Courses Added in Fall 2019 and Spring 2020

	Fall 2019	Spring 2020
Course Name	**No. of Sections Added**	**No. of Sections Added**
Elementary Computing Specialty	322	1
Creative Coding	3	7
Computer Science Discoveries	1	4
Introduction to Python	1	1
Exploring Computer Science 1	0	2
Other	3	5
Total	330	20

Different Types of Enhancements Were Made to Dedicated Computing Courses in Fall 2019 and Spring 2020, Although the Most Prevalent Course Enhancement Done in Both Semesters Was Updating Course Curricula

LEAs were asked to identify the type of enhancements that were made to dedicated computing courses in Fall 2019 (Figure 6) and Spring 2020 (Figure 7) from the following eight options: "additional coding content," "new curriculum," "curriculum updated," "new materials or technology," "expanded to other grade levels," "offered to more students," "increased duration," and "additional keyboarding content." As Figure 6 illustrates, the more popular course enhancements made in Fall 2019 were updating course curricula and incorporating new materials or technology, with 50% of reporting LEAs indicating that they updated course curricula and 44% noting that they incorporated new materials or technology. In Spring 2020, 38% of LEAs indicated that they updated course curricula, while 34% indicated providing additional coding content and using new materials or technology.

Figure 6. Nature of Enhancements Made to Dedicated Computing Courses, Fall 2019

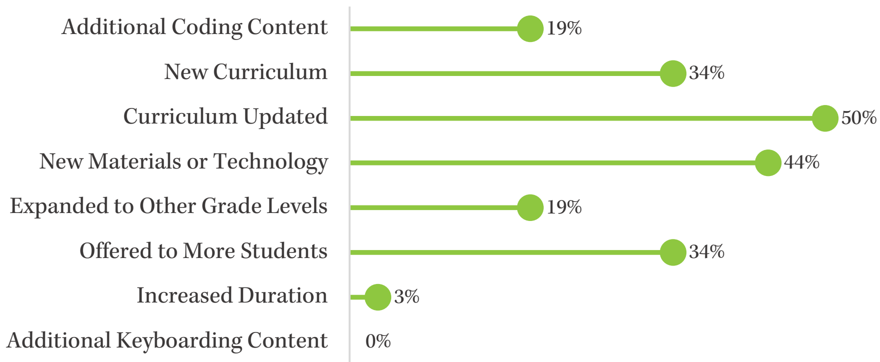
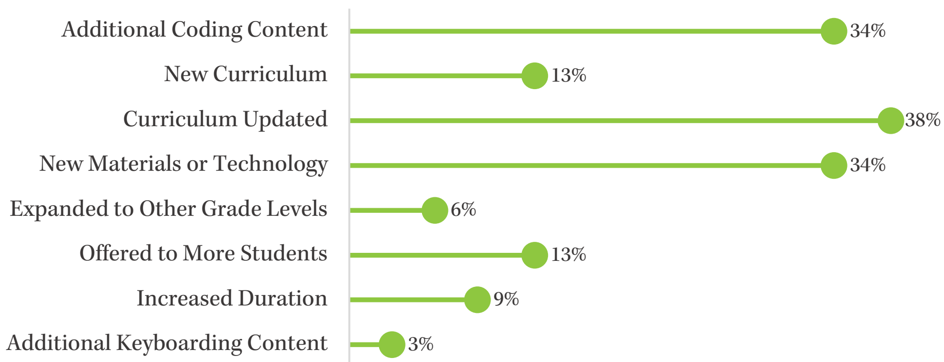


Figure 7. Nature of Enhancements Made to Dedicated Computing Courses, Spring 2020



Varied Numbers of Students Were Served Through the Dedicated Computing Courses Provided in Fall 2019 and Spring 2020

As Table 7 shows, differing numbers of students were served through the dedicated computing courses provided in Fall 2019 and Spring 2020. In Fall 2019, Elementary Computing Specialty served the highest number of students (n = 9,394) compared to other dedicated computing courses, and in Spring 2020, Creative Coding served more students (n = 514) than each of the other courses provided. Overall, a comparison of 2018-2019 (Fall 2018 and Spring 2019 only) and 2019-2020 (Fall 2019 and Spring 2020 only) data reveals that more students were served through Elementary Computing Specialty in 2018-2019 (n = 32,957) than in 2019-2020 (n = 9, 483).

Table 7. Numbers of Students Served Through Dedicated Computing Courses in Fall 2019 and Spring 2020

	Fall 2019	Spring 2020
Course Name	**No. of Students Served**	**No. of Students Served**
Elementary Computing Specialty	9,394	89
Creative Coding	334	514
Computer Science Discoveries	20	192
Introduction to Python	18	18
Exploring Computer Science 1	39	112
Other	37	103
Total	9,842	1,028

Underrepresented Student Populations Were Involved in Dedicated Computing Courses in Fall 2019 and Spring 2020, Although Some Were More Represented Than Others

LEAs were asked to specify the proportions of elementary students, middle/junior high students, and high school students, served through dedicated computing courses in Fall 2019 (Table 8) and Spring 2020 (Table 9), that were members of particular underrepresented student populations (i.e., girls, English learners, students with disabilities, students on Free or Reduced Lunch, rural students, and students who are refugees). As Table 8 indicates, more elementary students (n = 12,709) participated in dedicated computing courses in Fall 2019 than middle/junior high students (n = 835) and high school students (n = 430). In Fall 2019 also, girls were the most represented underserved group among elementary students (49%) and high school students (32%), while students on Free or Reduced Lunch (57%) were most represented among middle/junior high students. In Spring 2020, as with Fall 2019, more elementary students (n = 10,037) were served through dedicated computing courses than middle/junior high students (n = 1,052), and high school students (n = 569). However, the most represented underserved student groups among elementary, middle/junior high, and high school students in Spring 2020 were girls (50%), rural students (60%), and student on Free or Reduced Lunch (42%), respectively (Table 9).

Table 8. Proportions of Traditionally Underrepresented Groups Among Students Served Through Dedicated Computing Courses, Fall 2019

Fall 2019			
Student Group	**No. of Elementary Students Involved**	**No. of Middle/Junior High Students**	**No. of High School Students Involved**
Girls	6,184 (49%)	392 (47%)	137 (32%)
Boys[i]	6,515 (51%)	443 (53%)	292 (68%)
English Learners	869 (7%)	154 (18%)	33 (8%)
Students with Disabilities	1,515 (12%)	140 (17%)	43 (10%)
Students on Free or Reduced Lunch	5,321 (42%)	472 (57%)	111 (26%)
Rural Students	1,801 (14%)	343 (41%)	77 (18%)
Students who are Refugees	0 (0%)	25 (3%)	1 (<1%)

Table 9. Proportions of Traditionally Underrepresented Groups Among Students Served Through Dedicated Computing Courses, Spring 2020

Spring 2020			
Student Group	**No. of Elementary Students Involved**	**No. of Middle/Junior High Students**	**No. of High School Students Involved**
Girls	4,979 (50%)	439 (42%)	221 (39%)
Boys[ii]	5,058 (50%)	613 (58%)	348 (61%)
English Learners	447 (4%)	125 (12%)	8 (1%)
Students with Disabilities	1,190 (12%)	172 (16%)	76 (13%)
Students on Free or Reduced Lunch	3,715 (37%)	563 (54%)	240 (42%)
Rural Students	1,645 (16%)	631 (60%)	193 (34%)
Students who are Refugees	8,413 (84%)[iii]	13 (1%)	1 (<1%)

PART FIVE:

INTEGRATION OF COMPUTING INTO EXISITING COURSES

This section addresses the manner in which LEAs reported integrating computing into existing, non-computing courses in Fall 2019 and Spring 2020. It also identifies the individuals or organizations that oversaw the integration of computing into existing courses, the frequency with which computing was integrated into existing courses, and the participation of underrepresented groups in computing-enhanced courses. Computing-enhanced courses were not offered in the Summer, as such, this section does not provide data from Summer 2019. A description of the grant activity *Integration of Computing into Existing Courses* is provided in the *Terminology and Definitions* section of the report.

Key Findings

In Fall 2019 and Spring 2020, An Overwhelming Majority of LEAs Noted That Computing Was "Integrated" Into Course Curricula as Opposed to Provided as a "Stand Alone" Activity

LEAs were asked to specify the manner in which computing was integrated into existing, non-computing courses in Fall 2019 and Spring 2020. Precisely, they were asked to indicate whether computing was "integrated" into course curricula or provided as a "stand alone" activity. As Figures 8 and 9 indicate, most LEAs in Fall 2019 (77%) and Spring 2020 (80%) indicated that computing was "integrated" into course curricula.

Figure 8. Nature of Computing Integration in Existing Courses, Fall 2019

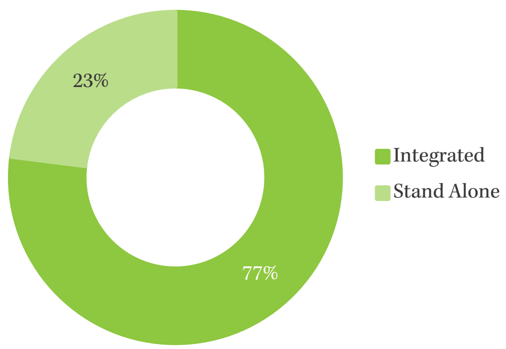
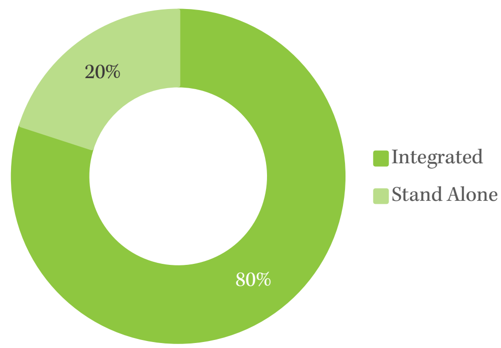


Figure 9. Nature of Computing Integration in Existing Courses, Spring 2020



In Fall 2019 and Spring 2020, A Majority of LEAs Identified "Classroom Teachers" as the Primary Supervisors of Computing Integration in Existing Courses

In Fall 2019 and Spring 2020, LEAs were asked to identify the individuals or organizations responsible for integrating computing into non-computing courses. As Figures 10 and 11 illustrate, most LEAs in Fall 2019 (69%) and Spring 2020 (70%) indicated that "classroom teachers" were the primary supervisors of computing integration in existing, non-computing courses.

Figure 10. Supervisor of Computing Integration, Fall 2019

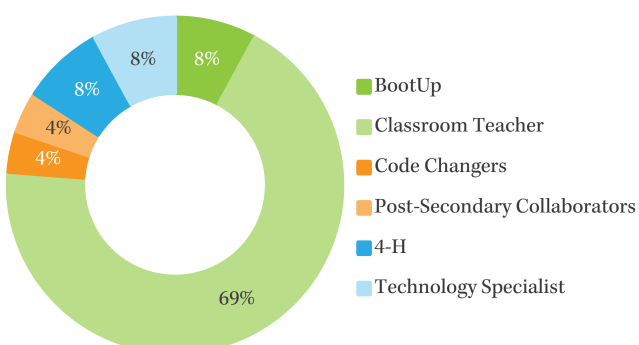
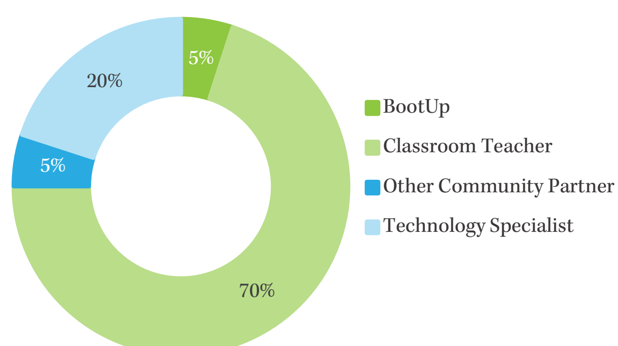


Figure 11. Supervisor of Computing Integration, Spring 2020



In Fall 2019 and Spring 2020, The Highest Percent of LEAs Noted That Computing Was Integrated into Existing Courses "1-3 Times A Month"

LEAs were asked to specify how often computing was integrated into non-computing courses in Fall 2019 and Spring 2020. To answer this question, they were provided with five options: "about daily," "2-4 times a week," "weekly," "1-3 times a month," and "less than once per month." As Figures 12 and 13 indicate, LEAs were more likely, in the Fall (30%) and Spring (50%), to note that computing was incorporated in existing courses "1-3 times a month." It is important to note here that this report does not evaluate the *quality* of computing integration in existing courses.

Figure 12. Frequency of Computing Integration, Fall 2019

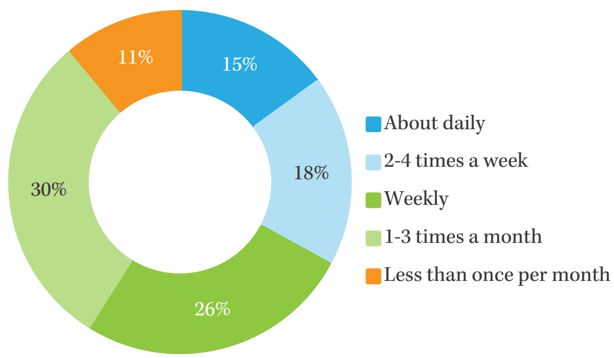
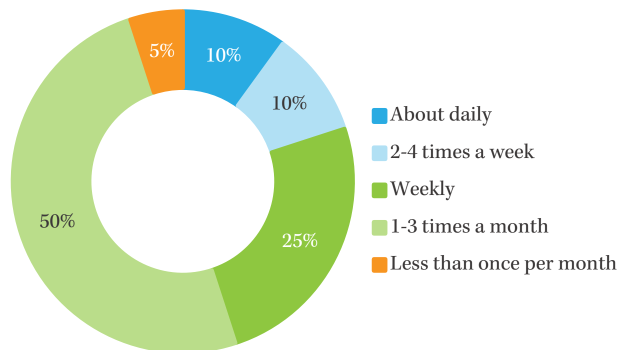


Figure 13. Frequency of Computing Integration, Spring 2020



Underrepresented Student Populations Were Involved in Computing-Enhanced Courses in Fall 2019 and Spring 2020, Although Some Were More Represented Than Others

LEAs were asked to specify the proportions of elementary students, middle/junior high students, and high school students, served through computing-enhanced courses in Fall 2019 (Table 10) and Spring 2020 (Table 11), that were members of particular underrepresented student populations (i.e., girls, English learners, students with disabilities, students on Free or Reduced Lunch, rural students, and students who are refugees). In Fall 2019, as Table 10 indicates, students on Free or Reduced Lunch were the most represented underserved group among elementary students (51%) and middle/junior high students (56%), while girls (46%) were most represented among high school students. In Spring 2020, as with Fall 2019, the most represented underserved student groups among elementary, middle/junior high, and high school students in Spring 2020 were students on Free or Reduced lunch (54%), students on Free or Reduced Lunch (76%), and girls (46%) respectively (Table 11).

Table 10. Proportions of Traditionally Underrepresented Groups Among Students Served Through Computing Enhanced Courses, Fall 2019

	Fall 2019		
Student Group	**No. of Elementary Students Involved**[iv]	**No. of Middle/Junior High Students**	**No. of High School Students Involved**
Girls	3,069 (38%)	744 (49%)	42 (46%)
Boys[v]	3,144 (39%)	783 (51%)	50 (54%)
English Learners	1,013 (13%)	288 (19%)	2 (2%)
Students with Disabilities	2,955 (37%)	243 (16%)	3 (3%)
Students on Free or Reduced Lunch	4,061 (51%)	859 (56%)	26 (28%)
Rural Students	3,192 (40%)	740 (48%)	0 (0%)
Students who are Refugees	4 (<1%)	27 (2%)	0 (0%)

Table 11. Proportions of Traditionally Underrepresented Groups Among Students Served Through Computing Enhanced Courses, Spring 2020

	Spring 2020		
Student Group	**No. of Elementary Students Involved**	**No. of Middle/Junior High Students**	**No. of High School Students Involved**
Girls	2,314 (46%)	170 (52%)	42 (46%)
Boys[vi]	2,685 (53%)	158 (48%)	50 (54%)
English Learners	642 (13%)	110 (34%)	2 (2%)
Students with Disabilities	655 (13%)	65 (20%)	3 (3%)
Students on Free or Reduced Lunch	2,703 (54%)	250 (76%)	26 (28%)
Rural Students	2,534 (50%)	0 (0%)	0 (0%)
Students who are Refugees	0 (0%)	0 (0%)	0 (0%)

PART SIX:

OUTREACH AND STUDENT ENGAGEMENT ACTIVITIES

This section identifies the types, count, and hours of outreach activities provided in Summer 2019, Fall 2019, and Spring 2020. It also covers the number of students served by these activities during the three grant implementation periods, the participation of underrepresented groups, and the level of student demand for these activities. A description of the grant activity *Outreach and Student Engagement Activities* is provided in the *Terminology and Definitions* section of the report.

Key Findings

Varied Types, Counts, and Hours of Outreach and Student Engagement Activities Were Provided in Summer 2019, Fall 2019, and Spring 2020

In Summer 2019, Fall 2019, and Spring 2020, LEAs were provided in the survey with 11 outreach and student engagement activities, as well as the option to indicate "other," and were asked to specify the total number of "clubs," "new clubs," and "hours" they provided for each activity. As Tables 12-14 illustrate, Coding Club was the most provided outreach and student engagement activity across the three grant implementation periods as reflected by the total number of "clubs," "new clubs," and "hours" provided for the activity. Additionally, a comparison of 2018-2019 (Fall 2018 and Spring 2019 only) and 2019-2020 (Fall 2019 and Spring 2020 only) data shows that more hours of outreach and student engagement activities were provided in 2019-2020 (n = 4,346 hours) than in 2018-2019 (n = 3,761 hours).

Table 12. Outreach and Student Engagement Activities Provided, Summer 2019

	Summer 2019		
Outreach Activity	**Total No. of Clubs**	**Total No. of New Clubs**	**Total Hours**
Coding club	17	4	168
First Tech Challenge	0	0	0
Lego League	1	0	52
Other robotics club	1	0	0
Student conferences/events	0	0	0
Aspirations in Computing program	0	0	0
Hour of Code	0	0	0
Family Hour of Code	0	0	0
eSports Competition	0	0	0
Hack-a-thon	0	0	0
Out-of-school kick-off/family events	0	0	0
Other	10	3	295
Total	29	7	515

Table 13. Outreach and Student Engagement Activities Provided, Fall 2019

	Fall 2019		
Outreach Activity	**Total No. of Clubs**	**Total No. of New Clubs**	**Total Hours**
Coding club	45	4	703
First Tech Challenge	2	0	53
Lego League	30	3	535
Other robotics club	3	0	0
Student conferences/events	9	2	31
Aspirations in Computing program	1	0	0
Hour of Code	20	0	423
Family Hour of Code	1	0	0
eSports Competition	0	0	0
Hack-a-thon	1	0	8
Out-of-school kick-off/family events	11	0	22
Other	8	1	380
Total	131	10	2,155

Table 14. Outreach and Student Engagement Activities Provided, Spring 2020

Outreach Activity	Spring 2020 Total No. of Clubs	Total No. of New Clubs	Total Hours
Coding club	38	20	1693
First Tech Challenge	2	0	44
Lego League	31	1	156
Other robotics club	1	1	30
Student conferences/events	2	0	18
Aspirations in Computing program	1	0	20
Hour of Code	13	10	50
Family Hour of Code	3	3	6
eSports Competition	4	4	65
Hack-a-thon	0	0	0
Out-of-school kick-off/family events	17	1	44
Other	16	5	65
Total	128	45	2,191

Varied Numbers of Students Were Served Through Each Outreach and Student Engagement Activity in Summer 2019, Fall 2019, and Spring 2020

LEAs were asked to indicate the numbers of elementary students, middle/junior high students, and high school students served through each outreach and student engagement activity in Summer 2019, Fall 2019, and Spring 2020. As Tables 15-17 show, more elementary students, than middle/junior high students and high school students, were involved in outreach and student engagement activities across the three grant implementation periods. In Summer 2019, the highest number of elementary students (n = 215) were involved in Coding Clubs while middle/junior high students (n = 62) and high school students (n = 42) were primarily served through "Other" activities. In Fall 2019, Hour of Code garnered the highest level of involvement from elementary students (n = 2,200) and middle/junior high students (n = 445) in comparison to other activities provided. High school students (n = 100), however, were more involved in Out-Of-School Kick-Off/Family Events in that semester. In Spring 2020, the highest numbers of elementary students (n = 1,853), middle/junior high students (n = 48), and high school students (n = 160) were involved in Out-Of-School Kick-Off/Family Events, "Other" activities, and the Aspirations in Computing Program respectively. Finally, a comparison of 2018-2019 (Fall 2018 and Spring 2019 only) and 2019-2020 (Fall 2019 and Spring 2020 only) data reveals that more students were served through outreach and student engagement activities in 2018-2019 (n = 17,230) than in 2019-2020 (n = 11,204). Despite these findings, it is important to note here that information was not collected on whether or not, and how consistently, LEAs kept attendance records for these activities.

Table 15. Numbers of Students Served Through Outreach and Student Engagement Activities, Summer 2019

Summer 2019			
Outreach Activity	**Total No. of Elementary Students**	**Total No. of Middle/Junior High Students**	**Total No. of High School Students**
Coding club	215	23	0
First Tech Challenge	0	0	0
Lego League	16	0	0
Other robotics club	12	12	0
Student conferences/events	0	0	0
Aspirations in Computing program	0	0	0
Hour of Code	0	0	0
Family Hour of Code	0	0	0
eSports Competition	0	0	0
Hack-a-thon	0	0	0
Out-of-school kick-off/family events	0	0	0
Other	116	62	42
Total	359	97	42

Table 16. Numbers of Students Served Through Outreach and Student Engagement Activities, Fall 2019

Fall 2019			
Outreach Activity	**Total No. of Elementary Students**	**Total No. of Middle/Junior High Students**	**Total No. of High School Students**
Coding club	680	116	32
First Tech Challenge	26	0	8
Lego League	322	70	0
Other robotics club	30	10	0
Student conferences/events	1,017	77	8
Aspirations in Computing program	0	0	0
Hour of Code	2200	445	0
Family Hour of Code	112	31	0
eSports Competition	0	0	0
Hack-a-thon	40	30	15
Out-of-school kick-off/family events	510	350	100
Other	58	12	69
Total	4,995	1,141	232

Table 17. Numbers of Students Served Through Outreach and Student Engagement Activities, Spring 2020

Spring 2020			
Outreach Activity	**Total No. of Elementary Students**	**Total No. of Middle/Junior High Students**	**Total No. of High School Students**
Coding club	612	32	28
First Tech Challenge	26	0	8
Lego League	239	20	0
Other robotics club	30	0	0
Student conferences/events	8	0	100
Aspirations in Computing program	0	0	160
Hour of Code	1143	0	0
Family Hour of Code	32	0	0
eSports Competition	20	20	36
Hack-a-thon	0	0	0
Out-of-school kick-off/family events	1,853	0	8
Other	370	48	43
Total	4,333	120	383

Underrepresented Student Populations Were Involved in Outreach and Student Engagement Activities in Summer 2019, Fall 2019 and Spring 2020, Although Some Were More Involved Than Others

LEAs were asked to specify the proportions of elementary students, middle/junior high students, and high school students, served through outreach and student engagement activities in Summer 2019 (Table 18), Fall 2019 (Table 19) and Spring 2020 (Table 20), that were members of particular underrepresented student populations (i.e., girls, English learners, students with disabilities, students on Free or Reduced Lunch, rural students, and students who are refugees). In Summer 2019, as Tables 18-20 indicate, rural students were the most represented underserved group among elementary students (37%) and high school students (86%), while girls (98%) were most represented among middle/junior high students (Table 18). In Fall 2019, the most represented underserved groups among elementary students, middle/junior high students, and high school students were girls (33%), students on Free or Reduced Lunch (56%), and rural students (54%) respectively (Table 19). In Spring 2020, rural students accounted for a higher percent of elementary students (36%), middle/junior high students (65%), and high school students (80%) than any one of the other underrepresented populations.

Table 18. Proportions of Traditionally Underrepresented Groups Among Students Served Through Outreach and Student Engagement Activities, Summer 2019

Summer 2019			
Student Group	**No. of Elementary Students Involved**	**No. of Middle/Junior High Students**	**No. of High School Students Involved**
Girls[vii]	100 (28%)	61 (98%)	14 (32%)
English Learners	31 (9%)	10 (16%)	11 (25%)
Students with Disabilities	11 (3%)	2 (3%)	6 (14%)
Students on Free or Reduced Lunch	107 (30%)	49 (79%)	28 (64%)
Rural Students	130 (37%)	42 (68%)	38 (86%)
Students who are Refugees	0 (0%)	2 (3%)	0 (0%)

Table 19. Proportions of Traditionally Underrepresented Groups Among Students Served Through Outreach and Student Engagement Activities, Fall 2019

Fall 2019			
Student Group	**No. of Elementary Students Involved[viii]**	**No. of Middle/Junior High Students**	**No. of High School Students Involved**
Girls	1,084 (33%)	432 (47%)	55 (28%)
Boys[ix]	1,228 (38%)	488 (53%)	140 (72%)
English Learners	124 (4%)	129 (14%)	14 (7%)
Students with Disabilities	98 (3%)	165 (18%)	9 (5%)
Students on Free or Reduced Lunch	762 (23%)	513 (56%)	58 (30%)
Rural Students	712 (22%)	127 (14%)	106 (54%)
Students who are Refugees	2 (<1%)	26 (3%)	1 (1%)

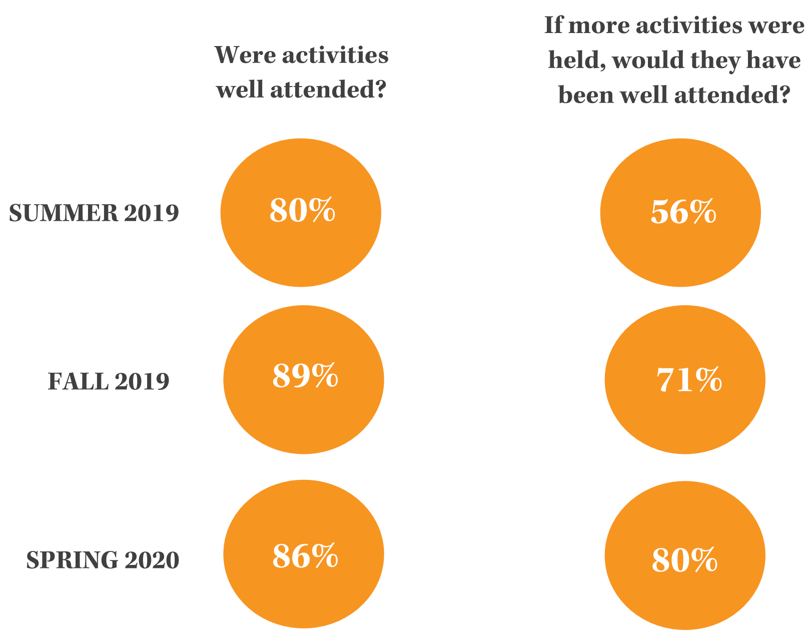
Table 20. Proportions of Traditionally Underrepresented Groups Among Students Served Through Outreach and Student Engagement Activities, Spring 2020

Spring 2020			
Student Group	**No. of Elementary Students Involved[x]**	**No. of Middle/Junior High Students[xi]**	**No. of High School Students Involved[xii]**
Girls	784 (21%)	34 (30%)	147 (63%)
Boys[xiii]	1,053 (28%)	62 (54%)	115 (49%)
English Learners	130 (4%)	8 (7%)	10 (4%)
Students with Disabilities	106 (3%)	12 (10%)	7 (3%)
Students on Free or Reduced Lunch	618 (17%)	56 (49%)	99 (42%)
Rural Students	1,344 (36%)	75 (65%)	186 (80%)
Students who are Refugees	0 (0%)	0 (0%)	0 (0%)

Responses from LEAs Suggest That Outreach and Student Engagement Activities Were Very Much in Demand in Summer 2019, Fall 2019, and Spring 2020

To understand the level of student demand for outreach and student engagement activities, LEAs were asked in Summer 2019, Fall 2019, and Spring 2020 to indicate whether or not "activities were well attended" and whether or not "if more activities were held they would have been well attended." As Figure 14 illustrates, an overwhelming majority of LEAs indicated that activities were well attended in the Summer (80%), Fall (89%), and Spring (86%). Additionally, most LEAs in the Summer (56%), Fall (71%), and Spring (80%) indicated that additional activities would also be well attended, if they were provided.

Figure 14. Percent of LEAs That Responded "Yes" to Questions About Student Demand for Outreach and Student Engagement Activities in Summer 2019, Fall 2019, and Spring 2020



PART SEVEN:

WORK-BASED LEARNING EXPERIENCES

This section addresses the types of work-based learning experiences provided by LEAs in Summer 2019, Fall 2019, and Spring 2020. It also covers the number of students served through work-based learning experiences, the participation of underrepresented student populations, and the level of student demand for these activities. A description of the grant activity *Work-Based Learning Experiences* is provided in the *Terminology and Definitions* section of the report.

Key Findings

LEAs Mostly Offered Internships and “Other” Types of Work-Based Learning Experiences Across the Three Grant Implementation Periods. Additionally, More Students Were Served Through These Opportunities in the Fall Than in the Summer or Spring

LEAs were asked to identify the types of work-based learning experiences they provided in Summer 2019, Fall 2019, and Spring 2020 and to specify the numbers of students who were involved in these experiences. As Table 21 illustrates, internships were the only form of work-based learning experiences provided in Summer 2019. However, in Fall 2019 and Spring 2020, LEAs provided internships and “other” types of work-based learning experiences. As it concerns student involvement in work-based learning experiences, Table 21 also shows that more students participated in work-based learning experiences in the Fall (n = 77) than in the Summer (n = 7) or Spring (n = 28).

Table 21. Numbers of Students Served Through Work-Based Learning Experiences in Summer 2019, Fall 2019, and Spring 2020

	Summer 2019	Fall 2019	Spring 2020
Work-Based Learning Experience	**No. of Unique Students Served**	**No. of Unique Students Served**	**No. of Unique Students Served**
Internships	7	49	11
Apprenticeships	0	0	0
Job shadows	0	0	0
Other	0	28	17
Total	7	77	28

Underrepresented Student Populations Were Involved in Work-Based Learning Experiences in Summer 2019, Fall 2019 and Spring 2020, Although Some Were More Involved Than Others

LEAs were asked to specify the proportions of students who participated in the various types of work-based learning experiences in the Summer, Fall, and Spring that were members of particular underrepresented student populations (i.e., girls, English learners, students with disabilities, students on Free or Reduced Lunch, rural students, and students who are refugees). As Tables 22-24 suggest, girls (100%) were the most represented underserved group among students who were involved in internships in the Summer. In the Fall, however, rural students accounted for the majority of students who participated in internships (89%) and all of the students who were involved in “other” work-based learning experiences (100%). Finally, in the Spring, students on Free and Reduced Lunch were the most represented underserved group among students involved in internships (60%), while all students who participated in “other” work-based learning experiences were rural (100%).

Table 22. Proportions of Traditionally Underrepresented Groups Among Students Served Through Work-Based Learning Experiences, Summer 2019

Summer 2019				
Student Group	**Internships**	**Apprenticeships**	**Job Shadows**	**Other**
Girls[xiv]	1 (33%)	0 (0%)	0 (0%)	0 (0%)
English Learners	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Students with Disabilities	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Students on Free or Reduced Lunch	3 (100%)	0 (0%)	0 (0%)	0 (0%)
Rural Students	1 (33%)	0 (0%)	0 (0%)	0 (0%)
Students who are Refugees	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Table 23. Proportions of Traditionally Underrepresented Groups Among Students Served Through Work-Based Learning Experiences, Fall 2019

Fall 2019				
Student Group	**Internships**	**Apprenticeships**	**Job Shadows**	**Other**
Girls	27 (50%)	0 (0%)	0 (0%)	11 (39%)
Boys[xv]	27 (50%)	0 (0%)	0 (0%)	17 (61%)
English Learners	7 (13%)	0 (0%)	0 (0%)	0 (0%)
Students with Disabilities	3 (6%)	0 (0%)	0 (0%)	3 (11%)
Students on Free or Reduced Lunch	25 (46%)	0 (0%)	0 (0%)	17 (61%)
Rural Students	48 (89%)	0 (0%)	0 (0%)	28 (100%)
Students who are Refugees	0 (0%)	0 (0%)	0 (0%)	0 (0%)

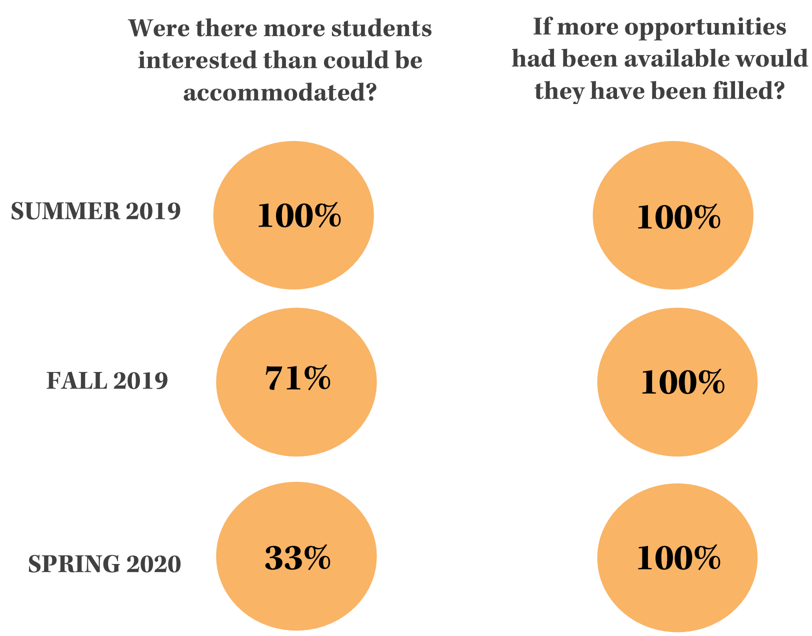
Table 24. Proportions of Traditionally Underrepresented Groups Among Students Served Through Work-Based Learning Experiences, Spring 2020

Spring 2020				
Student Group	**Internships**[xvi]	**Apprenticeships**	**Job Shadows**	**Other**
Girls	5 (50%)	0 (0%)	0 (0%)	10 (59%)
Boys[xvii]	4 (40%)	0 (0%)	0 (0%)	7 (41%)
English Learners	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Students with Disabilities	0 (0%)	0 (0%)	0 (0%)	2 (12%)
Students on Free or Reduced Lunch	6 (60%)	0 (0%)	0 (0%)	6 (35%)
Rural Students	0 (0%)	0 (0%)	0 (0%)	17 (100%)
Students who are Refugees	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Responses from LEAs Suggest That Work-Based Learning Experiences Were in Demand in Summer 2019, Fall 2019, and Spring 2020

To understand the level of student demand for work-based learning experiences, LEAs were asked in Summer 2019, Fall 2019, and Spring 2020 to indicate whether or not "more students were interested in work-based learning experiences than could be accommodated" and whether or not "more work-based learning experiences would have been filled if they were made available." As Figure 15 indicates, all LEAs in the Summer and most (71%) in the Fall indicated that more students were interested in work-based learning experiences than could be accommodated. Also, an important fraction of LEAs in the Spring (33%) also shared the same sentiment. As it concerns the provision of additional opportunities, all LEAs in the Summer, Fall, and Spring indicated that additional opportunities, if provided, would have been filled by students.

Figure 15. Percent of LEAs That Responded "Yes" to Questions About Student Demand for Work-Based Learning Experiences in Summer 2019, Fall 2019, and Spring 2020



PART EIGHT:

PROFESSIONAL LEARNING IN COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

This section identifies the types of professional learning activities in CS/IT provided to teachers and staff in Summer 2019, Fall 2019, and Spring 2020. It also discusses the amount of hours of professional learning in CS/IT provided, the numbers of teachers and staff served, the numbers of teachers and staff who have earned or are working towards earning certifications, and the level of teacher demand for professional learning activities. A description of the grant activity *Professional Learning in CS/IT* is provided in the *Terminology and Definitions* section of the report.

Key Findings

LEAs Provided Various Professional Learning Activities in Each Grant Implementation Period, Although More Opportunities and Hours of Professional Learning Were Provided in Fall 2019

LEAs were asked in the survey to identify the types of professional learning opportunities they provided in Summer 2019, Fall 2019, and Spring 2020 and to estimate the number of hours they provided for each activity. As Table 25 suggests, greater selections of professional learning activities were provided in the Fall and Spring than in the Summer. Furthermore, LEAs provided the highest number of hours of professional learning in the Fall (n = 1,460 hours) than in the Spring (n = 963 hours) or the Summer (n = 225 hours). Finally, a comparison of 2018-2019 (Fall 2018 and Spring 2019 only) and 2019-2020 (Fall 2019 and Spring 2020 only) data suggests that more hours of professional learning were provided by LEAs in 2019-2020 (n = 2,423 hours) than in 2018-2019 (n = 1,992 hours).

Table 25. Types and Hours of Professional Learning Opportunities Provided in Summer 2019, Fall 2019, and Spring 2020

	Summer 2019	Fall 2019	Spring 2020
Professional Learning Activity	**Hours of Professional Learning Provided**	**Hours of Professional Learning Provided**	**Hours of Professional Learning Provided**
Events	4	58	12
Face-to-face trainings	51	74	81
Modeling by computer expert	4	165	244
Online courses/webinars	0	32	90
College classes	0	0	0
Accredited classes provided by vendors	0	180	64
Out-of-school conferences/Workshops	123	195	85
Vendor mentoring	0	138	106
Other	43	618	281
Total	225	1460	963

More Teachers Were Served Through Professional Learning Activities in Fall 2019, and More Staff Were Served Through Professional Learning Activities in Spring 2020

To assess the impact or reach of professional learning activities, LEAs were asked to indicate how many teachers and staff were served through these opportunities in Summer 2019, Fall 2019 and Spring 2020. As Tables 26 and 27 illustrate, teachers and staff were reached through professional learning activities in the Summer, Fall, and Spring, although more teachers were involved in professional learning activities the Fall (n = 1,080) than in the Summer (n = 227) or Spring (n = 388), and a higher number of staff participated in the Spring (n = 217) than in the Summer (n = 37) or Fall (n = 87). Additionally, a comparison of 2018-2019 (Fall 2018 and Spring 2019 only) and 2019-2020 (Fall 2019 and Spring 2020 only) data reveals that more teachers and staff participated in professional learning activities in 2018-2019 (n = 2,193) than in 2019-2020 (n = 1,772).

Table 26. Numbers of Teachers Served Through Professional Learning Opportunities in Summer 2019, Fall 2019, and Spring 2020

Professional Learning Activity	Summer 2019 No. of Teachers Served	Fall 2019 No. of Teachers Served	Spring 2020 No. of Teachers Served
Events	0	492	17
Face-to-face trainings	171	227	135
Modeling by computer expert	35	127	72
Online courses/webinars	0	54	79
College classes	0	0	0
Accredited classes provided by vendors	0	5	7
Out-of-school conferences/Workshops	15	45	23
Vendor mentoring	3	90	13
Other	3	40	42
Total	227	1080	388

Table 27. Numbers of Staff Served Through Professional Learning Opportunities in Summer 2019, Fall 2019, and Spring 2020

Professional Learning Activity	Summer 2019 No. of Staff Served	Fall 2019 No. of Staff Served	Spring 2020 No. of Staff Served
Events	0	26	16
Face-to-face trainings	21	29	106
Modeling by computer expert	8	20	17
Online courses/webinars	0	0	41
College classes	0	0	0
Accredited classes provided by vendors	0	0	1
Out-of-school conferences/Workshops	8	7	27
Vendor mentoring	0	3	7
Other	0	2	2
Total	37	87	217

More Teachers Than Staff Had Earned or Were Working Towards Computer-Related Certifications in Summer 2019, Fall 2019, and Spring 2020

LEAs were asked to specify the numbers of teachers and staff that had earned, or were working towards earning, computer-related certifications in Summer 2019, Fall 2019, and Spring 2020. As Tables 28 and 29 reveal, some staff and teachers were pursuing, or had earned, certifications during each grant implementation period. However, a much higher number of teachers than staff had earned, or were in the process of earning, certifications during each period. In Summer 2019, for instance, 50 teachers had earned or were working towards certifications, while the number of staff was 5. In Fall 2019, the numbers of teachers and staff were 51 and 4 respectively, and in the Spring, 42 teachers and 5 staff had earned, or were pursuing, certifications. Finally, a comparison of 2018-2019 (Fall 2018 and Spring 2019 only) and 2019-2020 (Fall 2019 and Spring 2020 only) data suggests that more teachers had earned or were working towards certifications in 2019-2020 (n = 93) than in 2018-2019 (n = 76).

Table 28. Numbers of Teachers Who Had Earned or Were Seeking Computer-Related Certifications in Summer 2019, Fall 2019, and Spring 2020

	Summer 2019	Fall 2019	Spring 2020
Certifications	**No. of Teachers**	**No. of Teachers**	**No. of Teachers**
Code.org CS Fundamentals	40	31	25
Code.org CS Discoveries	4	4	6
Code.org CS Principles	4	7	2
A+ (Computer Repair/Maintenance)	0	0	0
Cisco Certified Networking Associate	0	0	0
Computer Science, Level 1	0	5	6
Computer Science, Level 2	2	1	0
Database Development (Oracle)	0	0	0
Exploring Computer Science	0	0	0
Introduction to Information Technology	0	0	0
Linux	0	0	0
Microsoft Certified Professional	0	1	0
Network+	0	0	0
Security	0	0	0
Web Development	0	0	3
Other	0	2	0
Total	50	51	42

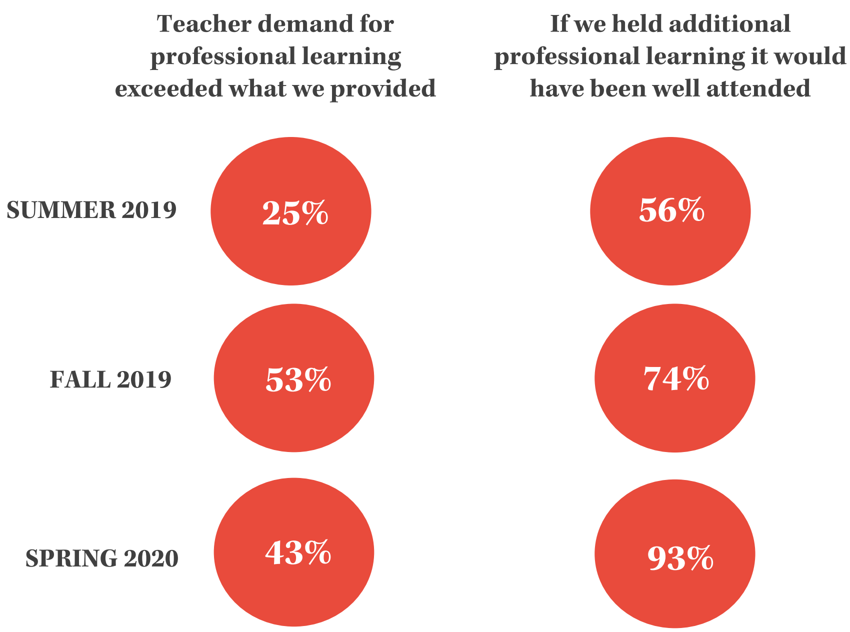
Table 29. Numbers of Staff Who Had Earned or Were Seeking Computer-Related Certifications in Summer 2019, Fall 2019, and Spring 2020

	Summer 2019	Fall 2019	Spring 2020
Certifications	**No. of Staff**	**No. of Staff**	**No. of Staff**
Code.org CS Fundamentals	0	2	2
Code.org CS Discoveries	2	1	0
Code.org CS Principles	1	0	0
A+ (Computer Repair/Maintenance)	0	0	0
Cisco Certified Networking Associate	0	0	0
Computer Science, Level 1	0	0	2
Computer Science, Level 2	2	0	0
Database Development (Oracle)	0	0	0
Exploring Computer Science	0	0	0
Introduction to Information Technology	0	0	0
Linux	0	0	0
Microsoft Certified Professional	0	1	0
Network+	0	0	0
Security	0	0	0
Web Development	0	0	1
Other	0	0	0
Total	5	4	5

Responses from LEAs Suggest That Professional Learning Activities Were in Demand in Summer 2019, Fall 2019, and Spring 2020

To understand the level of teacher demand for professional learning activities, LEAs were asked in Summer 2019, Fall 2019, and Spring 2020 to indicate whether or not "teacher demand for professional learning exceeded what we provided" and whether or not "additional professional learning would have been well attended if they were provided." As Figure 16 suggests, an important fraction of LEAs in the Summer (25%), Fall (53%), and Spring (43%) noted that more teachers requested to participate in professional learning than could be accommodated. Additionally, a majority of LEAs in the Summer (56%), Fall (74%), and Spring (93%) indicated that additional professional learning would have been well attended, had they been provided.

Figure 16. Percent of LEAs That Responded "Yes" to Questions About Teacher Demand for Professional Learning Opportunities in Summer 2019, Fall 2019, and Spring 2020



PART NINE:

POST-SECONDARY, INDUSTRY, AND COMMUNITY COLLABORATIONS

This section identifies the post-secondary institutions, industry, and community organizations with whom LEAs formed partnerships in Summer 2019, Fall 2019, and Spring 2020. It also covers the number of volunteer hours, amount of financial contributions, and value of in-kind contributions received through collaborations during each grant period, and the numbers of students and teachers served. A description of the grant activity *Post-Secondary, Industry, and Community Collaborations* is provided in the *Terminology and Definitions* section of the report.

Key Findings

LEAs Forged Various Types of Partnerships in Each Grant Implementation Period, Although More Partnerships Were Formed in the Spring than in the Summer or Fall

LEAs were asked to list the post-secondary institutions, industry, and community organizations with whom they collaborated to provide activities for students, teachers, and staff in the Summer, Fall, and Spring. As Tables 30 and 31 indicate, LEAs in the Summer, Fall, and Spring identified several post-secondary, industry, community, and "other" partners with whom they collaborated. However, more postsecondary partnerships (n = 6) and industry, community, and other partnerships (n =18) appear to have been formed by LEAs in the Spring Additionally, a comparison of 2018-2019 (Fall 2018 and Spring 2019 only) and 2019-2020 (Fall 2019 and Spring 2020 only) data suggests that more post-secondary, industry, community, and "other" partnerships were forged by LEAs in 2018-2019 than in 2019-2020.

Table 30. Post-Secondary Collaborations in Summer 2019, Fall 2019, and Spring 2020

Post-Secondary Institution	Summer 2019	Fall 2019	Spring 2020
Dixie State University	x		x
Salt Lake Community College	x	x	x
Southern Utah University	x	x	x
Southwest Technical College		x	x
Utah State University		x	x
Utah State University Eastern	x	x	x
Weber State University		x	
Total	4	6	6

Table 31. Industry, Community, and Other Collaborations in Summer 2019, Fall 2019, and Spring 2020

Industry, Community, and Other Collaborations	Summer 2019	Fall 2019	Spring 2020
Adobe		x	x
Best Friends			x
Boulder Community Alliance	x		
Bureau of Land Management			x
Canvas Alchemy			x
Castleview Hospital		x	x
Cleaver Octopus	x		
CodeChangers	x		x
Exchange Club of West Jordan		x	x
FIND		x	
Future IN Design	x		x
Grand Staircase Escalante			x
GuardSight			x
Iron Rock			x
Jordan District Spec.	x		
Kane Education Foundation			x
Lenovo		x	x
Nuttall's			x
Pluralsight		x	x
SoFi	x	x	x
South Central			x
Spy Hop	x		
Tech Up			x
Total	7	7	18

LEAs Received the Most Volunteer Hours from Partners in Spring 2020, the Largest Financial Contribution in Fall 2019, and the Highest Value of In-Kind Contributions in Summer 2019

To assess the quality of partnerships formed by LEAs in Summer 2019, Fall 2019, and Spring 2020, LEAs were asked in the survey to specify the number of volunteer hours, amount of financial contributions, and value of in-kind contributions provided by their partners during each grant period. Data suggests that LEAs received the highest number of volunteer hours from partnerships in Spring 2020 (n = 897 hours, Table 32), the largest financial contribution in Fall 2019 ($11,800, Table 33), and in-kind contributions totaling the highest fair market value in Summer 2019 ($6,750, Table 34).

Table 32. Volunteer Hours Provided by Partnerships in Summer 2019, Fall 2019, and Spring 2020

Type of Partnership	Summer 2019 Volunteer Hours	Fall 2019 Volunteer Hours	Spring 2020 Volunteer Hours
Post-Secondary Institutions	185	44	261
Industry Partners	0	456	502
Community Partners	96	206	134
Other	0	0	0
Total	281	706	897

Table 33. Financial Contributions Provided by Partnerships in Summer 2019, Fall 2019, and Spring 2020

Type of Partnership	Summer 2019 Value (in dollars) of Financial Contributions	Fall 2019 Value (in dollars) of Financial Contributions	Spring 2020 Value (in dollars) of Financial Contributions
Post-Secondary Institutions	$0	$1,000	$7,400
Industry Partners	$0	$7,920	$1,200
Community Partners	$750	$2,880	$1,300
Other	$0	$0	$0
Total	$750	$11,800	$9,900

Table 34. Value of In-Kind Contributions Provided by Partnerships in Summer 2019, Fall 2019, and Spring 2020

Type of Partnership	Summer 2019 Value of In-Kind Contributions	Fall 2019 Value of In-Kind Contributions	Spring 2020 Value of In-Kind Contributions
Post-Secondary Institutions	$6,500	$0	$2,300
Industry Partners	$0	$0	$300
Community Partners	$250	$0	$1,500
Other	$0	$0	$0
Total	$6,750	$0	$4,100

More Students and Teachers Were Served Through Partnerships in the Spring than the Summer or Fall

To assess the impact of partnerships, LEAs were asked to specify how many students and teachers were served (or impacted by the resources procured) through partnerships in Summer 2019, Fall 2019, and Spring 2020. As Tables 35 and 36 indicate, more students than teachers were served through partnerships in each of the grant implementation periods. However, more teachers and students were served through partnerships in Spring 2020, than in Summer or Fall 2019, perhaps owing to the higher number of partnerships formed that semester as highlighted in the previous finding.

Table 35. Numbers of Students Served Through Partnerships in Summer 2019, Fall 2019, and Spring 2020

	Summer 2019	Fall 2019	Spring 2020
Type of Partnership	**No. of Students Served**	**No. of Students Served**	**No. of Students Served**
Post-Secondary Institutions	182	304	696
Industry Partners	33	80	516
Community Partners	30	153	483
Other	0	0	0
Total	245	537	1,695

Table 36. Numbers of Teachers Served Through Partnerships in Summer 2019, Fall 2019, and Spring 2020

	Summer 2019	Fall 2019	Spring 2020
Type of Partnership	**No. of Teachers Served**	**No. of Teachers Served**	**No. of Teachers Served**
Post-Secondary Institutions	8	4	42
Industry Partners	1	0	28
Community Partners	3	0	30
Other	10	0	0
Total	22	4	100

PART TEN:
GENERAL EXPERIENCES

This section thematically analyzes LEA responses concerning four key topics: 1) teacher and student outcomes from participating in grant activities, 2) LEA experiences with increasing the participation of underrepresented students, 3) challenges they faced with implementing grant activities, and 4) their feedback for the STEM Action Center. The themes and comments highlighted in the tables below were gathered from across the three grant implementation periods.

Teacher and Student Outcomes from Participating in Grant Activities

LEAs were asked to discuss the outcomes of teachers that resulted from participation in grant activities. Their sentiments are captured by the themes and representative comments highlighted in the table below.

As noted in the table, LEAs observed increased knowledge and skills, increased interest in computing, improved confidence, and improved attitudes towards computing among teachers who participated in grant activities.

Table 37. Teacher Outcomes from Participating in Grant Activities

Theme	Example Quotes
Increase in Knowledge and Skills	"During our summer STEM camp, we had 2 certified teachers and 2 para professionals run the camp. We all gained skills by becoming experts in the area we taught." "Teachers have more experience and confidence in teaching coding, and in helping students with trouble shooting and de-bugging errors." "Teachers have gained an increased understanding of the "why's" and "how's" of integrated computational thinking in the classroom. They have also received tools to help them achieve success in this area."
Increase in Computing Interest	"The teachers show more interest in Computer Science, and are able to take lessons from the robotics program and use them in the regular classroom." "Teachers have enjoyed the project based learning and doing large projects with students. They are collaborating better together and looking for ways to partner up with each other. It has created an exciting environment." "Our teachers were looking forward to the training and utilizing the new STEM materials in hopes of gaining more participation for next year."
Increase in Confidence	"Our teachers are more confident in implementing ideas they have observed/co-taught in the Garage in their own classrooms than ever before. The have become comfortable visiting each other's classrooms and working together." "Staff are becoming more confident with the use of technology with 100% using technology regularly in the classroom. With the addition of the State contract for Adobe Creative Cloud, a few teachers have also integrated more computing use in their curriculum." "Computer specialists are more confident in providing quality instruction in coding and computational thinking."
Improvement of Attitude Towards Computing	"Teacher attitudes have shifted greatly from the onset of this project. Teachers who were once resistant have embraced the curriculum and love teaching coding!" "79% of computer teachers ranked the importance of teaching Computer Science 9 or 10 on a scale of 1-10. This shows a huge increase in teacher attitude. They have so much to teach, but most are now ranking CS as the most important thing they teach students. Teachers are enthusiastic and motivated by the content."

LEAs were asked to discuss the outcomes of students that resulted from involvement in grant activities. The table below features themes from their responses as well as a few illustrative comments.

As highlighted in the table, LEAs found that students' participation in grant activities helped to improve their attitudes towards computing, increase their confidence in computing, increase their involvement in computing-related courses and activities, improve their computing skills, and increase their interest in computing and pursuit of computing-related industry certifications.

Table 38. Student Outcomes from Participating in Grant Activities

Theme	Example Quotes
Improvement of Attitudes Towards Computing	"Student attitude and efficacy toward computing has improved." "Students had positive attitudes toward computing, enjoyed summer program. " "Our students who have been involved are excited to utilize technology. With the new building next year, we plan to expand our resources and availability to involve more students in before and after school programs. This not only improves their attitudes towards academics and computing but it improves their attendance at school overall." "Students were exposed to new technology and introduced to coding activities. Students learned that coding is something they can do. Surveys showed that students felt positive about their experience." "The most impactful student outcome was the changed in attitude toward computer science, agricultural science, nutritional science and electrical circuitry."
Increase in Confidence	"Our students have gained confidence, skills and knowledge in what computer science entails and has to offer them in the future." "Students have developed increased capacity and confidence in computational thinking." "All elementary students have received a rigorous and robust CS curriculum. Both teacher and student confidence has improved." "Improved confidence in computer information technology, specifically computer science and web development." "Student interns have gained increased confidence in web design."
Increase in Participation in Computing-Related Courses and Activities	"The main student outcomes have been the rapid growth of our enrollment and increased retention of our students through specialized academic coaching and STEM preparation of students at a younger age." "Out of the nine students that completed an internship at Itineris five of the students are females and six are from underrepresented populations."
Improvement of Computing Skills	"Elementary students gained skills in keyboarding. Junior High students were exposed to coding and to computer science classes. High school students developed deeper skills in coding and computer science." "Our students learned skills and created ways to be creative in each of their individual projects. They were very excited to share their projects with families when they were done." "Our greatest gain has been in application of computational thinking skills to various areas of life. Students have learned that computational thinking skills are life skills, and are motivated to continue learning. We don't have a lot of hard data outcomes this term because data was so hard to track from home. What we do have is a lot of very positive feedback from students and parents." "The students involved with our Lego League are showing growth in their ability to code in the robot." "Students had the opportunity to continue expanding their coding skills. They were then able to share their new skills with parents and other family members in the Community Coding Night." "Students are learning CS skills such as coding, network and internet, computing systems, data, and impacts of computing."
Increase in Computing Interest	"Teachers reported increased student interest in STEM areas." "There is improved interest in Computer Science from students who have participated in the program." "Improved interest in and attitudes toward computing: 86% of participants surveyed express increased interest in learning more about computing after participation." "We have gone from students who no very little about computer science and coding to students that want to know more." "Students have gained an increased interest in CS and robotics. They have been able to learn more about careers in CS and have learned that these careers are something that they can aspire to become."
Increase in Industry Certifications	"Approximately 20 students earned industry certifications (MOS: Word)." "There is an increased focus on industry exams and potential pathways for students."

Experiences with Increasing the Participation of Underrepresented Students in Grant Activities

LEAs were asked to discuss the strategies they utilized in increasing the participation of underrepresented students in grant activities. Their sentiments are captured by the themes and representative comments highlighted in the table below.

As discussed in the table, LEAs employed a variety of strategies to increase the participation of underrepresented students in grant activities. For example, some LEAs advertised available computing courses and activities to their entire student body, mandated participating for all students in computer science instruction, employed targeted recruitment, provided targeted programming, hired female staff, and reduced financial and other costs associated with participating in grant activities.

Table 39. Strategies Employed by LEAs to Increase the Participation of Underrepresented Student Populations in Grant Activities

Theme	Example Quotes
Use of General Advertisements	"Advertising, word of mouth, flyers." "We continued to use word of mouth, flyers, school announcements." "We provided flyers and posters." "We have made sure to advertise it to all populations and had an assembly to get students excited about coding from SPYHOP."
Mandating Participation for All Students	"Mandated 30 minutes of CS prep for all elementary students per week." "All elementary students across the district will participate in a minimum of 30 minutes a week computer science instruction through a prep period." "We continue to emphasize that coding instruction should happen in every class and every grade level. By providing a consistent expectation that coding is for every student, we are reaching every student, including underrepresented groups." "The typing classes are mandatory so the participation is representative of the entire elementary." "All students have participated. Students with disabilities have received additional time and support in the Garage as necessary; however, they have done incredibly well demonstrating their learning in non-traditional ways. No student has been kept from the Garage, and students love to attend."
Use of Targeted Recruitment	"Female and underrepresented students have been encouraged to participate as interns." "Being mindful of the demographic of our school and committing to having the demographic of the class match that of the school. We used direct recruiting methods." "We did individual outreach to underrepresented students at each high school with our SUU partner's Aspirations and Southern Utah Girls in Technology programs. These programs persisted well and adapted as things moved to a virtual environment this Spring." "Our school population facilitates inclusive behavior based on who attends. With 69.99% of students living in poverty and 29.99% of students with disabilities and 26% of students of color and we live in a rural community it is easier to increase participation of underrepresented students in computing activities. We serve the underrepresented in our school, that is who attends Pinnacle. Our teachers also heavily recruits girls to attend and we work closely with Girls Who Code to increase female participation."
Hiring of Female Staff	"I have made an effort to hire female instructors and female academic coaches to serve as role models for our students." "ACE recruited students from each of our local boundary schools to increase participation of underrepresented populations. ACE also hired female tutors and female adjunct instructors to serve as role models. In addition, we hired a full-time female CIT instructor which is a jointly funded position with Dixie State University."
Reducing Financial and Other Barriers	"Busing was provided by our district." "We only charged $60 for the 4-week summer program. We allowed fee waivers for anyone who qualified."

	"We removed all cost barriers for participation in FLL and as a result had 3 all girl First Lego League teams for the 2019-2020 season." "We offer full scholarships to any students with Free and Reduced Lunch status. We need to do a better job targeting these populations for summer offerings, our CodeCamp, in particular, can use enhanced outreach to these subgroups so they are aware of the offering." "We ask students to donate $25 for the summer STEM Camp but it is not required. We provide all of the materials, supplies, t-shirt, snacks, and lunch for the students whether or not they can pay the donation fee." "We provided all underrepresented students to participate in our code club. We had girls, ELLs, students with disabilities, low income students, and students of color all participate! We provided them with a snack after school, fun, and a safe place to be. It was free to participate thanks to our grant and for our school district for providing the snacks."
Providing Targeted Programming	"Our school is in a small, rural area. Our teacher knows all of the families, and consistently talks with parents and students, to encourage them to attend the activities." "3 of the schools are now offering and additional Girls Who Code program after school to meet more demand."
Increasing Parents' Awareness of Opportunities	"Our school is in a small, rural area. Our teacher knows all of the families, and consistently talks with parents and students, to encourage them to attend the activities." "We are still promoting the clubs heavily to girls. We have one all girls drone competition team. We market the clubs at elementary school STEM nights and at CTE open houses, and at places where there are a lot of families attending together."

LEAs were asked to describe the barriers they encountered while working to increase the participation of underrepresented students in grant activities. Themes from their responses, along with representative comments, are provided in the table below.

As findings discussed in the table below suggests, LEAs faced three key hindrances to increasing the participation of underrepresented students in grant activities. These barriers included students' own perceptions about their ability, or lack thereof, to do STEM, students' lack of access to technological resources, and lack of transportation for students to and/or from computing-related activities.

Table 40. Challenges Experienced by LEAs in Working to Increase the Participation of Underrepresented Student Populations in Grant Activities

Theme	Example Quotes
Students' Perceptions About Their Ability, or Lack Thereof, To Do STEM	"I think one barrier that we encounter is culture. We are finding that we get more boys participating than girls because of the cultural belief that computer science is more of a boy related field than a girl related field. It is also my belief that some of the students who come from low-income households are not as exposed to technology and that is why they are not signing up because they have not been exposed or had the experience that those from middle to higher income households may have." "Rural and low income students do not see the opportunities outside our area as possible for them so just sharing the information about these activities isn't enough, we need to facilitate their participation." "The barrier for the coding class was student self-perception that it would be too difficult for them." "Getting girls to understand they can be part of and enjoy the multiple careers in technology."
Lack of Access to Technological Resources	"Again, the greatest barrier has been inequity in the form of limited access to technology." "Computer and internet access in the homes of our underrepresented students." "Transportation, Internet access, and language barriers."
Lack of Transportation	"The largest barrier is transportation to camps. We tried to arrange for a van or small bus to transport students from the Shivwits reservation but we did not have support from the district. I think that if we could provide transportation, we would be able to include the students who underrepresented."

	"The biggest barrier we face is travel home from the activities. Some of our students live about 20 miles away, and do not have transportation from the school if they do not ride the bus home." "Transportation is an issue in our community. Low income students who are unable to be dropped off or picked up from STEM programming are sometimes unable to participate." "Our biggest barrier in getting participation from our underrepresented groups is mainly because of transportation issues." "The biggest barrier we encountered was transportation." "The ability for parents to transport as many come from single family homes with the parent working." "Transportation, Internet access, and language barriers." "We saw an increase, but travel requirements is a barrier. We are looking at doing more as part of after school programs and offering CS courses during the school year."

LEAs were asked to describe the supports they needed to increase the participation of underrepresented students in grant activities. The table below features themes from their responses as well as a few illustrative comments.

As highlighted in the table below, LEAs needed additional supports—in the form of buy-in from school, funding, concerted support and involvement of families, transportation, language translation assistance, and targeted campaigns/advertisements—to increase the participation of underrepresented students in grant activities.

Table 41. Types of Support Needed by LEAs to Increase the Participation of Underrepresented Student Populations

Theme	Example Quotes
Need for More Buy-In From School, Teachers, and Staff	"Additional funds are always nice but it is bigger than a money issue. There has to be a culture of encouraging students who are generally underrepresented to BELIEVE that they can do coding and have a career using computing skills. This is a culture problem more than anything. As educational institutions we must change our thinking and believe that girls, students with disabilities and students of color can and should join this field in their futures. Our teacher is very inclusive and that makes all the difference." "We need help or suggestions for getting information to administrators about the importance of computer science and the need to put it in the weekly or daily schedule." "We needed the support of the principal. In some schools with the highest need (Title I), the principal chose not to participate. We also need the support of the teachers in the building, because sometimes we are using their classroom. Also, custodians need to clean up, etc. It takes some extra effort on everyone's part." "More buy in from admin, dedicated time and increase in technology." "Buy in at a school level, ideas to integrate into the curriculum." "Support from our counselors in discussing class options with students." "We are working on counselors and talking about success that girl students are having in the IT courses."
Need for Additional Funding	"Additional funding for teacher learning and resources." "Funding always remains as a needed support." "Funding for additional supplies for virtual programming packets." "We currently only have one position which is filled. More funding for another paid internship would be helpful in hiring an underrepresented student."
Need for More Family Support and Involvement	"Collaborating with feeder schools and families to encourage students to take computer science course as an incoming tenth grader." "Family support and communication." "Technology in the home and parent support. When parents are at work and the students are left to do work on their own, it is hard for some to find motivation to do the work." "Parent understanding of what the program entailed could possibly generate more interest. Thus, we have planned our Dr. Seuss Night as a STEM night as this is typically a well-attended event."

Need for Transportation Assistance	"Possibly funding to support bussing." "After-school transportation would help." "We have provided rides for students sometimes, but this is a time-consuming, and costly task. A system of transportation would be very helpful." "We would like to start providing CS opportunities to our students that come from the Shiv Wits Indian reservation. We have found that those students are interested in learning about CS but they do not have transportation home after our clubs finish. A solution for that would be to take our program to them but at this time we do not have the capabilities to do that." "More access to travel options."
Need for Language Assistance	"Translation tools." "The greatest supports needed were 1. One on one communication in the home language (mostly Spanish) and 2. Adjustments to activities that don't require a lot of technology access." "Translators to help reach Spanish speaking students and parents."
Need for Targeted Recruitment Materials	"Additional support for marketing to minorities and other underserved populations." "I would love to have some materials promoting STEM (fliers social media posts etc.) that we could use that show underrepresented students." "We would appreciate some marketing materials promoting STEM that has under represented populations that could be used when we market specific programs."

Challenges with Implementing Grant Activities

LEAs were asked to report on the challenges, if any, they experienced with implementing grant activities, including any that may have resulted from the COVID-19 pandemic. Their sentiments are captured by the themes and representative comments highlighted in the table below.

As Table 42 illustrates, LEAs experienced a wide variety of challenges with implementing grant activities. Challenges faced by LEAs included, but were not limited to, shortage of staff, postponement/disruption of planned activities due to the COVID-19 pandemic, and the unanticipated creation or restructuring of lesson plans for computer science courses.

Table 42. Challenges Faced by LEAs with Implementing Grant Activities

Theme	Example Quotes
Lack of Staff	"More summer camp sessions were planned but staffing and student participation was not adequate." "The instructor of our dedicated computing class was not able to coach our Lego League team due to time constraints. We were unable to find a volunteer to serve as coach." "We were unable to have a summer school program because we could not staff it properly. We were on a tight schedule when we received the funding and were just unable to employ teachers." "The availability of staff limited our ability to provide after school club activities or summer camps."
Postponement or Cancellation of Professional Development Due to COVID-19	"We had to move the teacher training day and we were unable to host face to face activities in the makerspace. This is due to coronavirus and the restrictions placed by the health department." "We were not able to do all of the peer coaching/modeling because of COVID closures." "We were going to offer some professional development opportunities for teachers during Summer 2019. We decided to postpone that professional development until Summer 2020." "We had planned additional professional development for our teachers and principals, which would have involved attending Lego training in SLC. This happened just as the state shut down due to COVID-19 and all training was cancelled." "We also had planned to send more teachers to trainings, but they were cancelled."
Disruption of Planned Activities Due to COVID-19	"COVID pretty much changed everything. We were unable to finish the year as planned." "We were unable to have a summer camp due to COVID-19. We also had to cancel our code camp jr. for the same reason." "There were several after school/end of the year coding and robotics family/community events that were cancelled due to COVID-19 closures." "We were not able to host our 3rd annual Code Camp Jr because of the school closures. We also had to cancel our summer camps because of the pandemic." "Due to COVID-19 we had to stop our LEGO League and Coding clubs two months early." "We were not able to meet in person for our weekly club meetings. We were not able to attend Code Camp Jr. as a field trip. COVID-19 was the reason for not accomplishing these activities."
Unanticipated Need to Create or Restructure Lesson Plans	"Not all lessons were completed. Initially it was decided that elementary CS teachers be given links to free online lessons for their curriculum. It was later determined that more detailed lesson plans as well as the resources to teach each lesson needed to be developed to ensure student mastery of the standards." "We had no idea that the Tech Trep courses would no longer meet our needs as they were originally created. We also didn't anticipate that we would end up developing our own version of those courses to better meet our students where they are."

Feedback for the STEM Action Center

LEAs were invited to share any feedback they had about working with the STEM Action Center. The table below features themes from their responses as well as a few illustrative comments.

In response to the question about their feedback for the STEM Action Center, LEAs shared general remarks of appreciation and noted that the STEM Action Center provided them with needed support and funding, was receptive to feedback, and understanding of their needs to alter grant objectives.

Table 43. LEA Feedback for the STEM Action Center

Theme	Example Quotes
Appreciative of Grant Program	"Thank you for this opportunity, the impact has been huge for our teachers and students and we look forward to sustaining the momentum we were able to make." "The STEM Action Center staff have been wonderful to work with. I really appreciate their patience and kindness as they deal with us." "We are greatly appreciative of the funding and know we would not have been able to accomplish so much without this funding."
Provided Needed Support	"Lynn Purdin has been so amazing and helpful. I took over the last year of this grant as a new employee and she helped me every step of the way." "Lynn Purdin has been excellent at helping us with reporting. All the personnel are very responsive to email and phone calls. We couldn't have had a better experience." "STEM Action center has been very helpful and encouraging during our implementation." "I love working with Lynn at the STEM Action Center. She is so helpful, kind, and knowledgeable. My questions are always answered in a timely manner. She is willing to help me troubleshoot any problems or concerns. I look forward to many years with the STEM Action Center." "I am grateful for our relationship and the never-ending support we receive from the STEM Action Center. They are advocates and friends."
Facilitated the Achievement of Set Goals through Grant Funding	"This has been an overwhelmingly positive experience and we have made incredible progress towards our overarching goals of removing barriers and being able to provide high-quality STEM programming to all students in Kane County." "We were able to build something amazing which has transformed our school and opportunities for children. Thank you for being supportive of our big ideas. We welcome continued partnership in the future!" "The impact has been huge for our teachers and students and we look forward to sustaining the momentum we were able to make." "We appreciated the grant because we were able to service a lot of kids that would've otherwise not been serviced." "Most of the student who participated in the Code to Success and our Computer Science courses were Native American. We feel that this was a major success and the data does not necessarily reflect this." "The funding is the best support for meeting the needs of our 69.99% underprivileged student body. We could not do the wonderful things that are enriching our students lives without the additional funding!"
Receptive to Feedback	"Although reports are rarely fun to complete, the STEM AC staff have taken feedback to standardize the report."
Accommodating of Unanticipated but Necessary Changes to Goals and Objectives	"The STEM Action Center has been extremely understanding with our unique situation as we built this grant then had major shifts at our school due to a boundary change, new school building, moving to another school, and difficulties with one of our business partnerships not following through with information on a possible training. Thanks for understanding and allowing us to more forward by planning for our new location, students, and providing resources to kick off a new and improved STEM Technology program next year!" "They have provided flexibility when we have hit challenges we couldn't overcome and they try to find additional resources to help in meeting our students' needs." "STEM AC staff have been responsive and thoughtful in allowing InTech flexibility as circumstances deviated from those that existed when the original grant was written."

PART ELEVEN:

CONCLUSIONS AND CONSIDERATIONS

Utilizing survey data, this progress report addressed the implementation of the Computing Partnerships Grants Program in Summer 2019, Fall 2019, and Spring 2020. First, it examined the demographics and objectives of LEAs that received grant funding during the above-identified grant implementation periods. Second, it covered each of the grant activities that LEAs partook in as well as their key contributions including, but not limited to, the amount and type of offerings they provided for each grant activity, the numbers of students and teachers they served through each grant activity, and the participation of underrepresented students in each grant activity. Finally, the report thematically analyzed LEA responses concerning teacher and student outcomes from participating in grant activities, their experiences with increasing the participation of underrepresented students, challenges they faced with implementing grant activities, and their feedback for the STEM Action Center. This section reviews key findings from the report in relation to the topics highlighted above. It also provides considerations for the Computing Partnerships Grants Program that are informed by the progress report's findings and program objectives. Additional, and more nuanced, considerations are provided in the accompanying report that evaluates the impact of grant program.

Summary of Findings

Demographics and Objectives

As findings from Part 3 of the report reveal, 30 LEAs, 33 LEAs, and 29 LEAs, respectively, were involved in grant activities in Summer 2019, Fall 2019, and Spring 2020. These LEAs had multiple and varied objectives that they sought to achieve using grant funding including, but not limited to, augmenting computer science curricula, hiring content experts to teach particular computing courses, increasing the participation of students in work-based learning experiences, integrating new educational software and web programs into existing courses, creating more after-school activities focused on computer science, and providing subject-specific professional development to teachers. Among the various grant activities pursued by LEAs across the three grant periods, the two most popular were Outreach and Student Engagement and Professional Learning in CS/IT. And as findings from part 3 further illustrate, students from all grade levels—elementary school (K-6), middle/junior high school (7-9), and high school (10-12)—were impacted through the grant activities provided during each grant period.

Grant Activities, Priority Areas, and Key Contributions

As discussed in Parts 4 to 9 of the report, LEAs participated in six grant activities including Dedicated Computing Courses, Integration of Computing into Existing Courses, Outreach and Student Engagement Activities, Work-Based Learning Experiences, Professional Learning in CS/IT, and Post-Secondary Institutions, Industry, and Community Collaborations. As findings from these sections also reveal, LEAs provided a variety of offerings to students and teachers in their fulfilment of each grant activity. Additionally, students and teachers at all grade levels were served through the varied opportunities that LEAs provided. Students involved in grant activities were often members of underrepresented groups such as girls, English learners, students with disabilities, students on Free or Reduced Lunch, rural students, and students who are refugees. Additionally, the activities made available to students and teachers were so very sought that LEAs often indicated that more students and teachers expressed interest in participating than they could accommodate. Finally, findings also suggest that LEAs formed partnerships with various post-secondary institutions, industry, and community organizations and received noteworthy contributions (in terms of volunteer hours, financial gifts, and in-kind provisions) from them.

General Experiences

Part 10 of the report documented the open-ended responses of LEAs to questions concerning teacher and student outcomes from participating in grant activities, their experiences with increasing the participation of underrepresented students, challenges they faced with implementing grant activities, and their feedback for the STEM Action Center. Findings suggest that LEAs observed increased knowledge and skills, increased interest in teaching computing, improved confidence, and improved attitude among teachers involved in grant activities. Among student participants, LEAs observed improved attitude, increased confidence, increased participation in computing courses and activities, improved skills, increased interest in computing, and increased interest in and completion of industry certifications. With regard to their experiences with increasing the participation of underrepresented students, LEAs noted the strategies they employed, the barriers they encountered, and the supports they needed to accomplish this objective. Some of their more frequently cited strategies include general advertisements, mandating participation in computer science for all students, targeted recruitment, targeted programming, increasing parents' awareness of opportunities, and hiring female staff. Despite these strategies, LEAs faced obstacles in incentivizing participation among underrepresented students because of students' perceptions about their ability to do STEM and their lack of access to technological resources and transportation to and from activities. Additionally, LEAs perceived that they would have been more successful at accomplishing this objective if they had more supports in the form of buy-in from school, teachers, and staff, additional funding, more family support and involvement, transportation assistance, language assistance, and more support for targeted recruitment. When queried about the challenges, if any, they faced with implementing grant activities, LEAs noted that they were challenged by lack of staffing for activities, unanticipated needs to create or restructure lesson plans for certain computing courses, and cancellations, postponements, and other disruptions to activities because of school closures due to COVID-19. Finally, with regard to their feedback for the STEM Action Center, many LEAs provided general appreciation for their partnership with the STEM Action Center, providing specific thanks for the support they provided, their receptivity to feedback, the grant funding they provided that facilitated the achievement of important goals, and their flexibility in accommodating the unanticipated but necessary changes to goals and objectives.

Considerations for the Computing Partnerships Grants Program

Encourage the Provision of Dedicated Computing Courses that Serve High School Students

While early exposure to computer science—whether at the elementary, middle, or high school level—helps to increase students' curiosity and interest in computer science (Freeman et al., 2014; Papini et al., 2017), research also underscores the unique role that engagement in high school STEM coursework plays in a student's decision to pursue post-secondary education and a STEM major (Robinson, 2003). In Fall 2019 and Spring 2020, data from the evaluation suggests that a disproportionately greater number of course sections were added for *Elementary Computing Specialty*—a computer science course designed for elementary students—than for courses geared towards high school students such as *Introduction to Python* and *Exploring Computer Science 1.* In light of the aforementioned findings from extant literature, it is critical that important consideration is given to increasing the provision of dedicated computing courses for high school students.

Provide Incentives for Teachers to Earn Computer-Related Certifications

As research suggests, the vast majority of computer science teachers in U.S. K-12 schools do not hold a degree in computer science (Leyzberg & Moretti, 2017). As a result, many often lack the competence and confidence needed to provide effective instruction in computing-related courses (Joshi & Jain, 2018; Pollock et al., 2017). Given this research finding, and the relatively low numbers of teachers who were reported by LEAs to have earned, or began the process of earning, computing-related certifications in Summer 2019, Fall 2019, and Spring 2020, it is crucial that the Computing Partnerships Grants Program encourages or provides incentives to teachers to pursue these certifications.

Encourage the Participation of High School Students in Work-Based Learning Experiences

Researchers have unequivocally noted that co-curricular opportunities such as externships, internships, and job shadows are useful avenues for increasing students' interest and engagement in computer science (Sanzenbacher, 2013). Despite this research finding, data from the evaluation suggests that high school students are much less involved in work-based learning experiences (i.e., apprenticeships, internships, and job shadows) than they are in other Computing Partnerships grant activities. It is important, therefore, for more attention to be given to increasing the participation of high school students in these hands-on and experiential opportunities.

Narrow the Selection of Outreach and Professional Learning Activities to Those That Are Most Impactful

As findings from the progress report reveal, some outreach and professional learning activities provided receive no participation from teachers and students, while others receive some or a lot of participation. It is important, then, that attention is given to carefully selecting and providing opportunities based on the level of involvement they garner from students and teachers and their effectiveness at producing the desired student and teacher outcomes in computing.

Create and Make Available a Repository of Computer Science Lessons That Teachers Could Integrate in their Curricula

To facilitate the integration of computing into already-existing, non-computing courses, it may be useful for the Computing Partnerships Grants Program to create and make available a repository of "model computer science lessons" that computer science teachers in participating schools may integrate in their curricula.

Collect Data on the Participation of Other Underrepresented Student Populations

Currently, the grant program collects data on the participation of girls, English learners, students with disabilities, students on Free or Reduced Lunch, rural students, and students who are refugees. However, the involvement of other underrepresented populations, particularly students of color, is not currently assessed. This data may be important to collect given the efforts of some LEAs, as discussed in section 10 of the report, to increase the participation of students of color in their activities. Data on the level of involvement of this student population in provided courses and activities will therefore permit a better assessment of the progress of LEAs in achieving their goals.

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Issues Identified with Data Reporting

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[i] Boys are not an underrepresented student population. However, we provide data on them in this and other similar tables for the purpose of comparison to girls.
[ii] See endnote i.
[iii] The high percent of students who are refugees recorded here seems unreasonable and is due to grantee error in data reporting.
[iv] Percentages of girls and boys are expected to sum up to 100%. However, in some cases like this one, they do not because of grantee error in data reporting.
[v] See endnote i.
[vi] See endnote i.
[vii] The participation of boys is not reported for summer 2019 because the data was not collected. Boys, however, are not an underrepresented student population. We provide data on them in fall 2019 and spring 2020 for the sole purpose of comparison to girls.
[viii] See endnote iv.
[ix] See endnote i.
[x] See endnote iv.
[xi] See endnote iv.
[xii] See endnote iv.
[xiii] See endnote i.
[xiv] See endnote vii.
[xv] See endnote i.
[xvi] See endnote iv.
[xvii] See endnote i.

FOR RELEASE JULY 30, 2020

LEARNING MATHEMATICS WITH TECHNOLOGY IN UTAH

An Evaluation of Student Attitudes and Perceptions of Math Personalized Learning Software

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

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THE UNIVERSITY OF UTAH
UTAH EDUCATION POLICY CENTER

Bridging Research, Policy, and Practice

The Utah Education Policy Center (UEPC) is a an independent, non-partisan, not-for-profit research-based center at the University of Utah founded in the Department of Educational Leadership and Policy in 1990 and administered through the College of Education since 2007. The UEPC mission is to bridge research, policy, and practice in public schools and higher education to increase educational equity, excellence, access, and opportunities for all children and adults.

The UEPC informs, influences, and improves the quality of educational policies, practices, and leadership through research, evaluation, and technical assistance. Through our research, evaluation, and technical assistance, we are committed to supporting the understanding of whether educational policies, programs, and practices are being implemented as intended, whether they are effective and impactful, and how they may be improved and scaled-up, and become sustainable.

Please visit our website for more information about the UEPC.

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Introduction

The Utah STEM Action Center (AC), a division of the Utah Department of Heritage & the Arts, is an organization that seeks to advance STEM education best practices in Utah.[1] In 2013, the Utah Legislature passed House Bill 139[2] (HB 139), which created the STEM AC. According to the bill, the primary goal of the STEM AC is to provide STEM education and digital learning tools to support teacher professional development and excite students about STEM. The bill mandated the STEM AC act as a research and development center for education-related instructional technology. In 2014, Utah's Legislature passed House Bill 150,[3] which expanded the scope of the STEM AC's education-related technology activities and provided ongoing appropriation for the STEM AC from the general fund.

K-12 Math Personalized Learning Software Grant

The K-12 Math Personalized Learning Software Grant is a cornerstone of the STEM AC's education initiatives. The purpose of the K-12 Math Personalized Learning Software Grant is to provide students in kindergarten through grade 12 with access to math personalized learning software to improve student outcomes and math literacy[4]. By increasing student awareness, engagement, interest, and perceived utility of math, the digital math software programs are also expected to improve student math performance. School districts or charter schools apply to STEM AC for grant funds to purchase licenses that provide students and educators access to approved digital math software programs. The approved list of digital math programs is updated annually.

In 2016, the STEM AC contracted with the Utah Education Policy Center (UEPC) to conduct a five-year evaluation of the K-12 Math Personalized Learning Software Grant. The UEPC's evaluation of the grant program focuses on program outcomes across three domains: teacher knowledge, practice, and outcomes; student learning as measured by standardized math test scores; and student attitudes and perceptions—the focus of this particular report.

For more information on the other two domains of our digital math evaluation, we encourage readers to explore the 2020 *Teaching Mathematics with Technology in Utah: An Evaluation of Teacher Knowledge, Practices, and Outcomes Using Mathematics Personalized Learning Software*[5] and *Impact of K-12 Math Personalized Learning Software on Student Achievement.*[6]

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[1] https://stem.utah.gov/about/

[2] https://le.utah.gov/~2013/bills/static/HB0139.html

[3] https://le.utah.gov/~2014/bills/static/HB0150.html

[4] K-12 Math Personalized Learning Software Grant, https://stem.utah.gov/grants/k-12-math-personalized-learning-software-grant/

[5] Onuma, F. J., Rorrer, A. K., Pecsok, M., & Weissinger, K. (2020). *Teaching Mathematics with Technology in Utah: An Evaluation of Teacher Knowledge, Practices, and Outcomes with Using Mathematics Personalized Learning Software.* Utah Education Policy Center: Salt Lake City, UT.

[6] Owens, R., Rorrer, A., Ni, Y., Onuma, F., Pecsok, M., & Moore, B. (2020*). Longitudinal Evaluation of the Math Personalized Learning Software Grant Program.* Salt Lake City, UT: Utah Education Policy Center.

As a part of our evaluation of the K-12 Math Personalized Learning Software Grant, the UEPC administers an annual survey, the UEPC K-12 Math Personalized Learning Software Student Survey, to students in grades 3-12 who use math personalized learning software provided through a STEM AC-provided software license. Historically, this survey has asked students about the frequency with which they use math software and their attitudes toward math and math software. The 2020 version of the UEPC K-12 Math Personalized Learning Software Student Survey, which was administered in spring of 2020, was expanded to include additional survey items focused on student perceptions of how teachers integrate math software into classroom learning experiences. The findings from this survey are the focus of this report.

About the Math Personalized Learning Software Providers

Through the STEM AC's K-12 Math Personalized Learning Software Grant, six personalized learning software programs were available in 2019-2020: ALEKS, Imagine Math, ST Math, i-Ready, Mathspace, and DreamBox. These programs are geared toward different grade levels and approach the goal of providing math personalized learning experiences for students in unique ways. *Table 1. Descriptions of K-12 Math Personalized Learning Software Programs* provides a brief summary of the six programs of interest in this survey.

Table 1. Descriptions of K-12 Math Personalized Learning Software Programs

Personalized Learning Software Program	Grades Served	Description
ALEKS (Assessment and Learning in Knowledge Spaces)	K-12	ALEKS is a web-based software produced by McGraw Hill. The program uses adaptive questioning, focused instruction, and reassessment to ensure retention of new skills.[7]
Imagine Math	PreK-8	Imagine Math is a supplemental program that seeks to develop students' ability to communicate in the language of mathematics and make connections.[8]
ST Math	Pre-K-8	ST Math is a visual instruction program with a focus on spatial-temporal reasoning.
i-Ready	K-8	i-Ready is a program that uses personalized instruction and learning games; also provides teachers with tools for instruction.[9]
Mathspace	6-12	Mathspace is a program that uses personalized learning, interactive textbooks, and step-by-step feedback to help "high achievers" and "those who struggle."[10]
DreamBox	K-8	DreamBox is an adaptive K-8 program that meets student at all levels, from intervention to enrichment, and offers instruction in both Spanish and English.[11]

[7] See https://www.aleks.com/about_aleks for more information on ALEKS.

[8] See https://www.imaginelearning.com/math for more information on Imagine Math.

[9] See https://www.curriculumassociates.com/products/i-ready for more information on iReady.

[10] See https://mathspace.co/us for more information on Mathspace.

[11] See https://www.dreambox.com/ for more information on DreamBox.

Report Organization

In our introduction, we described the STEM AC's Math Personalized Learning Software Grant and the software providers available to students through the grant during the 2019-2020 school year. In the remainder of this report, we provide a review of relevant research in the areas of students' attitudes toward math and students' perceptions of technology in order to provide context and situate this study's findings in the literature base. We then explain the purpose of this study and our corresponding methodology, including information about the design and administration of our survey instrument. In the remaining sections of the report, we present our findings from five evaluation questions, pertaining to the characteristics of survey respondents, the nature and prevalence of math personalized learning software use, the integration of math personalized learning software into classroom learning experiences, students' attitudes and perceptions, and relationships among engagement with math software (frequency of software use and integration with classroom learning experiences) and students' attitudes and perceptions using correlational analysis. We conclude with a summary of our findings and a discussion of considerations for the K-12 Math Personalized Learning Software Program.

Background Research

Numerous studies have explored the impact of math personalized learning software on student achievement outcomes (Cornelius, 2013; Pane et al., 2010; Pane et al., 2014; Wang & Woodworth, 2011). Yet, these studies did not attend to students' perceptions, attitudes, or beliefs about these software programs. Therefore, we offer a review of literature in two related bodies of research: 1) students' attitudes toward math and the relationship of these attitudes to achievement, and 2) students' perceptions of technology in the math classroom. This report focuses on students' reported experiences with, perceptions of, and attitudes toward math and math personalized learning software. As such, we seek to provide context by reviewing studies with related aims in order to situate our findings. We encourage readers with a broader interest in STEM education or a particular interest in teacher practices to read *Teaching Mathematics with Technology in Utah: An Evaluation of Teacher Knowledge, Practices, and Outcomes Using Mathematics Personalized Learning Software.*[12] For those seeking to learn more about technology and student math achievement, please read our report titled *Impact of K-12 Math Personalized Learning Software on Student Achievement.*[13]

Students' Attitudes toward Math

For more than 50 years, researchers have explored students' attitudes toward mathematics (ATMs), guided by the assumption that math learning is influenced, in part, by a set of affective factors (Gómez-Chacón, 2000; McLeod, 1992; Zan, Brown, Evans, & Hannula, 2006). In a similar vein, teachers have been urged to cultivate productive mathematical dispositions in students (Lappan, 1999), which have been framed as a strand of mathematical proficiency (Kilpatrick, Swafford, & Findell, 2001). Influenced by the field of social psychology, a body of research has explored the relationship between various aspects of ATM (e.g., enjoyment, motivation, and self-confidence to do math; perceived value and utility of math; etc.) and student achievement in math (DiMartino, 2016; Lim & Chapman, 2013). It is important to note that in seminal studies, ATM was rarely explicitly defined (DiMartino, 2016) and definitions continue to vary across studies (Daskalogianni & Simpson, 2000; DiMartino & Zan, 2015). As a reference point, Ma and Kishor (1997) expanded Neale's (1969) definition of ATM as "an aggregated measure of 'a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless'" (p. 632, as cited in Ma & Kishor, 1997) "to include students' affective responses to the easy/difficult as well as the importance/unimportance of mathematics" (p. 27).

A number of studies document a relationship between ATM and math achievement. Ma and Kishor (1997) conducted a meta-analysis of 113 studies on the relationship between ATM and math achievement, which resulted in an overall mean effect size of 0.12, suggesting that the

[12] Onuma, F. J., Rorrer, A. K., Pecsok, M., & Weissinger, K. (2020). *Teaching Mathematics with Technology in Utah: An Evaluation of Teacher Knowledge, Practices, and Outcomes with Using Mathematics Personalized Learning Software.* Utah Education Policy Center: Salt Lake City, UT.

[13] Owens, R., Rorrer, A., Ni, Y., Onuma, F., Pecsok, M., & Moore, B. (2020*). Longitudinal Evaluation of the Math Personalized Learning Software Grant Program.* Salt Lake City, UT: Utah Education Policy Center.

relationship was positive and "statistically significant but not strong" (p. 39). More recent research has continued to document positive relationships between ATM and achievement (Bouchey & Harter, 2005; Chen et al., 2018; Hammouri, 2004; House & Telese, 2008; Reed, Drijvers, & Kirschner, 2010; Samuelsson & Granstrom, 2007; Stankov & Lee, 2014). In their review of large-scale studies of noncognitive predictors of achievement, Stankov and Lee (2014) found that confidence was highly predictive of achievement gains. Though correlations have been explored extensively, the research base has had difficulty establishing whether there is a causal relationship between students' attitudes and achievement (Hannula, 2012; Ma & Kishor, 1997). Ma and Xu (2004) found that "prior achievement significantly predicted later attitudes across grades 7-12" (p. 273), whereas Chen et al. (2018) suggest that positive attitudes in math have "a unique and significant effect on math achievement independent of general cognitive abilities" (p. 11). Hannula (2012) suggested that this variance in studies of the relationship between ATM and achievement may be due to reciprocal causality. Despite this discrepancy, scholars have continued to endorse studies of students' attitudes toward math under the assumption that a more proper, theoretically established framework and definition of attitude, along with more refined measures, will yield valuable information about students' math learning and achievement (DiMartino & Zan, 2011, 2015; Hannula, 2012). In this study, we explore students' attitudes toward math in order to paint a more complete picture of students' math learning and achievement in Utah.

Students' Perceptions of Technology in the Math Classroom

Extant research tells us that the use of mathematics technology has positive effects on math learning (Bokhove & Drijvers, 2012; Cheung & Slavin, 2013; Li & Ma; 2010). To better understand the relationship between technology and student learning, researchers have encouraged explorations of students' perceptions and experiences of technology integration in the classroom (Li, 2007; Pedretti, Mayer-Smith, & Woodrow, 1998). It is important to note that nearly all identified studies of students' perceptions of technology in math were conducted outside of the United States (note exception: Ichinose, 2010).

A body of research has documented positive student perceptions of technology in math instruction. Li (2007) found that a vast majority of students perceive technology to be "useful and effective for their learning" (p. 391). Students have reported that mobile devices led to more interactive (Bonds-Raacke & Raacke, 2008) and novel learning experiences, contributing to increased motivation and engagement (Baya'a & Daher, 2009). Research also tells us that students believe that technology allows them to see math "in a new light," allowing for more fun and creativity (Li et al., 2016, p. 30), as well as deeper, richer, and more challenging math learning experiences (Gadanidis, Hughes, & Cordy, 2011). In a similar vein, students have endorsed asynchronous online content as effective for their math learning (Ichinose, 2010), allowing them to take more responsibility for their learning and affording them a greater sense of autonomy (Muir & Geiger, 2016).

Math technology alone, however, is not enough. Successful student experiences with math technology require strategic implementation on the part of the instructor (Drijvers, 2016;

Drijvers, Monaghan, Thomas & Trouche, 2015). In the only identified study of students' perceptions of a math learning software, Kuiper and de Pater-Sneep (2014) found that the majority of students preferred to work in their physical math workbook instead of their drill-and-practice software program, citing a lack of autonomy and the rigid structure of the software as the primary deterrent. The authors also documented grade-level differences wherein younger students reported more positive attitudes about using the software than older students. The findings from this study suggest that providing students with math software may be insufficient on its own. There is a need to better understand how math personalized learning software is integrated into, and experienced within, the context of the math classroom.

Purpose

In this study, we seek to offer insight into students' experiences using math personalized learning software provided by STEM AC. The purpose of this report is to provide a rich description of the students who accessed math personalized learning software through the K-12 Math Personalized Learning Software Grant Program and their experiences engaging with this technology.

Specifically, we explore software user characteristics, the nature and frequency of math software use, the extent to which software was integrated into classroom experiences, and students' attitudes and perceptions. We also explore the relationships among software use (frequency and classroom integration) and students' attitudes and perceptions using a correlational analysis.

Our evaluations questions were:

1. What were the characteristics of students who reported using math personalized learning software during the 2019-20 school year?
2. What were the nature and prevalence of math personalized learning software use among Utah students?
    a. How common were particular programs?
    b. With what frequency did students report using programs? How did reported use vary by student characteristics?
3. To what extent did students report that math personalized learning software integrated with their classroom learning experiences? How did this vary across student characteristics?
4. What were students' attitudes toward, and perceptions of, math personalized learning software and math more generally? Specifically:
    a. What were students' attitudes toward math software?
    b. What were students' attitudes toward math as a result of math software?
    c. To what extent did students perceive that their math software was personalized?
    d. What were students' general attitudes of math?
5. Controlling for student characteristics, such as grade level, gender, and honors-course taking, to what extent do the following explain students' attitudes and perceptions of math software?
    a. Frequency of software use during math class
    b. Frequency of software use outside of math class
    c. Integration of software into classroom learning experiences

Method

Survey Instrument and Administration

The UEPC K-12 Math Personalized Learning Software Student Survey included 47 items that were developed with the intention of gathering information about software users' characteristics, how they engaged with math software, and their attitudes toward, and perceptions of, math software and math. While specific survey items and the constructs they measure are discussed in greater detail in our discussion of results, we provide a brief description here of the survey instrument as a whole.

Across the majority of items in the survey, respondents selected responses on a Likert scale that included the following response options: *strongly disagree, disagree, neutral, agree*, and *strongly agree*. The following are two examples of this question type:

- I use (software) to work with other students on math.
- Using (software) made math more interesting.

At other times, respondents indicated their level of agreement on a scale from 1-5. For example, we asked respondents to describe how fun math was on a five-point scale, where 1=not at all fun and 5=very fun. Some items pertained to frequency of software use. For example, we ask students how often they use math software during math class. In these cases, we provided a categorical scale, which included options such as *never, once a month or less, 2-3 times a month*, and *about once a week* as answer choices.

The UEPC K-12 Math Personalized Learning Software Student Survey was administered using a licensed version of Qualtrics, a web-based survey tool, in February-May 2020. No identifiable information was collected from participants. On average, respondents spent 11 minutes completing the survey. Students who had access to math personalized learning software during the 2019-2020 school year through the K-12 Math Personalized Learning Software Grant Program were invited to participate. STEM AC staff disseminated a confidential survey link to teachers and administrators and also made this link available on the STEM AC website. From here, students were typically invited to participate in the survey by their teachers. The survey was intended for all students who accessed personalized math software through a license provided by STEM AC. Surveys of this type are permitted in accordance with FERPA and the evaluation of an instructional program. However, due to the use of an open survey link and the reliance on local schools to distribute the survey link to students, we are unable to determine with certainty whether every user had the opportunity to participate in the survey. As a result, it is not possible to calculate an accurate response rate. That said, specific details about respondents are discussed in further detail in our presentation of results.

Analysis

To analyze survey data, we used summary descriptive statistics, hypothesis testing, confirmatory factor analysis, and ordinary least squares linear regression. While our first evaluation question was answered strictly through the use of descriptive statistics, we briefly describe our approach for the remaining four evaluation questions below:

What were the nature and prevalence of math personalized learning software use among Utah students?	We used two-sample tests of proportion and one-way analysis of variance (ANOVA) tests to identify differences in math software use across student characteristics. This approach allowed us to determine whether or not differences in math software use by gender, grade level, and course-taking were due to chance.
To what extent did students report that math personalized learning software integrated with their classroom learning experiences? How did this vary across student characteristics?	We used confirmatory factor analysis to generate a composite measure that captures this construct. Confirmatory factor analysis allowed us to group similar survey items together.
What were students' attitudes toward, and perceptions of, math personalized learning software and math more generally?	We used confirmatory factor analysis to generate four unique measures of student attitudes and perceptions. The specifics of these four measures are described in more detail as a part of our results.
Controlling for student characteristics, such as grade level, gender, and honors-course taking, to what extent do the following explain students' attitudes and perceptions of math software?	We used ordinary least squares (OLS) regression. This approach allowed us to account for student characteristics that might influence attitudes and perceptions (e.g., gender, grade level, software program, honors-course taking) so as to isolate the extent to which engagement with software explains attitudes and perceptions. We used models that took the following format: $Attitude_s = \beta_1 Female_s + \mathbf{GradeLevel_s}\beta_2 + \mathbf{Software_s}\,\beta_3 + \beta_4 Honors_s + \beta_5 EngagementwithSoftware_s + \varepsilon_s$ In the above model, $Attitude_s$ is a student's reported attitude or perception. $Female_s$, $GradeLevel_s$, $Software_s$, and $Honors_s$ control for student gender, grade level, software program, and honors-course taking, respectively. $EngagementwithSoftware_s$ is the primary predictor of interest. We estimated separate models where this measure indicates either the frequency with which a student used math software or the extent to which software was integrated into their classroom experience. Robust standard errors were used in all models. All analyses were conducted using Stata 16.0, a statistical analysis software program.

Survey Results

Characteristics of Survey Respondents

A total of 33,454 respondents participated in the K-12 Math Personalized Learning Software Student Survey out of a possible ~161,000 students[14] who were provided with licenses to use math personalized learning software by STEM AC. Respondents were those who consented to participating in the survey and indicated that they used one of six math personalized learning software programs (i.e., ALEKS, DreamBox, Imagine Math, Mathspace, ST Math, i-Ready) during the 2019-2020 school year. Summarized in *Table 2. Characteristics of Survey Respondents*, we asked respondents to indicate their gender and grade level; in the case of respondents in grade 8 and above, we also collected information about math coursework. As shown in Table 2, slightly more female respondents than male respondents participated in the survey and respondents were most commonly in grades 6-8 (~43%), followed by grades 3-5 (~38%) and grades 9-12 (~20%). Among respondents in grades 8 and above, respondents most commonly reported taking 8th Grade Math (~36%), followed by Secondary I and Secondary II (~29% and ~21%, respectively). Just over 30% of respondents enrolled in Secondary I, II, and III reported that they were an honors math course.

Table 2. Survey Respondent Characteristics

Respondent Characteristic	%
Gender	
Female	48.7%
Male	47.0%
Other/Prefer Not to Say	4.3%
Grade	
3	10.1%
4	12.9%
5	14.9%
6	14.0%
7	15.8%
8	12.7%
9	10.5%
10	5.4%
11	3.2%
12	0.6%
Math Course (Grade 8 and above)	
8th Grade Math	36.3%
Secondary I	29.1%
Secondary II	20.8%
Secondary III	9.4%
Other	4.6%
In an honors course*	30.3%

*Only respondents in Secondary I, II, and III were asked whether their math course was honors level.

[14] This estimate is based on the number of software licenses issued as of spring 2020.

Nature and Prevalence of Math Personalized Learning Software Use

As illustrated in *Table 3. Math Personalized Learning Software Use,* respondents most commonly reported using ALEKS math software (48%), followed by Imagine Math, ST Math, and i-Ready (15-17%). Relatively few respondents reported using MathSpace or DreamBox.

Table 3. Math Personalized Learning Software Use

Software Program	%
ALEKS	48.3%
Imagine Math	17.0%
ST Math	16.1%
i-Ready	15.0%
Mathspace	2.2%
DreamBox	1.5%

Respondents reported the frequency with which they used math personalized learning software both during and outside of math class. *Table 4. Frequency of Math Personalized Learning Software Use* shows that the majority of respondents are using math software at least once a week during math class (~79%). Yet, use outside of math class is less frequent. Indeed, nearly one-third of respondents reported never using math software outside of math class and just under 35% of respondents reported using math software at least once a week outside of math class.

We contextualize these findings with a brief discussion of the recommendations for usage provided by some math personalized learning software vendors. Although ALEKS, for example, does not provide recommendations for minutes of use per week, the ALEKS website offers examples of implementation strategies enacted by districts across the country, ranging from two to five hours a week.[15] I-Ready currently recommends students use software for 45 minutes each week.[16] ST Math recommends 60 minutes of weekly use for students in grades K-1 and 90 minutes of weekly use for students in grades 2-5.[17] Whiles these guidelines on how much time to spend using math software do not directly translate into frequency of use, students would generally need to use math software at least once a week to meet these recommendations.

To allow for easier interpretation of survey results, we categorized respondents as "frequent users" if they reported using math software at least once a week through the remainder of this

[15] See https://www.ALEKS.com/k12/implementations/popup?_form_=true&parse_list=e*258&parse_request=true&cmscache=parse_list:parse_request#:~:text=Students%20will%20be%20expected%20to,minutes%2C%20four%20days%20per%20week and https://www.aleks.com/k12/implementations/index?_form_=true&parse_request=true&parse_list=h*323&cmscache=parse_list:parse_request

[16] https://www.curriculumassociates.com/products/i-ready/how-it-works

[17] https://dlassets.stmath.com/pdfs/massachusetts/MA-Implementation-Guide-EN-176.pdf

report. As noted below in Table 4, "Frequent users" are those who indicated they use math personalized learning software either "more than 2-3 days a week," "2-3 days a week," or "about once a week."

Table 4. Frequency of Math Personalized Learning Software Use

Frequency	During Math Class	Outside of Math Class
More than 2-3 days a week*	32.0%	8.0%
2-3 days a week*	27.0%	11.9%
About once a week*	20.3%	14.6%
2-3 times a month	7.3%	9.4%
Once a month or less	5.3%	15.1%
Never	3.6%	32.4%

*Respondents who indicated "more than 2-3 days a week," "2-3 days a week," and "about once a week" are collectively referred to as "frequent users" throughout the remainder of this report.

Variation in Math Personalized Learning Software Use by Gender

As summarized in *Table 5. Math Personalized Learning Software by Gender,* we used two-sample tests of proportion and found that there were no statistically significant differences in software use across male and female respondents.

Table 5. Math Personalized Learning Software Use by Gender

Math Personalized Learning Software	Gender		
	Male	Female	Difference
ALEKS	49.3%	50.6%	1.3%
DreamBox	52.1%	47.9%	4.2%
Imagine	49.0%	51.0%	2.0%
Mathspace	48.5%	51.5%	3.0%
ST Math	48.8%	51.2%	2.4%
i-Ready	48.4%	51.6%	3.2%
Total	**49.1%**	**50.9%**	**1.8%**

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

Turning to frequency of software use, we found differences in the frequency of math software use outside of math class by gender. Here, we used a binary measure where "frequent users" are those who reported using math software at least once a week. In other words, they selected one of the following options: "more than 2-3 days a week," "2-3 days a week," or "about once a week." We conducted two two-sample tests of proportion to compare the proportions of male and female respondents who were frequent software users. Summarized in *Table 6. Frequency of Software Use by Gender*, we found that female students were more likely to be frequent users than male respondents (38% vs. 35%). There were no statistically significant differences by gender in rates of frequent users during math class.

Female students were somewhat more likely to use software frequently outside of math class. Just over 38% of female respondents reported using software frequently versus 35% of male students.

Table 6. Frequency of Software Use by Gender

	% Frequent Users	
	During Math Class	Outside of Math Class
Male	83.3%	34.6%
Female	83.3%	38.1%
Difference	0.0%	3.5%***

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

Variation in Math Personalized Learning Software Use by Grade Level

Table 7. Math Personalized Learning Software Use by Grade Level demonstrates variation in software use by grade level that aligns with the intended audiences for each program. ALEKS, a K-12 program, was used by respondents across all grade levels with a majority of users in grades 7-9; Imagine Math, ST Math, i-Ready, and DreamBox were used primarily by respondents in grades 6 and below; MathSpace was used primarily by respondents in grades 9-11.

Table 7. Math Personalized Learning Software Use by Grade Level

	Math Personalized Learning Software					
Grade	ALEKS	Imagine Math	ST Math	i-Ready	Mathspace	DreamBox
Target Grade Levels	K-12	PreK-8	PreK-8	K-8	6-12	K-8
3	1%	14%	28%	16%	0%	20%
4	2%	24%	24%	22%	0%	34%
5	4%	24%	29%	28%	0%	11%
6	9%	27%	15%	14%	3%	31%
7	27%	7%	2%	8%	14%	4%
8	22%	3%	1%	7%	3%	0%
9	19%	1%	0%	3%	24%	0%
10	9%	0%	0%	1%	37%	0%
11	6%	0%	0%	0%	15%	0%
12	1%	0%	0%	0%	4%	0%

We also considered whether the frequency with which respondents reported using math software varied by grade level. *Table 8. Frequency of Software Use by Grade Level* summarizes the results of two two-sample tests of proportions where we compared the proportions of elementary respondents (grades 3-8) and secondary respondents (grades 9-12) who reported that they were frequent users of math software during and outside of math class. As illustrated in Table 8, elementary respondents are significantly more likely to be frequent users of math software during math class (85% vs 75%, p<.001), while secondary respondents are significantly more likely to be frequent users outside of class (40% vs. 35%, p<.001).

Table 8. Frequency of Software Use by Grade Level

	% Frequent Users	
	During Math Class	**Outside of Math Class**
Elementary	85.0%	35.0%
Secondary	75.4%	40.1%
Difference	9.6%***	5.1%***

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

Variation in Math Personalized Learning Software Use by Math Coursework

As illustrated in *Table 9. Math Personalized Learning Software Use by Math Course among Respondents in Grades 8 and Above*, we compared software use by math coursework among respondents in grades 8 and above. In this section, we limit our findings to ALEKS and Mathspace, as these are the only two programs designed for respondents in traditional secondary math courses. We note that a small percentage of students in secondary grade levels reported using software programs designed for K-8 students. For example, 1% of Imagine Math users and 3% of i-Ready users were in grade 9. However, due to these small proportions of students, we focus our analysis of software use by math coursework to ALEKS and Mathspace.

We found that ALEKS was more frequently used among respondents in 8^{th} Grade Math and Secondary I, while Mathspace was used most often by respondents in Secondary II. Rates of honors-course taking were slightly higher among ALEKS users than Mathspace users.

Table 9. Math Personalized Learning Software Use by Math Course among Respondents in Grades 8 and Above

	Math Personalized Learning Software	
Math Course	ALEKS	Mathspace
8th Grade Math	35%	4%
Secondary I	30%	26%
Secondary II	20%	45%
Secondary III	10%	14%
Other	4%	10%
Honors Course*	31%	28%

*Only respondents in Secondary I, II, and III were asked whether their math course was honors level.

To compare frequency of software use by math course, we conducted two one-way analysis of variance (ANOVA) tests to compare the proportion of frequent users across math course both during math class and outside of math class. As shown in *Table 10. Frequency of Software Use by*

Math Course among Respondents in Grade 8 and Above, we found significant variation in frequency of software use in both settings. Respondents in lower levels of math, such as 8th Grade Math and Secondary I, tended to report more frequent software use in class (86% and 82%, respectively). Outside of math class, respondents in Secondary I tended to report the highest rates of use (47%).

Also summarized in Table 10, we used a two-sample test of proportions to compare frequency of use among student in honors and non-honors courses. We found no statistical difference in in-class use but higher rates of use among honors respondents outside of class (49% vs. 38%, p<.001).

Table 10. Frequency of Software Use by Math Course among Respondents in Grade 8 and Above

	% Frequent Users	
Math Course	During Math Class	Outside of Math Class
8th Grade Math	85.7%	32.9%
Secondary I	82.3%	47.1%
Secondary II	74.6%	38.7%
Secondary III	60.2%	29.9%
Other	72.1%	39.6%
F-statistic	120.38***	81.49***
Honors Status		
Honors Course	77.0%	48.8%
Non-Honors Course	75.6%	38.2%
Difference	1.4%	10.6%***

*Only respondents in Secondary I, II, and III were asked whether their math course was honors level.
***p<.001, **p<.01, *p<.05

Students who took honors-math courses were more likely to use math software frequently outside of class. Nearly half of students in honors courses use math software frequently versus 38% of students who were not in honors-math courses.

Integration of Math Personalized Learning Software into Classroom Learning Experiences

Through the administration of the UEPC K-12 Math Personalized Learning Software Student Survey, we aimed to better understand from the student's perspective the extent to which math software is integrated into classroom learning experiences. To do this, we used confirmatory factor analysis to identify and group similar survey items that collectively measure respondents' classroom learning experiences with their math personalized learning software. Throughout the remainder of this report, we will refer to this construct as "classroom technology integration."

We included eight survey items in our composite measure of classroom technology integration. In these items, we asked respondents to rate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of

agreement. Respondents indicated their level of agreement, for example, with the extent to which they use math software to work with others and the extent to which math software is similar to worksheets or bookwork. These items, including means and standard deviations, are summarized in *Table 11. Summary of Classroom Technology Integration Survey Items.*
The mean level of classroom technology integration reported by students was 2.6 on a scale of 1-5, suggesting that respondents' math software experiences were not particularly well-integrated into their classroom learning experiences. Only two of eight items had mean levels of agreement above a "3" (where "3" indicates a neutral response). These two items were the extent to which math software included interactive content (3.1) and the extent to which respondents felt they could engage in real-world math problems while using their math software (3.2). This finding suggests there may be room for educators to more intentionally integrate math personalized learning software into classroom learning experiences.

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Table 11. Summary of Classroom Technology Integration Survey Items

Survey Item	Mean	Standard Deviation
(Software) work is just like worksheets or bookwork, except on the computer. (reverse coded)	2.9	1.1
(Software) includes videos, interactions, demonstrations or other content that support my learning.	3.1	1.2
I use (software) to work with other students on math.	2.2	1.1
I use (software) to present or demonstrate my work to the teacher or other students.	2.5	1.2
I do work in (software) that wouldn't be possible without it.	2.6	1.2
Through (software) I can engage in real-world math problems and solutions.	3.2	1.2
I create math problems for other class members using (software).	1.9	1.0
I collaborate with other students or professionals outside of my class using (software).	2.1	1.1
Overall Composite Measure Cronbach's alpha: 0.81	**2.6**	**0.7**

Note: In place of "(software)," personalized text piping was used throughout the survey so as to allow respondents to answer questions pertaining to the specific software they reported using.

Attitudes and Perceptions

Attitudes toward Math Software

We used confirmatory factor analysis to generate a measure of respondents' attitudes toward their math personalized learning software based on five survey items. These items assessed respondents' level of agreement that, for example, they enjoyed using math software, that it was boring, and that it was a waste of time. Throughout the remainder of this report, we will refer to this construct as "attitudes toward math software."

In these items, we again asked respondents to indicate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of agreement. The five items included in this construct, along with their means and standard deviations, are summarized in *Table 12. Attitudes toward Math Software.*
The mean attitude toward math personalized learning software was 3.0 on a scale of 1-5, indicating that respondents were generally neutral about their experiences. The lowest rated item in this construct was agreement that respondents enjoyed using math software at home (2.4), while the highest rated item was agreement that using math software was a waste of time (3.5). As noted in Table 12, this item was reverse coded such that higher values indicate disagreement that math software was a waste of time. Collectively, these relatively neutral attitudes toward math software indicate that there may be room to improve user experiences.

Table 12. Attitudes toward Math Software

Survey Item	Mean	Standard Deviation
I like using (software) in school.	3.1	1.3
I like using (software) at home.	2.4	1.3
(Software) is boring. (reverse coded)	2.9	1.3
(Software) is a waste of time. (reverse coded)	3.5	1.3
(Software) made me feel frustrated or discouraged. (reverse coded)	3.2	1.3
Overall Composite Measure Cronbach's alpha: 0.85	**3.0**	**1.0**

Note: In place of "(software)," personalized text piping was used throughout the survey so as to allow respondents to answer questions pertaining to the specific software they reported using.

The lowest rated item in this construct was agreement that respondents enjoyed using math software at home (2.4), while the highest rated item was agreement that using math software was a waste of time (3.5, reverse coded).

Attitudes towards Math as a Result of Math Software

We also asked respondents to indicate the extent to which their use of math personalized learning software influenced their attitudes toward math more generally. Using confirmatory factor analysis, we generated a measure of respondents' attitudes toward math due to their math software use based on five survey items. These items assessed respondents' level of agreement that using math software, for example, made math more interesting, more fun, and easier.

In these items, we again asked respondents to indicate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of agreement. The five survey items included in this construct, along with their means and standard deviations, are summarized in *Table 13. Attitudes toward Math as a Result of Math Software.*

The mean attitude toward math as a result of math software was 3.0 on a scale of 1-5, indicating that respondents were generally neutral about their experiences. The lowest rated item in this construct was agreement that using math software made math more fun (2.8), while the highest rated items were agreement that using math software helped respondents see that math is useful in everyday life and that software made learning math easier (3.1). Collectively, these findings suggest that, on average, respondents do not feel that math software has either positively or negatively influenced their attitudes toward math.

Table 13. Attitudes toward Math as a Result of Math Software

Survey Item	Mean	Standard Deviation
Using (software) made math more interesting.	2.9	1.2
Using (software) made math more fun.	2.8	1.3
Using (software) helped me see math is useful in everyday life.	3.1	1.2
Using (software) helped me see the importance of math in my long-term plans.	3.0	1.2
Using (software) made learning math easier.	3.1	1.3
Overall Composite Measure Cronbach's alpha: 0.90	**3.0**	**1.1**

Note: In place of "(software)," personalized text piping was used throughout the survey so as to allow respondents to answer questions pertaining to the specific software they reported using.

Perceptions of Personalization as a Result of Math Software

We asked respondents to reflect on the extent to which they felt math software was personalized to meet their needs. Through confirmatory factor analysis, we created a measure of personalization based on four survey items. These items assessed respondents' level of agreement that they were able to work at their own pace, receive support with difficult material, work ahead, and have their learning style accommodated through the use of math personalized learning software.

In these items, we again asked respondents to indicate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of agreement. The four items included in this construct, along with their means and standard deviations, are summarized in *Table 14. Perceptions of Personalization as a Result of Math Software.*

On average, respondents scored 3.4 on a scale of 1-5 points, indicating somewhat favorable perceptions of the extent to which math software was personalized. All four items in this construct had a mean value above 3.0, and the highest rated item was agreement that it is possible to work at one's own pace while using math software (mean=3.7). This suggests that self-pacing may be a particularly beneficial feature of math personalized learning software. Collectively, these findings offer some evidence that math software may offer users a personalized learning experience.

Table 14. Perceptions of Personalization as a Result of Math Software

Survey Item	Mean	Standard Deviation
I can work in (software) at my own pace	3.7	1.1
(Software) provides help and support with difficult material	3.3	1.1
(Software) lets me work ahead to more challenging material if something is too easy.	3.4	1.2
(Software) works well with my learning style.	3.2	1.3
Overall Composite Measure Cronbach's alpha: 0.78	**3.4**	**0.9**

Note: In place of "(software)," personalized text piping was used throughout the survey so as to allow respondents to answer questions pertaining to the specific software they reported using.

Math Attitudes

Students' reported math attitudes cannot be specifically attributed to their math personalized learning software use. However, we asked respondents to describe their math attitudes through a set of four survey items (adapted from Yasar, 2014). We asked students to indicate the extent to which they agree math is fun, interesting, useful in everyday life, and something they are good at. Using confirmatory factor analysis, we generated a composite measure of math attitudes based on these four items.

In these items, we again asked respondents to indicate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of agreement. The four items included in this construct, along with their means and standard deviations, are summarized in *Table 15. Respondents' Math Attitudes.*
On average, respondents' math attitudes were slightly above neutral, 3.3 points on a scale of 1-5. Although agreement that math is useful and something respondents are good at were slightly higher (3.6 and 3.5, respectively), respondents were relatively neutral about the extent to which

math is fun and interesting (3.1 in both cases). In future analyses, it may be beneficial to assess student math attitudes at the beginning of the school year and end of the school year in order to more accurately attribute these attitudes to math software use.

Table 15. Respondents' Math Attitudes

Survey Item	Mean	Standard Deviation
Math is fun.	3.1	1.2
Math is interesting.	3.1	1.3
Math is useful in everyday life.	3.6	1.2
Math is something I am good at.	3.5	1.2
Overall Composite Measure Cronbach's alpha: 0.81	**3.3**	**1.0**

Predicting Attitudes and Perceptions

Finally, we examined the extent to which various predictors of interest—frequent software use during math class, frequent software use outside of math class, and technology integration—predicted respondents' attitudes and perceptions of math personalized learning software. We used OLS regression to control for student gender, grade level, software program, and honors-course taking. In other words, when two students are exactly the same in terms of gender, grade level, software program, and whether or not they are in an honors course, this approach allows us to measure whether attitudes and perceptions are higher for the student who, for example, use software frequently in math class.

Table 16. Frequency of Software Use and Classroom Technology Integration as Predictors of Attitudes and Perceptions contains the results from our regression analyses. As an example of how to interpret this table, the value in the top leftmost corner, "+0.3," indicates that relative to otherwise similar students who used math software infrequently during math class (less than once a week), on average, respondents who used math software frequently (those who indicated "more than 2-3 days a week," "2-3 days a week," or "about once a week"), had perceptions of math personalized learning software that were 0.3 points higher than infrequent users.

A similar interpretation applies to frequency of math software use outside of math class. In the middle column of the top row of Table 16, "+0.4" indicates that, relative to those who infrequently use math software outside of math class, those who used it frequently had perceptions of math personalized learning software that were, on average, 0.4 points higher than infrequent users.

The interpretation for values under the column titled "Classroom Technology Integration" is slightly different. Using the top rightmost value as an example, holding all else equal, every one-point increase in classroom technology integration (on a scale of 1-5) was associated with a 0.8

point increase in perceptions of math personalized learning software. Students who report higher levels of classroom technology integration also have more positive perceptions of their math software.

Across all models, our results were positive and statistically significant (p<.001). These findings suggest that respondents who frequently used math personalized learning software during and outside of math class, as well as those who perceived that math software was integrated into their classroom experiences, had more positive attitudes toward, and perceptions of, their math personalized learning software.

We remind the reader that these results are not causal. That is to say, we cannot confirm that more frequent use or better classroom technology integration *caused* respondents to have more positive perceptions of math software. These analyses only indicate that respondents who used software more frequently or experienced strong classroom technology integration also had more positive perceptions. There are other unobservable factors, such as personal dispositions, that these models cannot account for.

As an example of how to interpret this table, "+0.3," indicates that relative to otherwise similar students who used math software infrequently during math class (less than once a week), on average, respondents who used math software frequently (those who indicated "more than 2-3 days a week," "2-3 days a week," or "about once a week"), had perceptions of math personalized learning software that were 0.3 points higher than infrequent users.

Table 16. Frequency of Software Use and Classroom Technology Integration as Predictors of Attitudes and Perceptions

	Predictors of Interest		
Attitudes and Perceptions	Frequent Software Use During Math Class	Frequency of Software Use Outside of Class	Classroom Technology Integration
Attitudes toward Math Software	+0.3	+0.4	+0.8
Attitudes toward Math as a Result of Math Software	+0.4	+0.4	+0.9
Perceptions of Personalization as a Result of Math Software	+0.3	+0.3	+0.8

Note: All values in this table control for respondent gender, grade level, software program, and honors-course taking. Each value is on a five-point scale. For example, frequent in-class software users report perceptions of math personalized learning software that are, on average, 0.3 points higher than infrequent software users, holding gender, grade level, software program, and honors-course taking constant. All values in this table were statistically significant (p<.001).

Discussion

Summary of Findings

Our analyses of student responses to the UEPC K-12 Math Personalized Learning Software Student Survey revealed a number of noteworthy findings. First, we found variation in the frequency of software use across student groups. Specifically, female students, secondary students, and those taking honors math courses were more likely to be frequent software users outside of math class as compared to male students, elementary students, and student who did not take honors math courses, respectively. In the case of math-course taking of among students in grade 8 and above, we found that students taking 8th grade math used math software during math class most frequently. Among students taking 8th grade math, 86% reported doing so at least once a week versus as few as 60% in the case of other secondary math courses. Outside of math class, students enrolled in Secondary I were the most frequent users of math software outside of class; 47% of Secondary I students used math software outside of class at least once a week versus as few as 30% of students in the case of other secondary math courses. It is not clear from these survey data how much of this variation is due to individual student preferences or motivation as opposed to teachers' instructional decisions.

We also found that, on average, students' perceptions of classroom technology integration were relatively low—2.6 on a scale of 1-5. Within this construct, survey items related to collaboration with peers and educators were particularly low, suggesting that math software use is often an individual activity for students.

Attitudes toward math software and math as a result of software use were, on average, neutral. The mean level across both of these measures was 3.0 on a scale of 1-5. Perceptions of personalization as a result of software use were a bit higher; on average, students reported a 3.4 on a scale of 1-5 for this measure. These findings suggest that while math software is offering a fairly personalized experience to students, students do not always perceive their experiences all that positively.

Finally, we found positive relationships among engagement with math software—frequent use both during and outside of math class and integration of math software into classroom learning experiences—and three measures of students attitudes toward math: their attitudes toward math software, their attitudes toward math as a result of software use, and their perceptions of personalization as a result of math software. These relationships held even after accounting for student gender, grade level, software program, and honors-course taking status. We found that when students use software frequently and when it is integrated into their classroom learning experiences, they also had more positive attitudes. In light of these findings, considerations for the UEPC K-12 Math Personalized Learning Software Grant Program going forward are discussed below.

Considerations for the K-12 Math Personalized Learning Software Grant Program

Encouraging frequent use of math software may be one pathway to developing more positive attitudes toward math software and math.

Given our finding that students who use math software more frequently also have more positive attitudes and perceptions, we recommend that educators encourage regular use of math software. Our findings build upon prior research that has established the relationship between frequent math software use and positive math learning outcomes (Cheung & Slavin, 2013; Li & Ma, 2011). For example, Cheung and Slavin (2013) found that students who used math software at least 30 minutes each week had the greatest learning gains. Similarly, Li and Ma (2011) found evidence that the targeted use of math technology over the course of a term was an effective strategy for boosting math achievement. Findings from our evaluation indicate that students who frequently use math software will experience benefits that extend beyond math learning. Even after controlling for characteristics such as gender, grade level, software program used, and honors-course taking, we found consistent evidence that frequent software users expressed more positive attitudes toward math software, math as a result of software use, and personalization as a result of software use. While the relationship between frequent software use and attitudes is not necessarily causal, it may be the case that when students are in the habit of engaging with math software on a regular basis, they become more comfortable interacting with the technology. Regular use of math personalized learning software may allow students to more easily build upon and retain skills, therefore leading to more positive experiences with the software. These positive experiences, in turn, might shape students' attitudes toward the software and math more generally. Over 90% of respondents indicated that they have a home device on which they can use math software, suggesting that access to technology is unlikely to be a barrier for most students. Therefore, encouragement from educators to both students and their families may be an effective strategy to increase math software use and, in turn, student attitudes and perceptions.

Strengthening the integration of math software into classroom learning experiences may be another pathway to developing more positive attitudes toward math software and math.

Students who reported higher levels of classroom technology integration also had more positive attitudes toward, and perceptions of, math software. Our finding confirms and buildings upon the findings of other scholars who have investigated the use math technology (e.g., Gadanidis, Hughes, & Cordy, 2011; Ichinose, 2010). When students were in greater agreement that their interactions with math software were a part of their classroom learning experiences—for example, that math software allowed them to collaborate with peers and work through real-world math problems in interactive ways—they also reported more positive attitudes and perceptions. Based on this finding, we encourage educators to look for ways to more thoroughly integrate math software into students' classroom experiences. Within our measure of classroom technology integration, the lowest rated survey items were specific to collaboration with peers. Based on this finding, it may be beneficial for teachers to explore ways for students to use math software to learn together more often rather than in isolation. Specifically, teachers might consider matching students together who are working to master similar skills with their math software in order to build upon individual learning experiences.

When students are able to perceive their math personalized learning software as a part of their classroom learning experiences, they may, in turn, perceive math software and math more positively.

Future Directions

Given the rapid shift toward virtual learning as a result of the COVID-19 pandemic, we plan to refine our measure of classroom technology integration going forward. Because many aspects of this construct rely on interactions among students and educators (e.g., "I use (software) to work with other students on math."), we will need to revisit what it means for technology to be integrated into the classroom in future iterations of this survey.

In our future work, we also plan to explore how educators can better differentiate their support for math learners based on gender, grade level, and math course taking. Given our finding that software use outside of math class varies across these student characteristics, it is particularly important for educators to identify ways to encourage the use of software for those groups who are less likely to use it frequently outside of the classroom. Our survey findings suggest that additional support for male students, elementary students, and those who are not taking honors courses may be a helpful strategy. Future work may focus on how teachers engage with these particular groups of students. This investigation would be further strengthened if student and teacher survey data could be linked together so as to allow for comparison of students' and teachers' perceptions of the support that teachers provide students (Li, 2007).

Education research is complex; it is often challenging to isolate and attribute particular interventions and strategies to student outcomes. The relationships we have identified in this report are strictly correlational. Although we cannot, with any certainly, claim that the use of math software *caused* students to have more positive attitudes and perceptions, our results do suggest positive relationships among frequent software use, strong integration of technology into the classroom, and more positive attitudes and perceptions among students. Future evaluation of students' use of math software might be strengthened by administering a survey at both the beginning of the school year and the end of the school year. In doing so, we may be able to more accurate attribute changes in students' attitudes toward math to the use of math personalized learning software.

Finally, if possible, we recommend exploring the possibility of linking students' attitudes and perceptions with their math learning outcomes. While we do not dispute the importance of students having positive experiences with their math software programs, the question of whether or not those positive experiences are associated with greater learning gains still remains.

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THE UNIVERSITY OF UTAH
UTAH EDUCATION POLICY CENTER

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TEACHING MATHEMATICS WITH TECHNOLOGY IN UTAH

An Evaluation of Teacher Knowledge, Practices, and Outcomes with Using Mathematics Personalized Learning Software

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

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THE UNIVERSITY OF UTAH
UTAH EDUCATION POLICY CENTER

Bridging Research, Policy, and Practice

The Utah Education Policy Center (UEPC) is an independent, non-partisan, not-for-profit research-based center at the University of Utah founded in the Department of Educational Leadership and Policy in 1990 and administered through the College of Education since 2007. The UEPC mission is to bridge research, policy, and practice in public schools and higher education to increase educational equity, excellence, access, and opportunities for all children and adults.

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PART ONE:

INTRODUCTION

This section sets the context for the evaluation by reviewing literature on mathematics education in the United States. The review addresses topics including, but not limited to, the personal and societal benefits of rigorous K-12 mathematics education; the performance of U.S. K-12 students in mathematics; the rising use of digital mathematics software in U.S. K-12 classrooms; and the role of teacher quality in effective integration of digital technologies in instruction. In Part One, the report also provides an overview of the K-12 Math Personalized Learning Software Grant Program, the evaluation's methods, and the report's organization.

Setting the Context

The Private and Social Benefits of High-Quality K-12 Mathematics Education

Receiving a rigorous mathematics education at the K-12 level serves both personal and societal interests. At the personal level, obtaining a high-quality pre-college education in mathematics, and STEM (Science, Technology, Engineering, and Mathematics) more generally, has been found to be strongly correlated with scoring higher on standardized college entrance examinations, enrolling in a four-year university, pursuing a major in a STEM field, and graduating with a bachelor's degree (Darling, 2010; McCormick, Rorrer, Onuma, Moore, & Pecsok, 2020; Robinson, 2003; Walston & McCarroll, 2010; Zelkowski, 2008). Moreover, STEM degree recipients in the United States have access to occupations that provide significantly higher earnings and are much less susceptible to economic downturns (Berhane, Onuma, & Secules, 2017).

At the societal level, the benefits of a populace that is mathematically competent is equally notable. For centuries, economic growth in the United States, as with other highly technological nations, has been driven in large part by innovations often spearheaded by individuals with backgrounds in mathematics or engineering (May & Chubin, 2003; U.S. Congress Joint Economic Committee, 2012). Such scientific and technological advances are also chiefly responsible for the United States' position as global leader in the STEM arena. However, as researchers, policymakers, and industry alike maintain, the nation must bolster its production of STEM degree recipients if it is to remain competitive in today's fierce global economy (National Science Foundation, 2014; President's Council of Advisors on Science and Technology, 2012).

The Underperformance of U.S. K-12 Students in Mathematics

Sustaining the nation's success in STEM demands that important attention is given to its K-12 and higher education systems. And as noted, the nation's STEM pipeline is especially "leaky" at the K-12 level (Desilver, 2017; Hossain & Robinson, 2012; Ladson-Billings, 1997; McCormick & Lucas, 2011). Over the past decade, scrutinization of the U.S. K-12 system by the local and international communities has risen due to mounting evidence about the inadequate preparation that U.S. school-age students receive in mathematics and their paltry performance on international assessments in comparison to their Asian and Finnish counterparts (Desilver, 2017; McCormick & Lucas, 2011). As researchers have found, U.S. K-12 students, on a general level, do not receive sufficient exposure to mathematics to meet even college readiness benchmarks (ACT, 2014). Moreover, this issue is especially pronounced among students of color whom, as evidence reflects, are more likely to be clustered in low-ability mathematics classes, discouraged from enrolling into advanced mathematics courses by teachers, and represented in school districts with limited availability of Advanced Placement (AP) and International Baccalaureate (IB) mathematics course options (Berhane at al., 2017; Berry III, Ellis, & Hughes, 2014; Harper, 2010; Ladson-Billings, 1997). Data on the mathematics performance of U.S. K-12 students on international assessments is equally troubling. Desilver (2017) notes that on the most recent Programme for International Student Assessment (PISA), an international examination that measures reading ability and math and science literacy among students who are roughly 15 years of age, the United States ranked 38th out of the 71 countries that participated; moreover, when compared to the 35 member countries of the Organization for Economic Cooperation (OECD), the United States places at an unremarkable 30th out of the 35 countries.

The Role of Teacher Quality in the Performance of U.S. K-12 Students in Mathematics

Fortunately, the large-scale underperformance of U.S. students in mathematics has little, if any, to do with their ability. Unfortunately, it is due in significant part to a more systemic issue, including that the subject matter knowledge and pedagogical practices of mathematics K-12 educators is inadequate. As researchers have found, mathematics teachers in U.S. schools often receive inadequate training in mathematics themselves, leaving them largely unable to provide the demanding curriculum necessary for students' deep understanding of mathematics and competitive performance on a global level (Hossain & Robinson, 2012; Jensen, Roberts-Hall, Magee, & Ginnivan, 2016; Swars, Smith, Smith, Carothers, & Myers, 2016). Describing this issue in 2008, the National Mathematics Advisory Panel noted that, "it is self-evident that teachers cannot teach what they do not know" (p. xxi). In other words, it is difficult, if not impossible, for teachers to provide substantive instruction in a subject area in which they themselves do not have strong grounding or foundational knowledge. Weak training in mathematics is particularly prevalent among elementary teachers whom are typically prepared as generalists—that is, to teach all subjects—and lack confidence in their abilities to teach mathematics or to even perceive themselves as mathematics teachers, even though they are (Reys & Fennell, 2003; Jensen et al., 2016; Stewart, 2009). Moreover, the poor training of U.S. K-12 mathematics teachers often results in unimaginative and ineffective pedagogical practices that emphasize activities with low cognitive demands such as repetition, drill, and formulas (Berry III et al., 2014).

Benefits of Digital Mathematics Software for Students' Achievement in Mathematics

In an effort to enhance mathematics learning in K-12 classrooms, mathematics education reform in the United States ushered in the use of information and communications (ICT) technology in instruction (Li & Ma, 2010). To make the case for its use, the National Council of Teachers of Mathematics (NCTM) in 2000 asserted that "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (NCTM as cited in Li & Ma, 2010, p. 216). In recent years, researches have pointed to the increased use of technology in mathematics instruction and the significant investments being made by school districts around the country to procure software for teaching and learning (Cheung & Slavin, 2013; Li & Ma, 2010). Several research studies, since 2000, have also produced findings that confirm the sentiments of the NCTM (Kiger, Herro, & Prunty, 2012; Cheung & Slavin, 2013; Li & Ma, 2010). In 2010, Li and Ma conducted a meta-analysis of the effects of computer technology on K-12 students' mathematics learning and found that computer technology has a moderate but significantly positive effect on mathematics achievement. In 2012, Kiger, Herro, and Prunty explored the effects of a mobile learning intervention on third grade mathematics achievement and found that third grade students who utilized the mobile learning intervention scored significantly higher than comparison students on a post-intervention multiplication test. And in 2013, Cheung and Slavin sought out to understand the effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms and found that educational technology produced moderate positive effects on students' mathematics achievement in comparison to traditional methods.

The Role of Teacher Knowledge in Effective Integration of Digital Mathematics Software

While a number of research studies have, in fact, observed positive effects for educational technology on mathematics learning and achievement, researchers caution that educational technology does not singly, or by itself, produce these effects (Cheung & Slavin, 2013; Li & Ma, 2010). Rather, they contend that educational technology is more often effective when used by teachers with adequate knowledge about the technology and ways to implement it to bring about educational goals (DeCoito & Richardson, 2018; Rahman, Krishnan, & Kapila, 2017). Indeed, several studies have utilized the Technological Pedagogical Content Knowledge (TPACK) framework, posited by Mishra and Koehler in 2006, to explore the role that knowledge plays in effective technology integration. And many have found that teachers with TPACK—the most robust form of the seven forms of knowledge identified by Mishra and Koehler (2006)—are better able to employ technology to create alternative methods of representing disciplinary content to facilitate students' comprehension of challenging course material (Rahman et al., 2017). Despite this finding, researchers have consistently noted a strong and troubling disconnect between mathematics teachers' use of technology and TPACK (DeCoito & Richardson, 2018; Gonzalez & González-Ruiz, 2017; Urbina & Polly, 2017). Put another way, researchers more often note that mathematics' teachers use of technology neither reflects a possession of TPACK nor the educational potential of the technology. As DeCoito and Richardson (2018) described it, mathematics teachers are confident about their knowledge of content, pedagogy, and technology; however, their use or intended use of technology suggests that they are poorly informed about how to effectively utilize technology to teach different course content (an indicator of technology content knowledge or TCK). Relatedly, they are largely unaware about how the culminating form of knowledge, TPACK, can be used to fully realize the potential of the technology. Expressing a similar sentiment, Urbina and Polly (2017) opined that despite teaching in one-to-one environments (i.e., classrooms where each student was provided their own technology), elementary classroom instruction rarely employed technology; moreover, when it did, students were often tasked with technology-based activities that required low-level mathematics computations.

Merits of the Current Evaluation

The current report extends the bodies of literature reviewed above in its evaluation of the knowledge, practices, and outcomes of mathematics teachers in Utah who utilize mathematics personalized learning software in their instruction. The next section of the introduction provides a broad overview of the *K-12 Math Personalized Learning Software Grant Program* that made possible Utah teachers' procurement of mathematics education technology.

Overview of the K-12 Math Personalized Learning Software Grant Program

In 2013, House Bill 139 (H.B. 139)[1], passed in the Utah State Legislature, called for the creation of a Science, Technology, Engineering, and Mathematics (STEM) Action Center and a STEM Education Related Instructional Technology Program (commonly referred to as the *K-12 Math Personalized Learning Software Grant Program*). As stipulated in the bill text, the STEM Action

[1] https://le.utah.gov/~2013/bills/static/HB0139.html

Center Board is to fulfill the following responsibilities in relation to the K-12 Math Personalized Learning Software Grant Program: 1) vet and identify providers of education related instructional technology; 2) select school districts and charter schools to which the technology will be distributed; and 3) provide related professional development to school districts and charter schools that receive the technology. In calling for the establishment of the STEM Action Center and creation of the K-12 Math Personalized Learning Software Grant Program, the overarching goal of H.B. 139 is to improve student outcomes in mathematics and prepare secondary students for college mathematics courses.

Program Implementation

In administering the K-12 Math Personalized Learning Software Grant Program, the STEM Action Center takes guidance from H.B. 139. Guidance provided by H.B. 139 includes criteria for the STEM Action Center to consider in choosing vendors of educational related instructional technology, selecting school districts and charter schools for participation in the grant program, and providing professional development to teachers who receive the technology. In keeping with stipulations in H.B. 139, the STEM Action Center chooses vendors whose digital mathematics software provides individualized instructional support to students using the software, adapts to the needs and progress of each user, provides frequent, quick, and informal assessments, and comes equipped with a tool for monitoring the progress of students and providing feedback to students and teachers.

School districts and charter schools selected to participate in the grant program are also chosen through a competitive process as required by H.B. 139. Finally, with regard to professional development, the STEM Action Center, as mandated by H.B. 139, supports educators in making instructional materials more dynamic and engaging, creating targeted instruction for students who are not enthusiastic about STEM, designing engaging engineering courses, and introducing other research-based methods that support student achievement in STEM.

Purpose of the Evaluation

Given teachers' use of mathematics personalized learning software and exposure to relevant professional development, the current evaluation seeks to assess their knowledge, practices, and outcomes from using mathematics personalized learning software.

Methods

Evaluation Questions

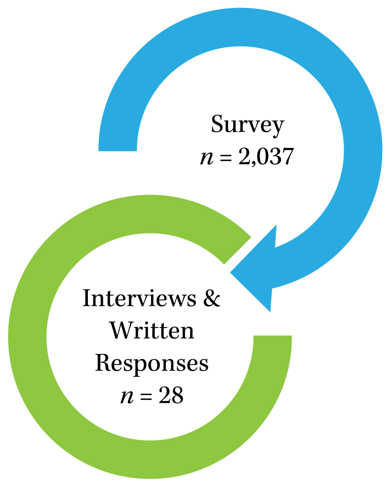
The purpose of the evaluation is addressed through the following questions:

1. What are the demographics of teachers who use mathematics personalized learning software in their classrooms?
2. What forms of knowledge do teachers who use mathematics personalized learning software possess?
3. What are the practices of teachers in classrooms supported by mathematics personalized learning software?
4. How does teaching with mathematics personalized learning software affect teacher outcomes?

Data Sources

Data for this evaluation was collected using instruments designed by the Utah Education Policy Center (UEPC). These instruments included a survey and an interview protocol. The survey served as the primary means of data collection and garnered a total of 2,037 responses. The interview protocol was used in conducting individual interviews, which for this initial study yielded three participants. Additionally, the interview protocol was transformed into an on-line submission form for use in gathering written responses from teachers (n = 25) who were interested in participating in interviews but were unable to do so because of major alterations to their schedules and teaching arrangements brought on by the novel coronavirus, or COVID-19, pandemic.

Figure 1. Data Sources



Survey and Interview Protocol Design

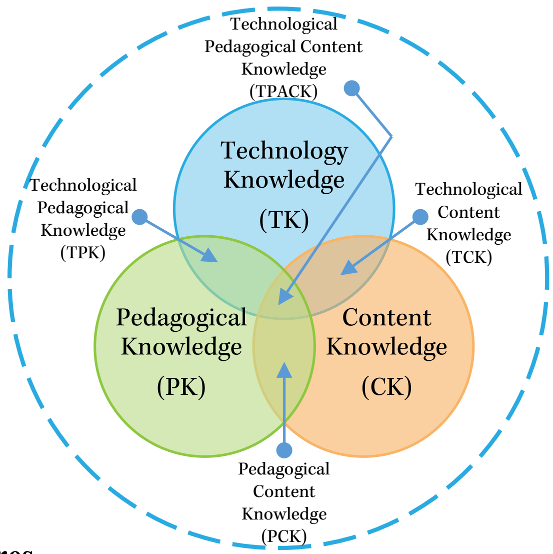
The survey used in this evaluation included items on teacher demographics, knowledge, practices, and outcomes. The interview protocol, however, focused primarily on teacher practices.

Items in the survey pertaining to teacher knowledge were informed by the Technological Pedagogical Content Knowledge (TPACK) framework developed by Mishra and Koehler (2006). As the scholars note, effective integration of technology in the classroom hinges on teachers' possession of knowledge that is complex, multi-faceted, and nuanced. Whereas prior theories, such as that espoused by Shulman (1986), emphasized the importance of content knowledge, pedagogical knowledge, and pedagogical content knowledge (created by the interaction of content and pedagogy), Mishra and Koehler maintain that these forms of knowledge are not sufficient for effective teaching in the current era where classrooms are more often supported by technology.

They argue that good teaching requires knowledge of content (C), pedagogy (P), and technology (T). More importantly, they note that these three forms of knowledge, when used in tandem, activate other forms of knowledge that are also integral to effective teaching. These additional knowledge forms include Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological

Pedagogical Content Knowledge (TPACK). Survey items related to teacher knowledge therefore draw on tenets of the TPACK framework and aim to shed light on the breadth of knowledge possessed by mathematics teachers in technology-supported classrooms.

Figure 2. TPACK Framework



Data Collection Procedures

The survey developed for this evaluation was launched in early March 2020 and stayed open for four weeks. On the day of the survey launch, the UEPC shared the survey link with the STEM Action Center. In turn, the STEM Action Center contacted administrators at school districts and charter schools participating in the grant program and asked that they disseminate the link to their teachers. Over the course of the survey participation period, the UEPC maintained contact with the STEM Action Center and provided them with updates about participation.

The final question in the survey was used to recruit participants for the interview phase of the evaluation. Survey participants who were interested in participating in interviews were asked to provide their name and an email address at which they could be reached. While the initial plan, as discussed in the final survey question, was to conduct focus group interviews, impediments caused by the COVID-19 pandemic necessitated a switch to individual interviews and creating an alternate format (i.e., a form with the interview protocol) through which interested teachers could share written responses to interview questions.

Data Analysis

Survey responses provide data for answering all four evaluation questions. Interviews and written responses to the interview protocol, on the other hand, only provide insight into the third evaluation question that pertains to teacher practices in classrooms supported by mathematics personalized learning software. In analyzing close-ended responses in the survey, we used descriptive statistics (e.g., frequencies, averages, and percentages). Additionally, to represent 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). Open-ended survey data, interview data, and written responses to the interview protocol were analyzed using open or inductive coding, which is a process of aggregating responses using themes that emerge directly from the data (Merriam, 2009). 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).

Table 1. Data Sources for Evaluation Questions

Evaluation Questions	Data Sources	
	Survey	Interviews & Written Responses
Q1: What are the demographics of teachers who use mathematics personalized learning software?	✓	
Q2: What forms of knowledge do teachers who use mathematics personalized learning software possess?	✓	
Q3: What are the practices of teachers in classrooms supported by mathematics personalized learning software?	✓	✓
Q4: How does teaching with mathematics personalized learning software affect teacher outcomes?	✓	

Report Organization

This introduction constitutes the first of seven sections of this report. The second section of the report, *Terminology and Definitions,* provides definitions for terms used in the report to describe the forms of knowledge that teachers possess and their instructional practices. *Demographics,* the report's third section, provides key demographic data about teachers who participated in the evaluation. The fourth section of the report, *Teacher Knowledge,* covers the forms of knowledge possessed by teachers who utilize mathematics personalized learning software in their instruction. *Teacher Practices,* the report's fifth section, examines the practices of teachers who incorporate digital mathematics technologies in their instruction. The sixth section of the report, *Teacher Outcomes,* explores teachers' outcomes from incorporating mathematics personalized learning software in their instruction. Finally, the seventh section of the report, *Conclusions and Considerations,* provides a summary of the report's findings as well as considerations for the K-12 Math Personalized Learning Software Grant Program.

PART TWO:

TERMINOLOGY & DEFINITIONS

This section provides definitions for terms used in the report to describe the forms of knowledge that teachers possess. It also reviews terms used in the report to refer to teachers' instructional practices. The forms of knowledge that are of interest in the current report include content knowledge, pedagogical knowledge, pedagogical content knowledge, technology knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge. The instructional practices covered in this report include pre-assessments, formative assessments, summative assessments, differentiation, remediation, enrichment, homework, and supplementary classroom practice.

Forms of Knowledge

Content Knowledge – Knowledge about the actual subject matter that is to be learned or taught (Mishra & Koehler, 2006).

Pedagogical Knowledge – Knowledge of the process, practices, and methods of teaching and learning (Mishra & Koehler, 2006).

Pedagogical Content Knowledge – Knowledge of the process, practices, and methods that are most appropriate for teaching a specific content (Mishra & Koehler, 2006).

Technology Knowledge – Knowledge of mainstream technologies, such as chalkboards, and digital technologies, such as educational software and the internet (Mishra & Koehler, 2006).

Technological Content Knowledge – Knowledge of the ways in which technology can be employed to teach a specific content and the manner in which a subject matter can be changed by integrating technology (Mishra & Koehler, 2006).

Technological Pedagogical Knowledge – Knowledge of the existence, components, and utility of various technologies and how teaching can be modified by integrating particular technologies (Mishra & Koehler, 2006).

Technological Pedagogical Content Knowledge – Regarded as the basis of good teaching, technological pedagogical content knowledge requires thoughtful integration and utilization of the three key forms of knowledge: content knowledge, pedagogical knowledge, and technology knowledge ((Mishra & Koehler, 2006).

General Instructional Practices

Pre-Assessments – Evaluations administered prior to the start of a lesson, unit, or course to assess students' prior knowledge and establish a baseline against which to measure learning progress in relation to the lesson, unit, or course to be taught (Brownstein et al., 2009).

Formative Assessments – Evaluations administered during the learning process to assess students' learning progress and, if needed, modify teaching and learning to improve student achievement (Schoenfeld, 2015).

Summative Assessments – Evaluations administered at the conclusion of a lesson, unit, or course to assess what students learned or did not learn. Examples of summative assignments include end-of-unit tests and state assessments (Schoenfeld, 2015).

Differentiation – A practice of putting comparable emphasis on individual students and course content and adapting teaching and learning to accommodate each individual student's prior knowledge, interests, abilities, and learning style. (Tomlinson & Imbeau, 2010).

Remediation – The practice of giving additional time, guidance, and instruction to a student in order to ensure that they achieve pre-set learning goals (Grant, Fazarro, & Steinke, 2014).

Enrichment – The practice of assigning additional tasks to students who have met learning goals in order to further their knowledge on the subject matter (Grant et al., 2014).

Supplementary Classroom Practice – The practice of assigning additional problems to students to help assess and reinforce their knowledge of concepts (Parsons & González, 2018).

Homework – Tasks assigned by teachers that are intended to be completed by students outside of school hours and are to help reinforce newly acquired skills and knowledge and facilitate the acquisitions of new skills through independent study (Cooper, Robinson, & Patall, 2006).

PART THREE:

DEMOGRAPHICS

This section examines the demographics of the 2,037 teachers who participated in the survey that informed this report. As teachers who participated in interviews, or submitted written responses to the interview protocol, were also survey respondents, their demographics are reflected in the data provided below.

Key Findings on Participant Demographics

Teachers Who Use Mathematics Personalized Learning Software in their Classrooms Are Affiliated with a Variety of Local Education Agencies

Teachers who teach mathematics with technology were asked to identify the local education agencies in which they teach. As Table 2 illustrates, these teachers belong to a variety of local education agencies including public school districts and charter schools. Precisely, 1,763 teachers indicated that they provide mathematics instruction in public school districts and 274 indicated that they teach mathematics at charter schools. Of the public school districts listed in Table 2, however, Davis District (n = 517), Granite District (n = 392), Canyons District (n = 167), Salt Lake District (n = 94), and Alpine District (n = 80) account for the highest numbers of teachers who teach mathematics with technology.

Teachers Who Use Mathematics Personalized Learning Software Teach Varied Grade Levels, Although They Primarily Serve the 3rd, 4th, and 5th Grades

Teachers were asked in the survey to identify the grade levels that they teach (Figure 3). As Figure 3 depicts, teachers who use mathematics personalized learning software in their instruction teach a variety of grade levels, spanning kindergarten to grade 12. Additionally, many teach more than one grade level as indicated by the percentages in Figure 3 that sum up to more than 100%. As it concerns the grade levels in which these teachers most frequently teach, a notable proportion of them report teaching grades 3 (22%), 4 (21%), 5 (20%). Also, teachers were least likely to indicate that they teach grades 9 (5%), 10 (5%), 11 (4%), and 12 (3%).

Figure 3. Grade Levels Taught by Teachers

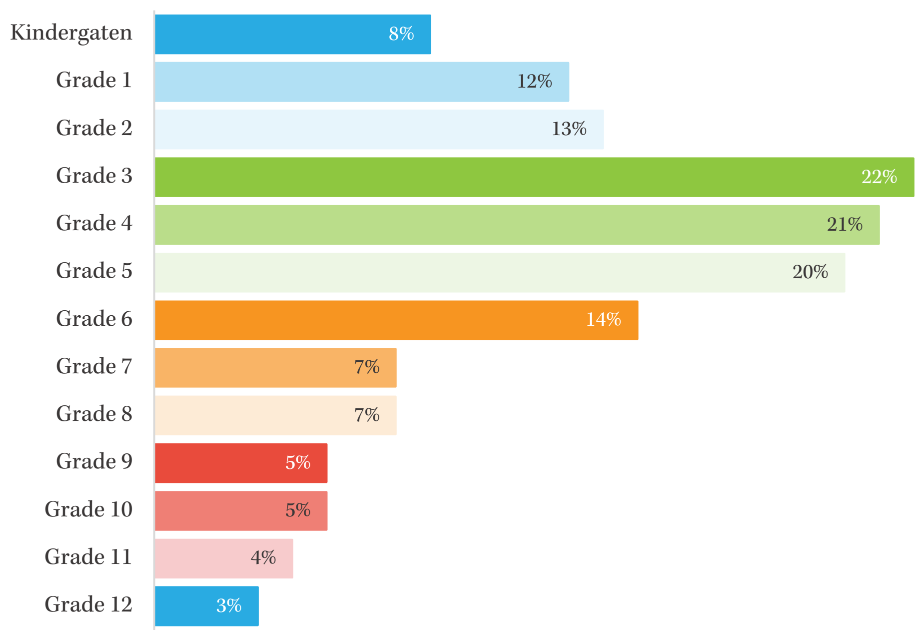


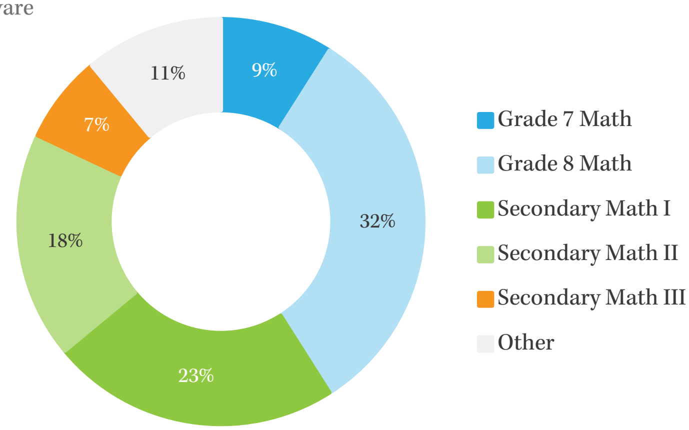
Table 2. Local Education Agencies and Number of Survey Respondents

Local Education Agencies (No. of Survey Respondents)	
Alpine District	(80)
Beaver District	(1)
Box Elder District	(1)
Cache District	(19)
Canyons District	(167)
Carbon District	(3)
Davis District	(517)
Duchesne District	(8)
Emery District	(17)
Garfield District	(3)
Grand District	(16)
Granite District	(392)
Iron District	(9)
Jordan District	(52)
Juab District	(24)
Kane District	(9)
Logan City District	(29)
Millard District	(14)
Morgan District	(11)
Murray District	(1)
Nebo District	(3)
North Sanpete District	(7)
Ogden City District	(1)
Park City District	(13)
Piute District	(14)
Provo District	(6)
Rich District	(8)
Salt Lake District	(94)
San Juan District	(35)
Sevier District	(56)
South Sanpete District	(21)
South Summit District	(15)
Tintic District	(5)
Toole District	(18)
Wasatch District	(1)
Washington District	(37)
Wayne District	(2)
Weber District	(54)
Charter Schools	(274)
Total	(2,037)

Among the Various Middle and High School Mathematics Courses Offered, Teachers Most Frequently Integrate Digital Mathematics Software in Grade 8 Math

Given that teachers often teach more than one grade level—a fact that also holds true for our sample as discussed in the prior finding—teachers were further prompted in the survey to specify the mathematics course in which they most frequently integrate digital mathematics software. To answer this question, teachers were provided with options including *Grade 7 Math*, *Grade 8 Math*, *Secondary Math I*, *Secondary Math II*, *Secondary Math III*, *Pre-Calculus*, *Introductory Calculus*, *AP Calculus*, *AP Statistics*, *College Prep Math*, *Mathematical Decision Making for Life*, *Mathematics of Personal Finance*, *Modern Mathematics*, and *Other*. As Figure 4 shows, teachers more regularly integrate digital mathematics software in *Grade 8 Math* (32%) and two required high school mathematics courses—*Secondary Math I* (23%) and *Secondary Math II* (18%). It is also important to note that among the teachers who indicated that they teach "other" mathematics courses (11%), many noted teaching *Grade 6 Math* (another middle school mathematics course) and *Applied Mathematics* courses (mathematics course options that are usually only available to high school students).

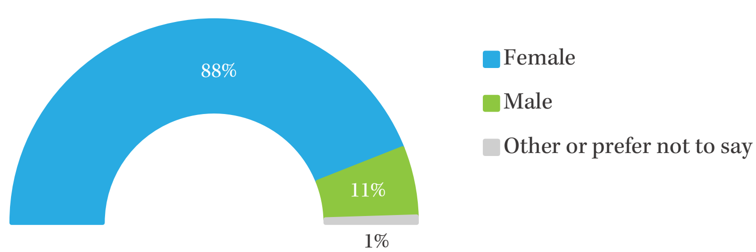
Figure 4. Middle and High School Mathematics Courses in Which Teachers Most Often Integrate Mathematics Personalized Learning Software



The Vast Majority of Teachers Who Teach Mathematics with Technology Are Female

Teachers were also asked in the survey to identify their gender. As Figure 5 illustrates, teachers were most likely to indicate that they were female (88%). Eleven percent of teachers indicated that they were male, and 1% selected the option of "other or prefer not to say."

Figure 5. Gender of Survey Respondents



Most Teachers Who Teach Mathematics with Technology Hold a Degree in Teaching but Not in Mathematics

Teachers who teach mathematics with technology were asked to indicate whether or not they have a degree in teaching (Figure 6). Additionally, they were also asked if they have a degree in mathematics (Figure 7). As Figure 6 suggests, the majority of teachers (86%) who utilize digital technologies in their mathematics instruction have a degree in teaching. At the same time, however, an overwhelming majority of them (94%) do not hold a mathematics degree (Figure 7).

Figure 6. Percent of Teachers Who Hold or Do Not Hold a Degree in Teaching

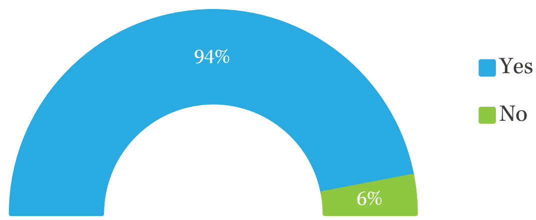
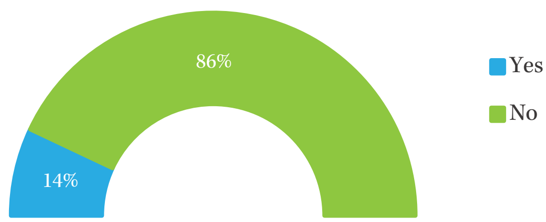


Figure 7. Percent of Teachers Who Hold or Do Not Hold a Degree in Mathematics



Many Teachers Who Use Mathematics Personalized Learning Software Have or Are Working Towards Endorsements

Teachers were asked to identify the endorsements, if any, they had or were working towards from the following options: business marketing/information technology; educational technology; gifted and talented; instructional coaching; mathematics; science, technology, engineering, and mathematics (STEM); special education; and other. Figures 8 and 9 report data on teachers who indicated that they had earned or were working towards endorsements. As Figure 8 illustrates, the highest number of teachers (*n* = 404) indicated that they were working towards "other" endorsements not included among the options. When prompted to specify what these "other" endorsements were, many noted seeking, or having already earned, endorsements in English as a second language (ESL), English language learners (ELL), early childhood education, and dual immersion. Besides "other" endorsements, an important fraction of teachers noted having or working towards mathematics (*n* = 364), educational technology (*n* = 220), and special education (*n* = 175) endorsements. Equally importantly, as Figure 9 indicates, teachers who selected special education (91%), other (78%), and mathematics (76%) endorsements were more likely than other teachers to have completed the process required to earn their certifications.

Figure 8. Number of Teachers Pursuing Each Type of Endorsement

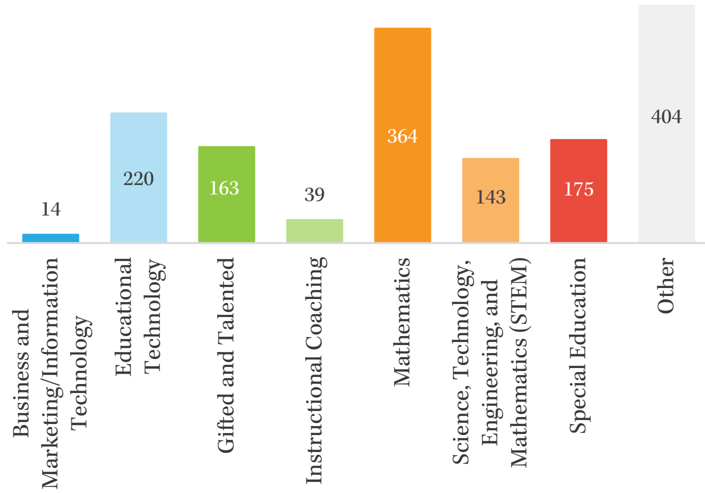
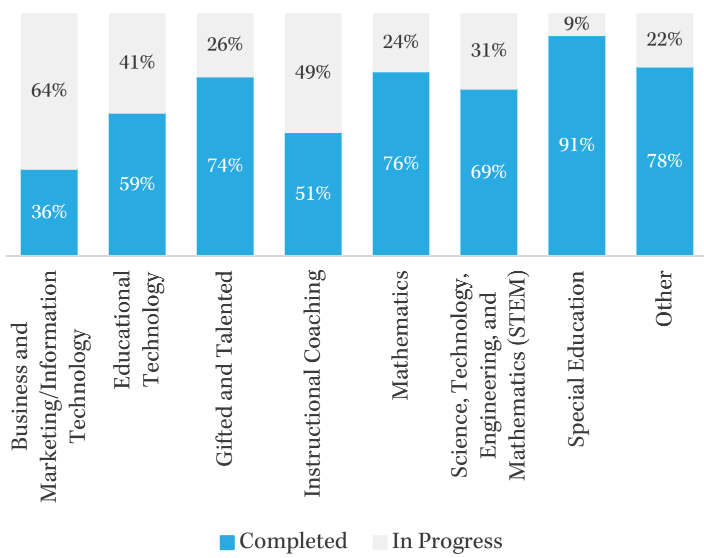


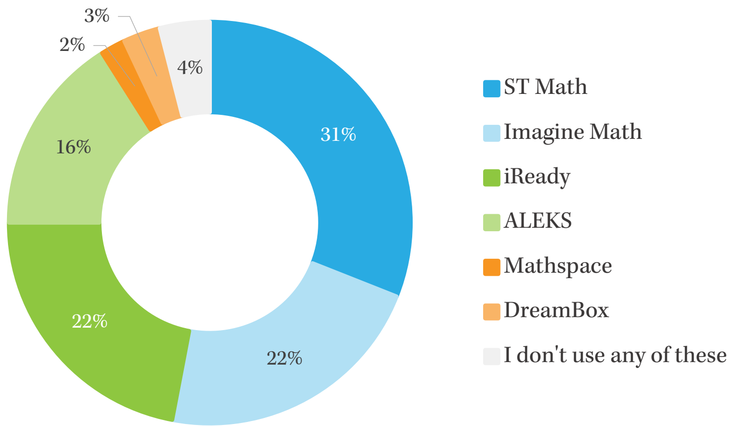
Figure 9. Percent of Teachers Who Have Completed or Are in Progress with Earning Endorsements



The Type of Mathematics Personalized Learning Software Utilized by Teachers Vary

Teachers were provided with a pre-defined list of digital mathematics software supported by the STEM Action Center—ALEKS, DreamBox, Imagine Math, iReady, and ST Math—and were asked to identify which of the software they most frequently use. They were also permitted to indicate that "I don't use any of these" in the case that their digital mathematics software of choice was not provided in the list. As Figure 10 suggests, the digital mathematics software most frequently used by teachers include ST Math (31%), Imagine Math (22%), and iReady (22%), while the least used is Mathspace (2%).

Figure 10. Mathematics Personalized Learning Software Used by Teachers



PART FOUR:

TEACHER KNOWLEDGE

This section explores the forms of knowledge possessed by teachers who use integrate personalized learning software in their mathematics instruction. The requisite forms of teacher knowledge for technology-supported instruction include content knowledge, pedagogical knowledge, pedagogical content knowledge, technology knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge. Definitions for these knowledge varieties are provided in the *Terminology and Definitions* section of this report (i.e., Part Two).

Key Findings on Teacher Knowledge

A Majority of Teachers Strongly Agree or Agree That They Possess the Seven Forms of Teacher Knowledge Necessary for Effective Teaching of Mathematics with Technology

Teachers who use mathematics personalized learning software in their instruction were asked to specify the extent to which they agree that they possess indicators of the various forms of teacher knowledge useful for teaching in such classrooms. As Figures 11-17 illustrate, teachers who integrate technology in their mathematics instruction are generally very confident of their knowledge of content (Figure 11), pedagogy (Figure 12), and technology (Figure 13) as well as their ability to simultaneously utilize two or more of these keys forms of knowledge in their instruction (Figures 14, 15, 16, and 17). Between 82% and 93% of teachers, for example, strongly agreed or agreed that they possess the indicators of content knowledge which include "having sufficient knowledge about mathematics," "knowing various ways and strategies of developing my understanding of mathematics," and "using a mathematical way of thinking" (Figure 11). A somewhat higher percentage of teachers, between 95% and 98% strongly agreed or agreed that they possessed the attributes associated with pedagogical knowledge. Concerning technology knowledge, 61% to 80% of teachers strongly agree or agreed that they possessed its various indicators (Figure 13). For pedagogical content knowledge (Figure 14), technological pedagogical knowledge (Figure 15), technological content knowledge (Figure 16), the percentages of teachers who strongly agreed or agreed to possessing their indicators were 90% to 93%, 78% to 90%, and 77%, respectively. Finally, technological pedagogical content knowledge, the most robust form of teacher knowledge, had 76% of teachers who strongly agreed or agreed that they possessed its sole indicator "I teach lessons that appropriately combine mathematics, technologies, and teaching approaches" (Figure 17). It is important to note here that among teachers who responded affirmatively about possessing the various forms of knowledge, nearly half of them, and in some cases more than half, tended to "agree" as opposed to "strongly agree."

Figure 11. Teachers' Self-Evaluation of Their Content Knowledge

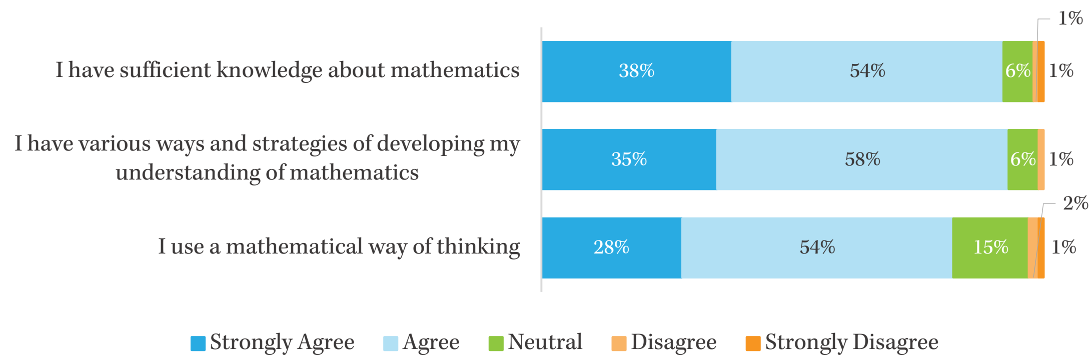


Figure 12. Teachers' Self-Evaluation of Their Pedagogical Knowledge

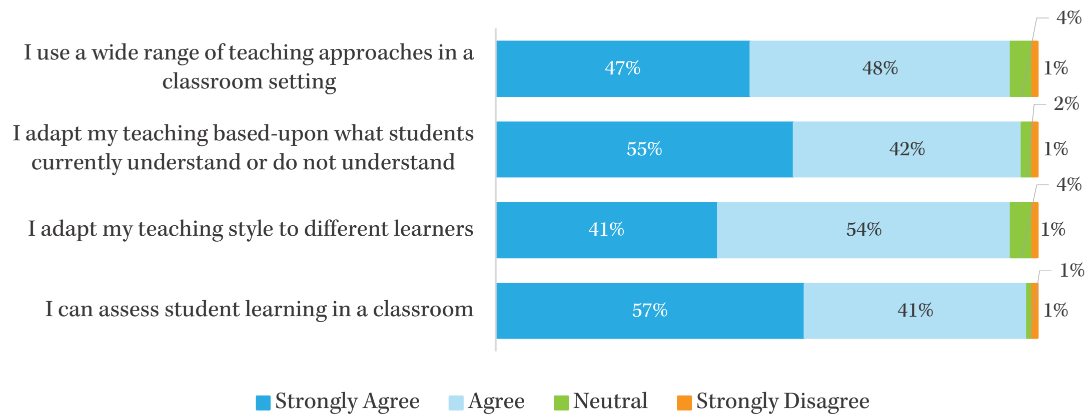


Figure 13. Teachers' Self-Evaluation of Their Technology Knowledge

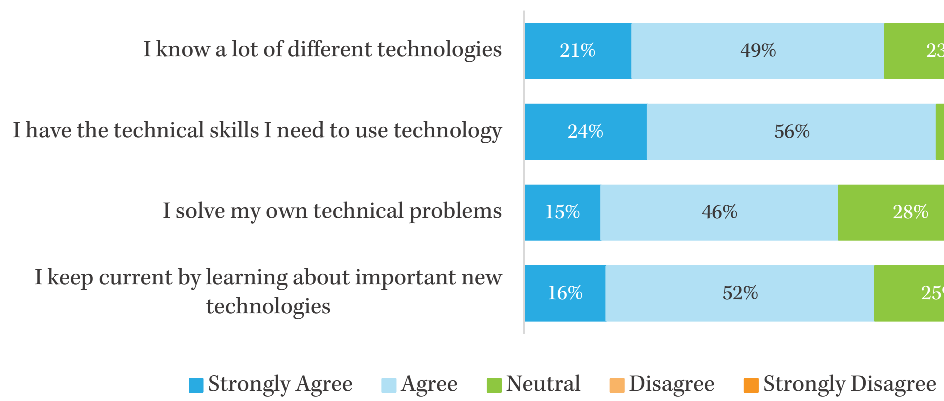


Figure 14. Teachers' Self-Evaluation of Their Pedagogical Content Knowledge

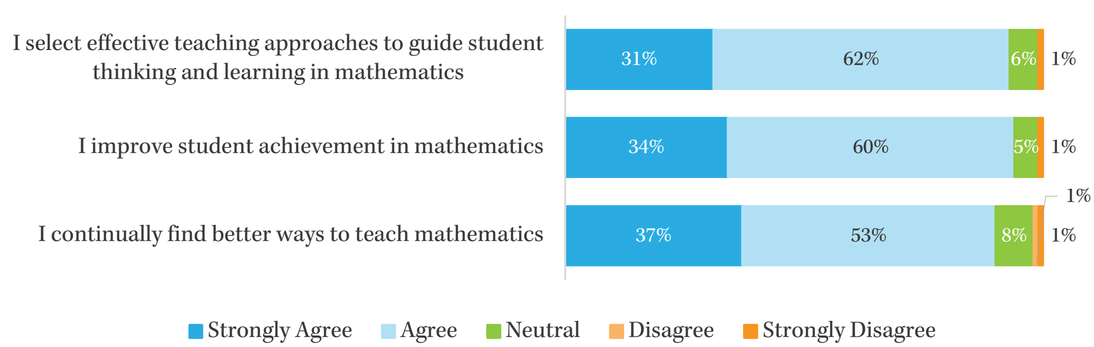


Figure 15. Teachers' Self-Evaluation of Their Technological Pedagogical Knowledge

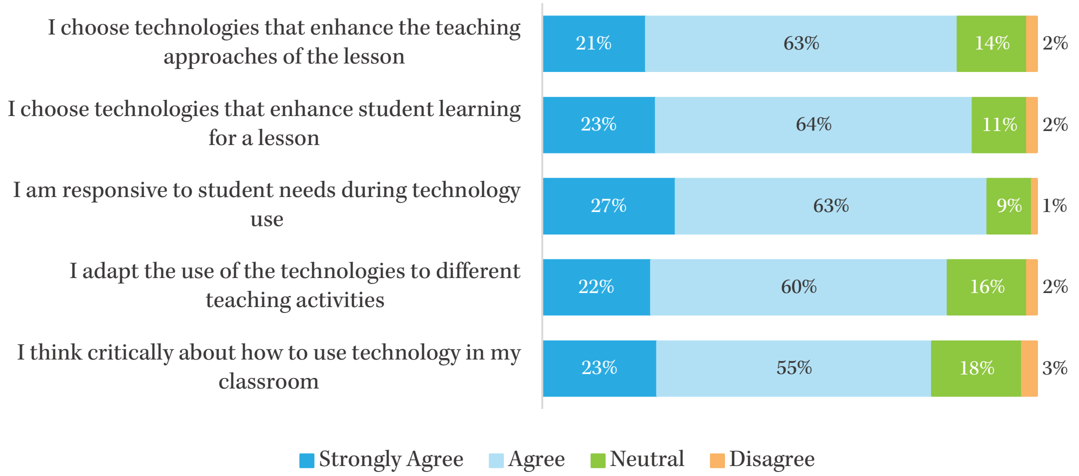


Figure 16. Teachers' Self-Evaluation of Their Technological Content Knowledge

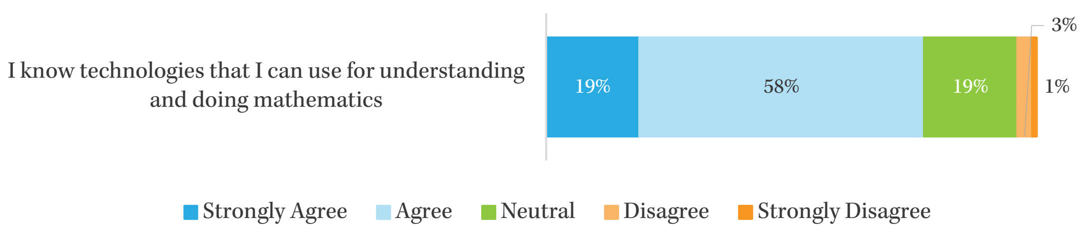
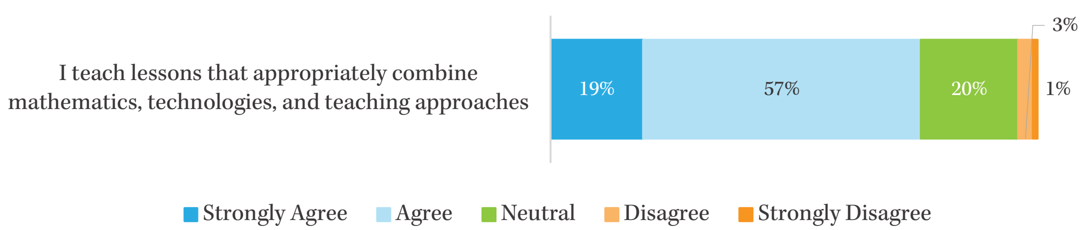


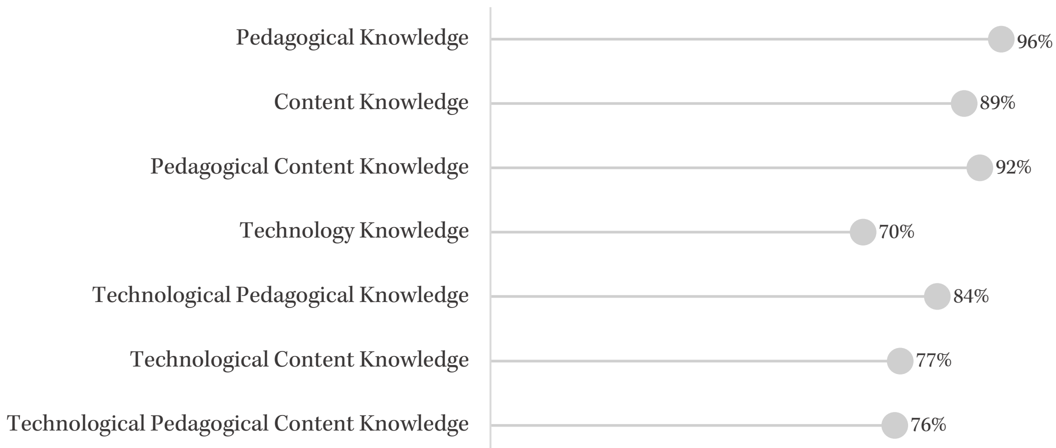
Figure 17. Teachers' Self-Evaluation of Their Technological Pedagogical Content Knowledge



Teachers Who Utilize Mathematics Personalized Learning Software in their Instruction Are Generally More Likely to Possess Pedagogical Knowledge and Pedagogical Content Knowledge

While teachers were relatively very confident about their possession of the various forms of knowledge as indicated in the prior finding, a closer examination of the data reveals that teachers were more likely to strongly agree or agree to having certain forms of knowledge than others. Figure 18 illustrates the average percentage of teachers who strongly agree or agree to possessing each form of teacher knowledge. As the figure reveals, teachers were least likely to indicate that they possess technology knowledge (70%) and technological pedagogical content knowledge (76%). However, they were most likely to strongly agree or agree to having pedagogical knowledge (96%) and pedagogical content knowledge (92%).

Figure 18. Average Percent of Teachers Who Strongly Agree or Agree to Having the Various Forms of Knowledge



PART FIVE:

TEACHER PRACTICES

This section examines the practices of mathematics teachers who incorporate digital technologies in their instruction. Topics discussed include how often teachers integrate technology in their instruction for classroom activities and out-of-classroom assignments (e.g., homework), how effective they perceive mathematics personalized learning software to be for key instructional practices—including pre-assessment, formative assessment, summative assessment, homework, differentiation, remediation, and enrichment—and their perceptions about how technology best supports teaching and learning in their classrooms. Findings concerning how often teachers use technology in their instruction and how effective they rate technology for instructional purposes utilize data from close-ended questions in the survey. On the other hand, findings about how technology best supports teaching and learning in teachers' classrooms are informed by teachers' responses to an open-ended question in the survey, their extended discourses during interviews, and their written responses to the interview protocol. The instructional practices identified above are defined in the *Terminology and Definitions* section of this report (i.e., Part Two).

Key Findings on Teacher Practices

Teachers Who Integrate Technology in Their Mathematics Instruction Use It More Often for Classroom Activities Than for Out-of-Classroom Assignments

Teachers were asked how often they use technology for classroom activities and out-of-classroom assignments. To answer each of the two questions, teachers were provided the following six options to select from: "more often," "2-3 days a week," "about once a week," "2-3 times a month," "once a month or less," and "never." As Figures 19 and 20 suggest, teachers utilize technology more often for in-class instruction than for out-of-classroom assignments. While 84% of teachers indicated using technology "more often," "2-3 days a week," or "about once a week" for classroom activities (Figure 19), only 37% of them indicated using technology that frequently for out-of-classroom assignments (Figure 20). Equally revealing is the percent of teachers who indicated that they "never" use technology. Whereas 6% of teachers indicated "never" using technology for in-class instruction, 43% of teachers indicated that they "never" use technology for out-of-classroom assignments.

Figure 19. Teachers' Frequency of Use of Mathematics Software for Classroom Activities

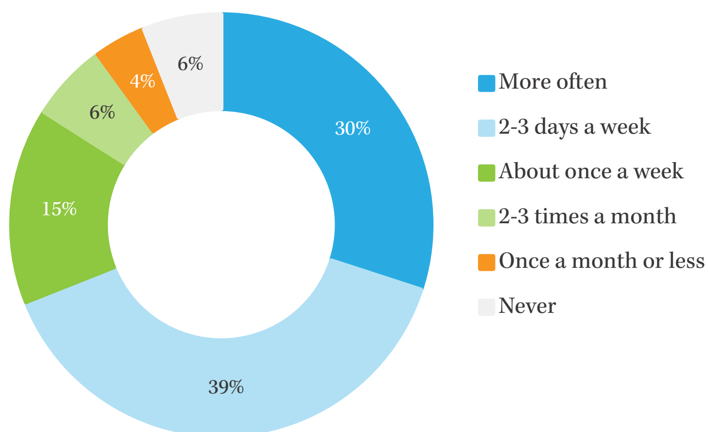
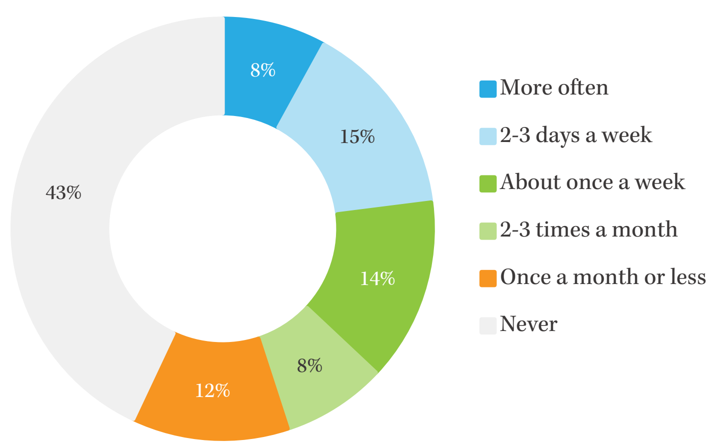


Figure 20. Teachers' Frequency of Use of Mathematics Software for Out-of-Classroom Assignments



Teachers Who Integrate Technology in Their Mathematics Instruction Find It More Effective for Individualized Instructional Activities Than for Group Activities

Teachers who teach mathematics with technology were asked to specify how effective technology is for key instructional practices, including pre-assessment, formative assessment, summative assessment, homework, differentiation, remediation, and enrichment. To rate the effectiveness of technology for the aforementioned purposes, teachers were provided the following options to select from: "extremely effective," "very effective," "moderately effective," "slightly effective," "not at all effective," and "did not use." As Figures 21-27 illustrate, teachers find technology much more effective for instructional practices that center the learning needs of individual students (i.e., differentiation, remediation, enrichment) than those that tend to involve the whole class (i.e., pre-assessment, formative assessment, summative assessment, homework). For example, whereas 35%, 37%, 35%, and 24% of teachers, respectively, indicated that technology is "extremely effective" or "very effective" for pre-assessment (Figure 21), formative assessment (Figure 22), summative assessment (Figure 23), and homework (Figure 24), 61%, 50%, and 67% of teachers, respectively, rated technology as "highly effective" or "very effective" for differentiation (Figure 25), remediation (Figure 26), and enrichment (Figure 27). Teachers were also more likely to indicate that they "did not use" technology for pre-assessment (33%), formative assessment (29%), summative assessment (34%), and homework (44%), than differentiation (10%), remediation (13%), and enrichment (7%).

Figure 21. Teachers' Evaluation of the Effectiveness of Mathematics Software for Pre-Assessment

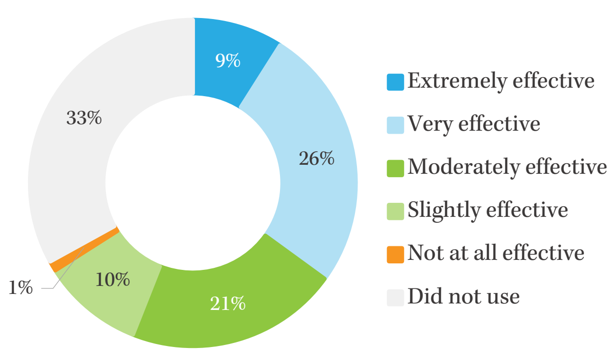


Figure 22. Teachers' Evaluation of the Effectiveness of Mathematics Software for Formative Assessment

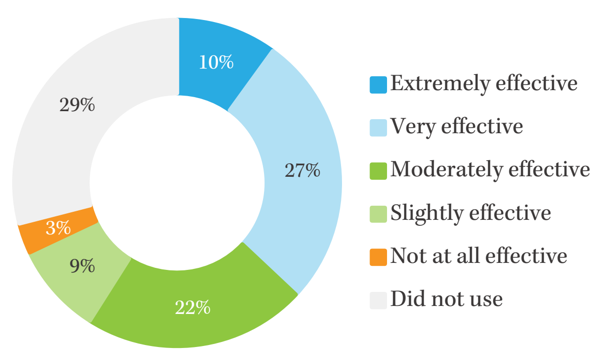


Figure 23. Teachers' Evaluation of the Effectiveness of Mathematics Software for Summative Assessment

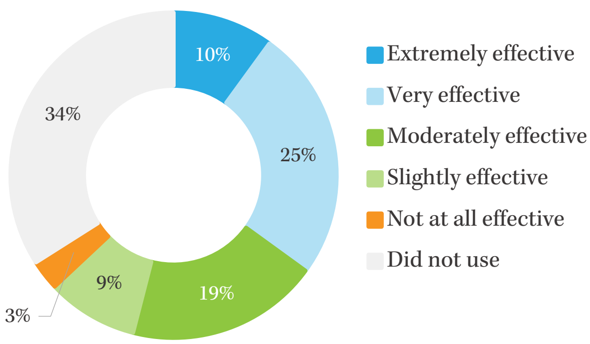


Figure 24. Teachers' Evaluation of the Effectiveness of Mathematics Software for Homework

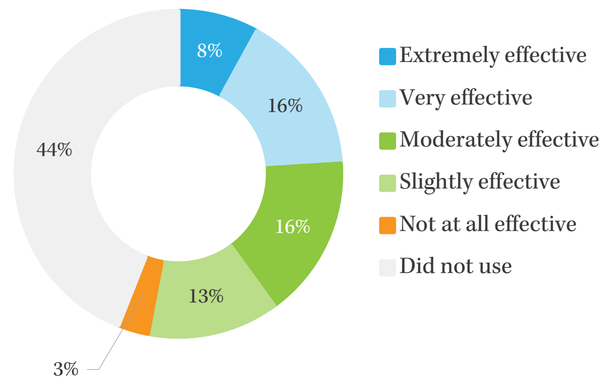


Figure 25. Teachers' Evaluation of the Effectiveness of Mathematics Software for Differentiation

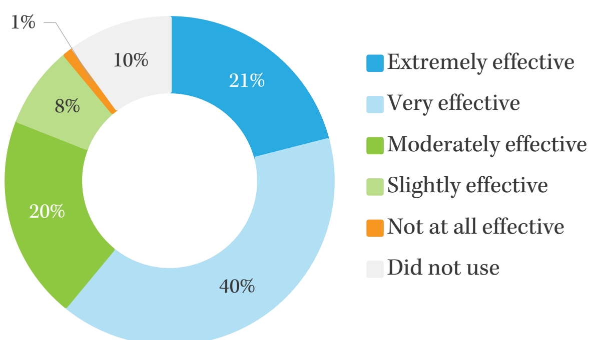


Figure 26. Teachers' Evaluation of the Effectiveness of Mathematics Software for Remediation

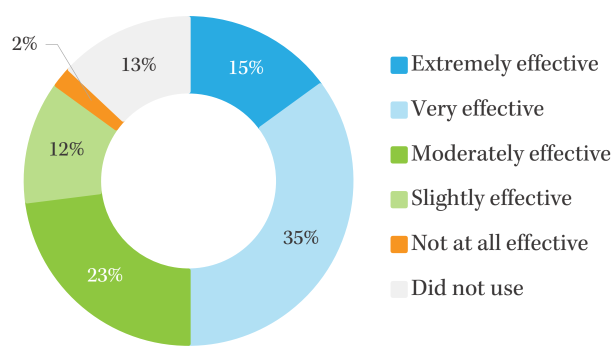
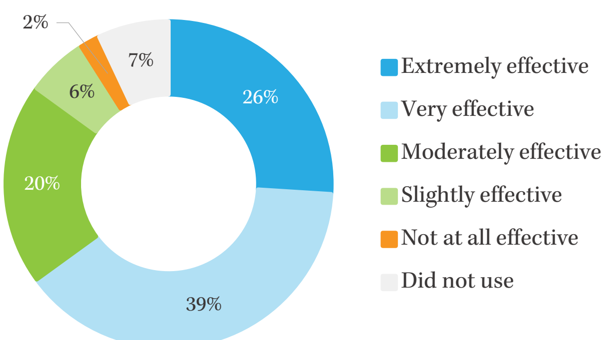


Figure 27. Teachers' Evaluation of the Effectiveness of Mathematics Software for Enrichment



In their Qualitative Responses, Teachers Noted That Technology Best Supported Teaching and Learning in their Classrooms in Various Ways, Although the Most Common Ways Identified Were Differentiation, Remediation, and Enrichment

In the same way that teachers were more likely to note that digital mathematics software was more effective for differentiation, remediation, and enrichment than for pre-assessment, formative assessment, summative assessment, and homework (as illustrated in Figures 21-27), they more frequently discussed in their qualitative responses that digital mathematics software best supported teaching and learning in their classrooms by facilitating the first three practices. To be sure, a few teachers also reported that mathematics personalized learning software was most useful in their instruction for pre-assessment, formative assessment, summative assessment, homework, and even supplemental exercises/practice. In the sub-sections below, we discuss these themes that emerged from the study's qualitative data and provide excerpts from teachers' accounts that best illustrate them.

Differentiation: Individualizing Instruction

Because no two students are alike, as Tomlinson and Imbeau (2005) opine, personalization of teaching and learning is a necessity. Much like Tomlinson and Imbeau (2005), teachers who participated in the study know first-hand the range of skills and abilities that can be present in a single classroom. As one teacher reported, *"I have students who cannot count to 10. I have students who were…proficient in 5th grade math since the first day of school year, and I have students at every level in between. In essence I have about 20 levels."* As another noted*, "each of my students is at a very different level."*

Given the great variation in academic readiness, interests, and needs that teachers often encounter in the classroom, many see the importance of paying careful attention to each student's learning progress and assigning tasks to students that are appropriate for their level of understanding. Describing the value she places on differentiating instruction for her students, one teacher noted*, "It is vital for me that I can look at a domain or area in which a student is struggling, pull up a lesson plan targeting that area, and teach a lesson one-on-one with that student."* In a similar vein, another teacher reported, *"students that work with me in small groups get to work with their own level, and we get to have individualized instruction one on one with where they are at in their learning."*

While differentiation is a practice that many teachers, like those highlighted above, find incredibly useful for fostering students' comprehension of course content and even their confidence, many also acknowledge the time-consuming nature of the practice and credit mathematics personalized learning software for increasing their efficiency at providing individualized instruction to their students. Describing the challenge of differentiation and the importance of digital technologies for this practice, one teacher asserted, *"I don't have time to differentiate for 60 students a day but this program allows them to work at their own pace."* Similar to this teacher, another noted, *"I can differentiate a little easier using technology than if I were just on my own."*

As teachers' accounts further revealed, mathematics personalized learning software did not merely serve to make their differentiation practice easier. Many teachers spoke at length about at how effective these digital technologies were at recognizing the learning needs of students and providing targeted tasks that accommodate their skills and abilities. As one teacher described, *"At the beginning of the year most students were on the same module…As the year progressed and students were at different levels of [software], student learning targets changed."* Also speaking about the level of personalization in instruction provided by digital mathematics software, another teacher said, *"each student was given individual goals through [software] rather than following the whole class target."* Similarly, another teacher noted, *"I like how [software] is geared to the student's level and aids in filling the gaps students may have."*

Indeed, when teachers were asked to provide one word that best describes the role of mathematics personalized learning software in their classroom, a good number of them shared words that capture the ethos of differentiation such as *"personalized," "adaptive,"* and *"individualized",* and *"accessible."*

Remediation: Filling the Holes

Grant, Fazarro, and Steinke (2014) discuss that the goal of mastery learning—that students achieve complete knowledge of material—is increasingly being abandoned in K-12 classrooms across the nation because of the considerable time and effort that it requires. In a typical K-12 classroom, teachers are expected to achieve the goal of mastery learning by teaching a unit or lesson to students, developing an assessment to gauge their understanding of the content, and for learners who did not achieve the mastery necessary, providing remediation. Remediation, with the goal that students should achieve mastery, involves giving additional instruction, followed by an assessment, as many times as is needed until the necessary progress is made. Needless to say, the amount of care and effort exerted in providing remediation or fostering mastery learning appear worthwhile for narrowing or closing achievement gaps in education, and in fact, several researchers have confirmed this to be the case (e.g., Grant et al., 2014; Guskey, 2007). However, the time-consuming nature of the practice has led to its declining popularity in recent years.

Given the arduousness of remediation, it comes as no surprise then that teachers who participated in the study valued mathematics personalized learning software for its ability to serve as a tool for remediation. Alluding to the feeling of relief she experienced because of the effectiveness of digital mathematics software at identifying students in need of remediation, one teacher said, *"I don't need to know where they are lacking in their math understanding because [software] will already do that with an assessment before they start."*

Beyond helping to identify students in need of additional instruction, many teachers shared detailed experiences with using mathematics personalized learning software to support their *"struggling"* students or to *"fill the holes"* in their students' learning. Describing an experience with a struggling student and how she utilized digital mathematics software to provide the needed remediation, one teacher said, *"A student came into my class behind where she should have been. She worked every day on [software] and it brought up concepts she needed help on. I was able to work with her and get her caught up to where she should be, and now she has very few struggles in math."* Similar to this teacher, another reported, *"One of my students was* *struggling with a concept in the University of Utah 6th grade Math book. I was able to choose a lesson on [software] that covered the same concepts. This extra reinforcement and instruction helped the student gain an understanding of the topic."*

Not only did teachers describe using mathematics personalized learning software for remediation, many in fact noted that remediation was primarily, if not solely, what they used software for. As one teacher said, *"I have used [software] the most to help students fill in their 'holes'"*. Similarly, another teacher opined, *"I use [software] most successfully in my class to help students who have gaps in their learning."* And another noted pithily, *"I use [software] for remediation."* Many teachers also alluded to using mathematics personalized learning software solely for remediation when they were asked to provide one word that best describes the role of digital technologies in their classroom. In response to this question, some teachers provided the following words: *"support," "aid,"* and *"supplemental."*

Enrichment: Moving Ahead

Much like remediation, enrichment—the practice of assigning advanced tasks to students who have met learning goals or are moving at a faster pace than other learners in the class—requires a considerable amount of time and planning (Grant et al., 2014). To identify students in need of enrichment, teachers must again teach a unit or lesson, create an assessment to measure learning, and for students who have achieved mastery of learning objectives, prepare and provide enrichment exercises (Grant et al., 2014).

Given the time and effort needed to develop unique lessons for students in need of enrichment, teachers in the study also frequently discussed using mathematics personalized learning software for this very purpose. One teacher excitedly shared, *"Each year I have several real top students that thrive because of [software]. They soar through our 5th grade level materials before mid-year. Then they are off to conquer the 6th and even 7th grade levels…[Software] is the best tool I have to keep my highest students showing exceptional growth during their 5th grade year!"* Similar to this teacher, others described using mathematics personalized learning software for their "high achievers," "gifted students," and "fast finishers." According to another teacher, *"[Software] has been very beneficial to those gifted in math. I'm thinking of a particular student who loves it and masters ideas so quickly. He has loved moving ahead of the group and learning new things."* Another teacher also reported, *"For my higher kids, [software] allowed them to move at a faster pace. Once they finished their pathway I was able to add curriculum that would be taught the following year."*

Indeed, the value of mathematics personalized learning software as a tool for enrichment was so extolled by teachers, that many reported using the digital technology mostly, if not only, for this instructional practice. According to one teacher, *"…the most common reason for use of [software] in my classroom is for fast finishers or as an enrichment activity."* Similar to this teacher, another shared, *"I mostly use [software] for fast finishers in my classroom."* As shared by another teacher, *"I only use [software] for early finishers."* And even another said, *"One of the main things I use [software] for is enrichment."*

Pre-Assessment: Understanding Where Students "Place"

Unlike differentiation, remediation, and enrichment, very rarely did teachers discuss using mathematics personalized learning software for pre-assessment. This instructional practice, while not a prevalent purpose for digital mathematics software use among teachers in the study, has been confirmed in research to be extremely critical for effective instructional planning, teaching quality, and the overall learning experience for students (Bautista, 2011; Brownstein et al., 2009).

Among the few teachers who used digital technologies for pre-assessment, two provided the most illustrative descriptions of how their software use facilitates the practice. According to the first teacher, *"[Software] has been used to get a clearer picture of where students place within the different math concepts…The data pulled from [software] helps inform the individual education maps for each of my students in math."* The second teacher shared, *"Students who needed intervention with [counting numbers to 20] were identified with the [software] diagnostic and then provided with teacher led intervention. Growth was assessed with Growth Monitoring in [software]."*

For both of these teachers, and the few others, who use mathematics personalized learning software for pre-assessment, the digital technology facilitates their gathering of diagnostic data on students' prior knowledge, which is then used to inform their lesson planning and to measure students' growth.

Formative Assessment: Using Student Data to Modify Teaching and Learning

Like pre-assessment, formative assessment was infrequently performed by teachers using mathematics personalized learning software. This instructional approach, as research suggests, is equally important as the previously discussed instructional practices. Moreover, it is uniquely important to student learning for the very fact that it involves collecting data about students' understanding midway into the teaching of a lesson or unit—a critical juncture when there are still opportunities to modify teaching and learning to ensure students' mastery of the material (Schoenfeld, 2015).

Among the few teachers who found digital mathematics software useful for formative assessment, some recalled a particular experience from recent memory when they used software for this practice. Recounting her use of digital mathematics software for formative assessment after a lesson on area and perimeter, one teacher said *"I taught multiple lessons on area and perimeter. I then assigned lessons for students to independently practice on [software]. Once I felt like students were ready, I assigned a comprehension check specific to area and perimeter. Based on the results, we went over questions that majority of the class missed."* Similar to this teacher, another shared her experience of using digital mathematics software for formative assessment after teaching a lesson on operations and algebraic thinking: *"The learning target I was focusing on was operations and algebraic thinking. I looked at my [software] data to see where my students scored on the last assessment in that standard. I was able to use that data to set small groups for remediation and for enrichment."*

Interestingly also, teachers who used mathematics personalized learning software for formative assessment often found the software most useful for this very practice. According to one teacher, *"I mostly use ALEKS as a formative assessment tool for common formative assessments with teachers. It allows us to instantly know where students are at and who we need to work more with."* Likewise, another teacher noted, *"The best way I utilize Mathspace is for collaboration and formative assessment…They work together collaboratively in groups, and then I can look at their data to see what immediate topics we need to address."*

Summative Assessment: Tracking Student Growth

Summative assessment—the practice of administering evaluations at the conclusion of a lesson for the express purpose of assigning students a grade that is a reflection of their knowledge—was also a less common use of mathematics personalized learning software (Schoenfeld, 2015). Additionally, teachers who noted using digital mathematics software for this practice tended not to elaborate on their experiences. According to one teacher, *"[Software] has great content in an easy to access format for pre and post assessments."* Similar to this teacher, another teacher briefly shared, *"I have only really used [software] for summative assessments."* Also, another teacher said, *"I am able to administer a PRE mastery check [using software] to my whole class, and…After 2 weeks…my students take the POST assessment and I track growth."*

Homework: More Independent Practice

Similar to pre-assessment, formative assessment, and summative assessment, teachers rarely discussed using mathematics personalized learning software for homework. Homework, as Cooper, Robinson, and Patall (2006) note, is an assignment intended to be completed by students outside of school hours for the purpose of reinforcing newly acquired skills and knowledge.

Much like Cooper and colleagues (2006) would expect, teachers who discussed using mathematics personalized learning software for homework valued the digital technology for the additional opportunity for practice that it provided students. Describing this benefit of using digital mathematics software for homework, one teacher asserted, *"I have experienced the most success with student learning involving [software] with homework…For homework, it provides [students with] experience trying to solve [problems] independently."* Similar to this teacher, another noted, *"[Software] was used as a homework assignment so students have more practice solving."* A third teacher also expressed the same sentiment, saying, *"I use [software] at home 1-2 times a week [for students] to grasp concepts taught in class."*

Interestingly, and much unlike the other instructional practices that have been discussed thus far, teachers who did not use digital mathematics software for homework often shared their reasoning and firm opinions for abstaining from the practice. Across these teachers' accounts was a shared sentiment that assigning homework with digital mathematics software was not a valid measure of student understanding as parents often completed assignments for students. According to one teacher, *"I've found success with [software, but]…never at home for homework. When they're at home, the parents are much too helpful and they progress more quickly than they truly should."* Other teachers discussed attempting to use mathematics personalized learning software for homework but quickly realizing that students never go through with completing the tasks assigned. Describing this experience, one teacher said, *"I've tried using it as homework, but the parents do not follow through and have them do it when I've* *requested."* Similar to this teacher, another noted, *"Students have the option to do it for homework most nights, but students rarely complete at home."*

Supplemental Classroom Practice: Mastering New Skills

In lieu of using mathematics personalized learning software for homework, many teachers have found much success with having students practice additional mathematics problems with the device in class. As with homework, supplemental classroom exercises give students the opportunity to assess and reinforce their knowledge of concepts through additional practice. And researchers have found that this instructional exercise is increasingly being done with educational software and web applications (Parsons & González, 2018).

Among the teachers who participated in the study, a good number of them highlighted supplemental, in-classroom mathematics practice as a key reason for incorporating mathematics personalized learning software in their instruction. Discussing the role that digital mathematics software plays in providing students with more practice with newly covered mathematics concepts, one teacher said, *"I used [software] to support instruction in the class and give the students more practice on concepts."* Another teacher shared the same sentiment, however with a more concrete example about how digital mathematics software is integrated on a weekly basis in her instruction for the purposes of supplementary practice: *"My main use of [software] involves using it as an opportunity for my students to get more practice with what we have been doing and learning in the classroom. I create my own pathways each week that correlate with which standards I'm teaching…and students are given one week to complete them."*

Like teachers who utilized mathematics personalized learning software for other instructional practices, those who incorporated it in their instruction for supplementary exercises also found it to be beneficial for supporting students' learning of course material. Sharing her use of digital mathematics software for additional practice and the student outcomes she observed, one teacher said, *"When students were learning addition and subtraction with regrouping, I used [software] as a support and extension. Students were able to practice the skills they learned and some students were better able to understand it after doing the skill in [software]."* In a similar vein, another teacher alluded to the "benefit" that digital mathematics software provides to students when used for supplementary practice: *"The learning target is for the students to have additional practice with topics that have already been taught. Students are using [software] as I work with students in small groups or individually. For many students I have seen [software] to be of benefit."*

PART SIX:

TEACHER OUTCOMES

This section explores teachers' outcomes from incorporating mathematics personalized learning software in their instruction. More precisely, it investigates the impact that teaching mathematics with technology has on teachers' interest in teaching mathematics, enjoyment of teaching mathematics, and job satisfaction.

Key Findings on Teacher Outcomes

Most Teachers Were Neutral or Disagreed That Teaching Mathematics with Technology Improved Their Outcomes

Teachers who integrate mathematics personalized learning software in their instruction were asked to specify the extent to which they agree that technology use positively affected their interest in teaching mathematics, enjoyment of teaching mathematics and job satisfaction. As Figures 28-30 illustrate, most teachers do not "strongly agree" or "agree" that teaching mathematics with technology improved their teaching experiences. Put another way, teachers were less likely to indicate that they "strongly agree" or "agree" than they were to select "neutral," "disagree," or "strongly disagree" in response to survey questions about their outcomes. For example, only 44% of teachers strongly agreed or agreed that using technology in their instruction increased their interest in teaching mathematics, compared to 56% who selected "neutral," "disagree," or "strongly disagree" (Figure 28). In a similar vein, only 49% of teachers strongly agreed or agreed that teaching mathematics with technology increased their enjoyment of teaching mathematics (Figure 29), and 47% shared the same sentiment about the impact of integrating technology on their job satisfaction (Figure 30). It is important to note, however, that among teachers who did not "strongly agree" or "agree" that technology use had a positive impact on their outcomes, the vast majority felt "neutral" about its effects. In other words, teachers who did not respond affirmatively about the impact of technology on their outcomes were mostly unsure about whether it did or did not influence their teaching experiences. For example, of the 56% of teachers who did not "strongly agree" or "agree" that integrating digital technology in their instruction increased their interest in teaching mathematics, most (43%) had indicated that they were "neutral;" additionally, 11% had indicated that they disagreed and only 2% noted that they strongly disagreed (Figure 28).

Figure 28. Teachers' Views About Whether Technology Integration Increased Their Interest in Teaching Mathematics

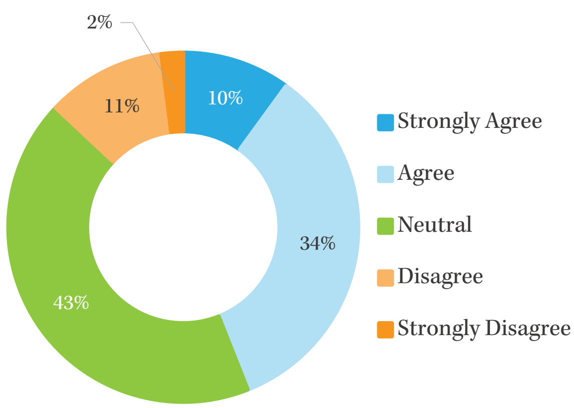


Figure 29. Teachers' Views About Whether Technology Integration Increased Their Enjoyment of Teaching Mathematics

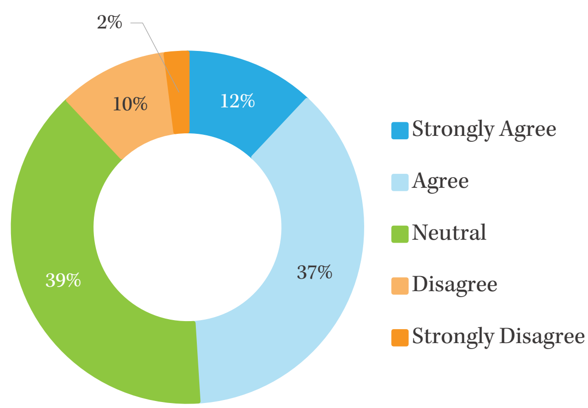
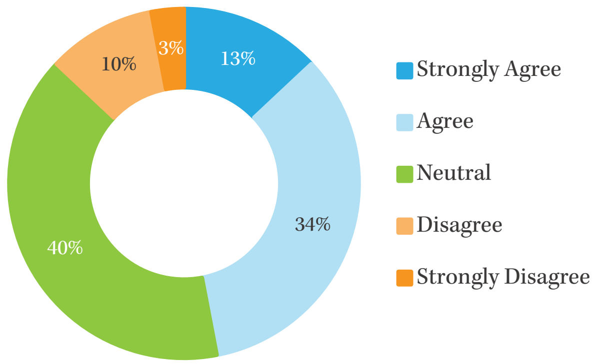


Figure 30. Teachers' Views About Whether Technology Integration Increased Their Job Satisfaction



PART SEVEN:

CONCLUSIONS AND CONSIDERATIONS

Drawing from two data sources—a survey and an interview protocol—this evaluation report investigated key areas of interest related to teaching mathematics with technology in Utah. More specifically, the report addressed the demographics, knowledge, practices, and outcomes of mathematics teachers in Utah who integrate digital software in their instruction. This section provides an overview of the report's main findings in relation to the aforementioned topics. It also provides considerations for the K-12 Math Personalized Learning Software Grant Program that are informed by the evaluation's findings, relevant research, and program objectives.

Summary of Findings

Demographics

The current examination of mathematics teachers in Utah who utilize digital software in their instruction reveals the practice to be somewhat widespread given the varied school districts and schools to which teachers who participated in the study are affiliated. Teachers who use mathematics personalized learning software in their instruction, as findings also suggest, primarily teach the 3rd, 4th, and 5th grades although they tend to more frequently integrate digital mathematics software in their instruction of middle school and high school mathematics courses, particularly grade 8 mathematics, secondary math I, and secondary math II. As it concerns other demographic attributes such as gender, degree attainment, and endorsements, the vast majority of teachers who participated in the evaluation identified as female, reported holding an education degree but not a mathematics one, and working towards a variety of endorsements, of which "other" endorsements was the most selected option followed by "mathematics" endorsements.

Teacher Knowledge

Informed by the TPACK framework, developed by Mishra and Koehler (2006), survey questions pertaining to teacher knowledge were designed to understand the extent to which mathematics teachers in Utah who use digital technology in their instruction possess content knowledge, pedagogical knowledge, pedagogical content knowledge, technology knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge. As findings indicate, the majority of teachers responded affirmatively (i.e., indicated that they strongly agree or agree) to possessing the aforementioned key forms of knowledge. At the same time, however, a lower majority of teachers indicated that they possess technology knowledge and the most robust form of knowledge, technological pedagogical content knowledge.

Teacher Practices

In relation to instructional practices with technology, teachers were asked how often they use technology for in-classroom and out-of-classroom assignments, how effective digital technology is for key instructional practices, and how technology best supports teaching and learning in their classrooms. As findings from the evaluation reveal, teachers more frequently use digital mathematics software for in-classroom activities than for out-of-classroom assignments. Additionally, they find technology to be most effective for instructional practices that emphasize the individual needs of students (i.e., differentiation, remediation, and enrichment) than those that do not require explicit distinction to be made between students (i.e., pre-assessment, formative assessment, summative assessment, homework). Relatedly, teachers also more frequently discussed that technology best supported teaching and learning in their classrooms through facilitating differentiation, remediation, and enrichment practices.

Teacher Outcomes

Finally, mathematics teachers were queried about the impact that employing technology in their instruction had on their outcomes, particularly their interest in teaching mathematics, enjoyment of teaching mathematics, and job satisfaction. Findings indicate that only a minority of teachers (i.e., less than 50%) strongly agree or agree that teaching mathematics with technology positively affected their outcomes. Additionally, among the teachers who did not respond affirmatively about the impact of technology on their experiences, most indicated that they were "neutral;" in other words, they could not answer one way or another about its effects.

Considerations for the K-12 Math Personalized Learning Software Grant Program

Provide Content- and Technology-Specific Professional Learning to Mathematics Teachers Who Teach with Technology

As discussed in Part 3 of the report, only 6% of mathematics teachers who participated in the study hold a degree in mathematics. Additionally, findings from Part 4 reveal that teachers were less likely to strongly agree or agree that they possess technology knowledge—knowledge of the different mainstream and digital technologies that can be employed in teaching—and technological pedagogical content knowledge—knowledge that facilitates a thoughtful integration of content, pedagogy, and technology and is regarded as the most robust and effective form of knowledge for teaching with technology. To be sure, these findings are no different from those that have been noted in extant literature. Historically and contemporarily, researchers have found that U.S. K-12 mathematics teachers often lack the subject matter expertise in mathematics—because of the generic teacher education they receive—to facilitate students' deep understanding of the subject (Hossain & Robinson, 2012; Jensen et al., 2016). Additionally, those who employ digital software in their instruction are often poorly informed about how to effectively use technology to teach particular mathematics content and use it more often for low-level tasks (DeCoito & Richardson, 2018; Gonzalez & González-Ruiz, 2017; Urbina & Polly, 2017). To support mathematics teachers in providing high-quality mathematics instruction, research suggests providing teachers with professional learning that emphasizes content and pairing them with "mathematics specialists" that can serve as coaches or mentors (Campbell & Malkus, 2013; Swars et al., 2014). Additionally, given mathematics teachers' use of technology in their instruction, it is important that the professional learning they receive showcases ways to effectively select and incorporate technology in teaching different mathematics topics (Hechter & Vermette, 2014). The STEM Action Center could consider partnering with the Utah Education Network (UEN) to provide professional learning to mathematics teachers.

Establish an Online Forum for Mathematics Teachers to Share and Learn Effective Practices for Integrating Digital Mathematics Software in Instruction

In addition to providing professional learning opportunities to teachers, another useful avenue to encourage teachers' effective use of technology in mathematics instruction may be to create an online forum where teachers can congregate virtually to share and learn effective practices from each other. This resource may be particularly beneficial in light of the national state of emergency posed by the COVID-19 pandemic and the more general switch from in-person to distance learning.

Explore the Quality of Technology Integration in Classrooms with Access to Digital Mathematics Software

While the current evaluation identified the various ways in which mathematics teachers use digital software in their instruction—including for differentiation, remediation, enrichment, pre-assessment, formative assessment, summative assessment, homework, and supplemental practice—it did not investigate the *quality* of technology integration for these purposes. As Puentedura (2013) suggests, student learning is mostly impacted and improved when technology is used in transformative ways, such as to significantly re-design tasks or to create new tasks that would otherwise be impossible without the use of technology. For the most part, as other scholars have indicated, K-12 mathematics teachers rarely use technology in transformative ways. Instead, the more standard practice among mathematics teachers is to assign technology-based tasks to students that require low-level computations and that poorly reflect the educational potential of the technology (DeCoito & Richardson, 2018; Gonzalez & González-Ruiz, 2017; Urbina & Polly, 2017). Given the aforementioned findings from relevant literature and discussion in the paragraph above—that highlights the need to support mathematics teachers' acquisition of subject matter knowledge, technology knowledge, and technological pedagogical content knowledge—it may be worthwhile to also examine the quality of tasks that teachers assign with mathematics software to understand if they are integrating technology in ways that would be deemed highly effective.

Provide A Repository of Model Mathematics Lessons That Effectively or Transformatively Integrate Digital Mathematics Software

As a more proactive step, given the aforementioned findings from research that teachers tend not to use digital mathematics software in transformative ways, it may be useful to create and make available an online repository of mathematics lessons that effectively integrate digital mathematics software. Following the creation of such a resource, it may be useful to disseminate it widely at participating schools and encourage mathematics teachers to adopt or adapt lessons from the repository for their instruction.

Organize Virtual Coaching to Educate Teachers on How to Effectively Integrate Technology for Pre-Assessment, Formative Assessment, Summative Assessment, and Homework

Findings from the evaluation suggest that teachers are much less likely to use mathematics personalized learning software for pre-assessment, formative assessment, summative assessment, and homework than they are to use it for differentiation, remediation, and enrichment. It is not necessarily constructive to immediately encourage teachers to use digital mathematics software more frequently for the former purposes. Rather, it may be more helpful that they are first provided with educated guidance on how *best* to use technology for these instructional practices. This professional development opportunity may be provided in the form of virtual coaching because of the COVID-19 pandemic.

Provide Mathematics Teachers with Enough Digital Mathematics Software to Support One-to-One Learning

Research has found that transformative or higher-order use of technology is difficult, if not impossible, in classrooms where each student does not have access to their own digital device (Donovan, Green, & Hartley, 2010). Additionally, studies have also found that students in one-to-one classrooms use technology more frequently and for various learning purposes, experience higher satisfaction with technology, demonstrate greater technological competence, and perform better in mathematics (Lei & Zhao, 2008; Oliver & Corn, 2008; Zheng, Warschauer, Lin, & Chang, 2016). Given the overarching goal of the K-12 Math Personalized Learning Software Grant Program to improve student outcomes in mathematics and prepare them for college mathematics courses, it is important that consideration is given to acquiring enough digital software to support one-to-one learning in mathematics classrooms.

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THE UNIVERSITY OF UTAH
UTAH EDUCATION POLICY CENTER

Impact of K-12 Math Personalized Learning Software on Student Achievement

June 2020

THE UNIVERSITY OF UTAH

UTAH EDUCATION POLICY CENTER

Bridging Research, Policy, & Practice

The Utah Education Policy Center (UEPC) is a an independent, non-partisan, not-for-profit research-based center at the University of Utah founded in the Department of Educational Leadership and Policy in 1990 and administered through the College of Education since 2007. The UEPC mission is to bridge research, policy, and practice in public schools and higher education to increase educational equity, excellence, access, and opportunities for all children and adults.

The UEPC informs, influences, and improves the quality of educational policies, practices, and leadership through research, evaluation, and technical assistance. Through our research, evaluation, and technical assistance, we are committed to supporting the understanding of whether educational policies, programs, and practices are being implemented as intended, whether they are effective and impactful, and how they may be improved and scaled-up, and become sustainable.

Please visit our website for more information about the UEPC.

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Introduction

Purpose of this Evaluation

In 2016, the Utah Science Technology Engineering and Mathematics Action Center (STEM AC) contracted with the UEPC to conduct a five-year evaluation of the Math Personalized Learning Software Grant. Evaluation results of Year 1 (2016-2017) and Year 2 (2017-2018) indicate that:

- Users had greater improvement in raw scores (compared to the previous year) than non-users.
- Of students who were proficient the year prior to the evaluation, software users were less likely to be not proficient in the year of the evaluation compared to other students.
- Of students who were not proficient the year prior to the evaluation, software users were more likely to be proficient the year of the evaluation compared to other students.
- Software users also had higher average student growth percentiles (SGPs) compared to other students.
- Higher levels of use were associated with better performance for most software vendors.

The positive findings reported in the Year 1 Report (*STEM Action Center Program Evaluation, 2016-17), and Year 2 Report (Utah STEM Action Center Program Evaluation, 2017-18)* were consistent with national research on the impact of math learning software on student achievement. For example, meta-analyses have found effect sizes for use of math software ranging from -.11 to 1.02, with the majority of studies yielding a small to moderate positive effect on math performance (Cheung & Slavin, 2013; Young, Gorumek, & Hamilton, 2018). Thus, to extend the analyses conducted in the past two annual evaluations, this year wwe examine the use and effectiveness of personalized learning math software to increase student achievement longitudinally. The personalized learning math software evaluated here was provided to Utah public schools through grant funds administered by the Utah STEM Action Center.

Longitudinal research is important because it allows us to understand the changes that occur over time and determine whether or not there is value in the persistence of implementation or use. Previous evaluation reports analyzed data and reported results for a single year. This year's evaluation is also a departure from previous evaluations in that we utilize propensity score matching to construct a more meaningful comparison group. Using propensity score matching for this evaluation permits us to compare software users to non-users in similar schools (e.g., schools similar in terms of race and ethnicity, regional variation, and rates of mobile student, chronically absent students, and students who qualify for free and reduced lunch). Use of propensity score matching in our analyses reduced bias by eliminating differences between the digital math software users and comparison groups in terms of demographic and other characteristics such as qualifying for free and reduced lunch, student mobility, and chronic absence. Previous evaluations compared software users to all other students.

Evaluation Questions

To understand the impact of use of the K-12 Personalized Learning Software, the UEPC examined the following evaluation questions:

User and Non-User Comparisons

1. How do digital math users differ from non-users in terms of demographic characteristics?
2. How do digital math users vary across vendors?
3. How do students use math software?

Software Use and Math Performance

1. Do software users perform better than non-users?
2. What student/school characteristics are related to performance?
3. How does the way students use math software relate to performance?

K-12 Math Personalized Learning Software Grant Overview

In 2013, the Utah Legislature passed House Bill 139[1] (HB 139) which created the STEM AC. The primary goal of the STEM AC, as stated in the legislation, is to provide STEM education and digital learning tools to support teacher professional development and get students excited about STEM. The bill also created the STEM education related technology program which involves the STEM AC acting as a research and development center for education related instructional technology. In 2014, the Legislature passed House Bill 150[2] which expanded the scope of the STEM education related technology program and provided ongoing appropriation for the STEM AC from the general fund.

A major component of the STEM education related technology program is the K-12 Math Personalized Learning Software Grant. The K-12 Math Personalized Learning Software Grant provides Utah schools with access to approved math software programs intended to improve student performance in mathematics. School districts or charter schools apply to STEM AC for grant funds to pay for licenses so students and educators can access math software from vendors on the approved list.

Program Purpose

The purpose of the K-12 Math Personalized Learning Software Grant is to provide students access to math software to improve student outcomes and math literacy[3]. The personalized math software programs are intended to improve student math performance by increasing student awareness, engagement, interest, and perceived utility of math. In addition, an

[1] https://le.utah.gov/~2013/bills/static/HB0139.html

[2] https://le.utah.gov/~2014/bills/static/HB0150.html

[3] K-12 Math Personalized Learning Software Grant, https://stem.utah.gov/grants/k-12-math-personalized-learning-software-grant/

intended outcome is improved performance on standardized math tests, which is outcome focus of this evaluation.

Criteria for Math Software Vendor Selection in Grant Program

In order to be included as an approved K-12 Math Personalized Learning Software provider, software vendors must meet the minimum criteria, as defined by the STEM-AC. First, vendors may offer licenses to schools for a trial use, or pilot program. As part of the mandatory criteria for consideration to be added to the STEM AC K-12 Math Personalized Learning Software Provider List, [4] the math software program must:

- Assess student ability.
- Have content that is tailored to individual students, including remediation and enrichment.
- Align with state core standards for mathematics.
- Provide performance data to parents and teachers.
- Provide for teacher customization of material or allow teachers to assign specific activities or problems.
- Receive positive responses from teachers and students on end of year surveys.

In addition, the Math Software Vendor must:

- Provide teachers and administrators with professional development and technical support in use of software.
- Demonstrate that the software is research-based and has been successfully implemented in the state.
- Provide usage data to the external evaluator, the Utah Education Policy Center (UEPC), and participate in evaluations.

The K-12 Math Personalized Learning Software Grant also requires vendors to provide support for effective in-class and at-home use of software. Vendors provide implementation guidelines, teacher training and presentations, and are available for technical assistance.

Target Population and Audiences

The Math Personalized Learning Software Grant is designed to support Utah public school students in kindergarten through twelfth grade. Districts and schools may choose to participate in the grant program. The analyses in this evaluation include scores from students in third grade and above on the Student Assessment of Growth and Excellence (SAGE) math test, which was Utah's previous state mathematics assessment prior to 2019. This evaluation report is provided to guide program improvement efforts for the Math Personalized Learning Software Grant supported by the STEM AC.

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[4] Utah STEM Action Center, *Request for Statement of Qualifications and Approved Vendor List for K-12 Mathematical Personalized Learning Software* (n.d.).

Review of Literature

Educational Technology in the 21st Century

The 21st century has seen increasing integration of technology into aspects of professional and personal life. Prominence of the role of technology in education has also increased. Demand for and use of technology in education has steadily increased (Blazer, 2008). Technology use and integration has increased in many classrooms world-wide. One survey found that 48% of classrooms worldwide utilize desktop computers in lessons (Cambridge Assessment International Education, 2018). In addition, 42% of classrooms world-wide use smartphones, 33% use smartboards, and 20% use tablets. Results of the same survey suggest technology use in the United States is greater, with 75% of classrooms utilizing desktop computers, 74% using smartphones (Cambridge Assessment International). Increased interest in technology can be seen in programs promoting one-to-one device adoption, in which each student is provided a device for personal use and may include access to specific educational software (Franklin, Orians, & Rorrer, 2016).

A review of literature on educational technology demonstrates many potential benefits of technology in teaching and learning (Franklin, Orians, & Rorrer, 2016; Blazer, 2008; IFC Consulting Services Ltd, 2015). Some potential benefits of technology for learning include the ability to accommodate for individual students learning pace and style, and increased access to educational material (Blazer, Bonifaz & Zucker, 2004). In addition, technology may provide students with technological skills necessary for future employment, develop critical thinking, problem-solving, and communication skills, and provide students with opportunities to collaborate with peers and engage in hands-on activities and the benefit of immediate feedback (Blazer, Jobe & Peck, 2008; Bebell, 2005). Furthermore, educational technology has the potential to benefit teaching in similar ways. Technology can enhance teacher ability to differentiate content and assessments to meet students' individual needs and provide access to additional materials and content for lessons (Blazer; Dunleavy et al., 2007; Waddoups, 2004). Technology can also improve communication with and engagement of parents in their child's learning. Educational technology can also result in increased efficiency and cost savings (IFC Consulting Services Ltd).

Despite the rhetoric touting the many benefits of technology in education, the way technology is implemented in classrooms is important and challenging (Franklin, Orians, & Rorrer, 2016). A number of strategies have been identified that contribute to success of educational technology. Some strategies to improve success of technology include planning and involving teachers in planning (Blazer, 2008; Franklin, Orians & Rorrer), providing students and teachers access to necessary tools, and providing access equitably to all students (Blazer). In addition, technology must be appropriately integrated into curriculum rather than treated as a supplement or separate subject. Strong leadership (Blazer) and teacher training and professional learning, as well as provision of technical support to teachers are also important to success of educational technology (Blazer; Franklin, Orians, & Rorrer). Finally, educational technology is more likely to be successful when parents and community stakeholders are informed and engaged, and when the implementation and outcomes of education technology are evaluated (Blazer).

When educational technology is used effectively student achievement increases (IFC Consulting Services Ltd, 2015). The focus of the present evaluation is the use of a specific kind of educational technology, personalized math learning software. Next, we provide a review of literature specific to educational technology and related outcomes, including mathematics achievement.

Educational Technology and Student Achievement in Mathematics

Many schools utilize digital technologies for instruction and learning (Hardman, 2019). A substantial amount of literature has been devoted to assessing the effectiveness of technology in enhancing math education, and many studies have demonstrated positive effects (Murphy, 2016; Cheung & Slavin, 2013; Young, Gorumek, & Hamilton, 2018). To date, research in this area has indicated that technology in education can have positive effects such as increased engagement and motivation, improved student-teacher interaction, and increased student collaboration. Technology can also increase students' comfort with learning math and their understanding of math concepts (Murphy, 2016).

The success of mathematics technology in raising student achievement is dependent on how well technology is integrated with curriculum. Yet, the challenge of curriculum integration is among the most widely cited in literature on education technology (Franklin, Orians, & Rorrer, 2016). The Substitution, Augmentation, Modification, and Redefinition (SAMR) model created by Puentedura (2013) and the Technological Pedagogical and Content Knowledge (TPACK) framework, developed by Mishra and Koehler (2006) provide useful perspectives for the integration of technology and curriculum.

Puentedura developed the SAMR model, which provides a framework for understanding how technology is integrated into teaching and learning. The SAMR model categorizes technology into four degrees of integration, substitution, augmentation, modification, and transformation. Puentedura (2013) labels the lower degrees, substitution and augmentation, as enhancement and labels the higher degrees, modification and redefinition, as transformation. Bray and Tangney (2017) reviewed 139 studies of technology use in mathematics education and classified them into the appropriate SAMR degree. They found that over 60% of studies employed technology at the augmentation level. Instructional videos are an example of augmentation, because they provide information like a teacher would, but are augmented with the ability to view them outside of class time and to pause and rewind. Bray and Tangney concluded that technology is predominantly used to enhance teaching and the potential of math technology to transform student learning experience is yet to be realized.

Mishra and Koehler (2006) expanded the Pedagogical Content Knowledge (PCK) framework proposed by Shulman (1986) to include Technology. Teaching, according to the PCK framework, involves the continuous interaction of content knowledge, curriculum knowledge, and pedagogical knowledge. Mishra and Koehler recognized that technology was introduced into educational settings with insufficient attention to how it would be used. In the TPACK framework, Mishra and Koehler sought to create a framework to provide a coherent way of thinking about technology integration and to transform teacher education and training. The TPACK framework emphasizes the importance of content knowledge (e.g. knowledge about mathematics), pedagogical knowledge (e.g. knowledge of instructional strategies and epistemologies), and technological knowledge (e.g. knowledge of the internet or specific apps and programs). The framework depicts these knowledge areas as three intersecting circles, emphasizing the overlap between the three knowledge areas and the notion that any of the three knowledge areas should not be considered independent of the context of the other knowledge areas (Mishra & Koehler, 2006).

Koh, Chai, and Lim (2017) assessed outcomes of a TPACK-based year-long professional development effort to increase integration of technology in elementary school teachers. In teams, teachers assessed existing lesson plans using a TPACK-21st Century Learning rubric, set goals to improve lesson plans, redesigned lesson plans, then implemented, evaluated, and reflected on the process and outcomes. Koh and colleagues found that on pre and post surveys, teachers' confidence in several knowledge domains increased, and based on observations, teacher integration of technology had improved.

Technology use in education is widespread, and has many benefits for teaching and learning, particularly when used effectively. The SAMR model and the TPACK Framework illustrate the complexity and importance of integrating and quality implementation of technology in education. The focus of the current evaluation is outcomes of students who participate in the digital math software program. Although a complete understanding of student outcomes cannot be achieved without an understanding of teacher practices and integration of math software, this report only address outcomes of student use. These important issues will be addressed in future reports utilizing additional data sources.

Report Organization

The remainder of this evaluation report is divided into four sections, as outlined below:

- **Brief Methodology.** We describe the design of the evaluation including samples and analyses. The method section also includes an explanation of the two sources of data used for the evaluation, and information about data use.
- **Digital Math Software User and Non-User Information.** In this section, we present findings on student characteristics of digital math software users and non-users as well as student characteristics of users compared across vendors. Student characteristics considered include race or ethnicity, rural status, gender, income, mobility, chronic absence, and grade level. In this section we also present information about student use, including overall use and consistency of use.
- **Digital Math Software Use Information.** This section provides information about how much students used software and information about how consistently students used software. Use and consistency of use are reported for each software vendor.
- **Digital Math Software Users and Non-Users Math Performance.** Findings in this section include average math performance indicators for users and non-users. We also present generalized estimating equations (GEE) regression model results demonstrating how software use is related to performance on the math SAGE test for all users and by vendor.
- **Student and School Characteristics and Performance.** In this section, we present regression results showing the relation of student and school characteristics to math

performance. Finally, we include GEE results of overall use, years of use, and consistency of use.

- **Amount and Consistency of Digital Math Software Use and Performance.** In the final section of the report, we examine how students use digital math software is related to SAGE performance. We include regression results showing how amount of use measured by use quartile, years of use, and consistency of use are related to performance for digital math software users. Note that non-users were not included in the models reported in this section of the report.
- **Summary of Findings.** We provide a summary of the highlights of each aspect of the analyses. Following the summary of findings, we discuss questions that have yet to be addressed by the larger evaluation. We also present possible future directions for evaluation activities.
- **Considerations for Improving the K-12 Math Personalized Learning Software Grant.** Finally, we conclude the report with recommendation for the K-12 Math Personalized Learning Software Grant program implementation and improvement.

Methodology Overview

In this section, we briefly describe the data sources, samples, statistical analyses, and outcome indicators used in this evaluation. For detailed information about our methodology see Appendix A. Methodology

Data Sources

Only three software vendors provided multiple years of student usage data to the UEPC for analyses. Table 1 shows the years of data provided by the vendors who provided sufficient data.

Table 1. Vendors Included and Years of Data Provided

Vendor	Years of Data
ALEKS	2016-2018
i-Ready	2017-2018
ST Math	2015-2018

Two additional vendors, Mathspace and Imagine Math were not included in this evaluation. Mathspace had not been part of the STEM AC K-12 Math Personalized Learning Software Grant long enough to have sufficient data for inclusion. Imagine Math had incomplete data, which were not sufficient for inclusion in the longitudinal study.

Outcome data for this study were accessible for use in this evaluation through a data sharing agreement between the Utah State Board of Education (USBE) and the UEPC.[5] Student outcomes included SAGE mathematics proficiency, standardized scores, and student growth percentile (SGP). We also used demographic variables for propensity score matching and to control for pre-existing differences between students, including student gender, race and ethnicity, qualification for free and reduced lunch, mobility status, regional status, and chronic absence. For inclusion in this study, we calculated school-level percentages of qualification for free and reduced lunch, mobility status, and chronic absence.

Samples

The primary sample for this evaluation consists of 155,866 Utah public school students who used at least one of the STEM-AC approved Math Personalized Learning Software Grant software programs one or more years from 2015-2018. SAGE math tests were offered for Grades 3 and above. Thus, the sample does not include data from students in kindergarten through second grade. For students whose data were provided by vendors and who completed a SAGE math test (n=127,571), most of the students (n=81,996) had only one year of data available, which means these students were included in user data of one of the software vendors during only one academic year. Some students (n=36,729) appeared in vendor data for two years. Thus,

[5] The views expressed in this report are those of the authors and are not necessarily the USBE's or endorsed by the USBE.

two years of data were available. For 7% of the sample (n=8,846), three or four years of data were available. We excluded vendor data if we were unable to match USBE records. Establishing parameters for usable data sets, records that had excessively high time usage data (e.g. about 14 hours a week) were excluded as these students were extreme outliers with much higher usage than other students. A data set for analysis was created using the following criteria: vendor login and school year information, name, school and school year matching algorithm.

We compared digital math software users to non-users. Non-users are defined as students who did not use any of the math software programs funded by the STEM AC. We had no way of verifying whether these students used other math software, but they were not matched to use data from any of the STEM AC funded software providers. Throughout this report and consistent with previous evaluation reports, non-users refers to students who did not use STEM AC funded software.

For descriptive comparisons, we report on a larger sample of all digital math software users in grades 3-12 (n=155,866) and a comparison group of all non-users in grades 3-12 from USBE data (n=442,994). Students were included in the larger sample for descriptive comparisons even if they did not have SAGE math scores. The longitudinal analyses included only students in grades 3-12 who completed one or more SAGE math test during 2015-2018, including digital math software users (n=127,571) and a comparison group that comprised a subset of non-users (n=223,878). We selected the comparison group using propensity score matching. This statistical matching technique permitted the selection of non-users from schools who matched user schools in terms of race, mobility status, rural status, testing below grade level, chronic absenteeism, and gender. The propensity score matched sample consisted of 223,878 students and provided a more appropriate comparison group than all non-users. The sample included:

1. Software users matched to USBE records (n=155,866)
    - Software users with SAGE scores (n=127,571)
2. All non-users (n=442,994)
    - Propensity Score Matched non-users with SAGE scores (n=223,878)

Statistical Analyses

The following statistical methods were used in analyses reported in this evaluation:

1. Frequencies of student characteristics were reported for digital math users and non-users for race and ethnicity, rural status, gender, whether students qualify for free or reduced lunch, mobility status, and chronic absence. Due to the longitudinal nature of the data, we do not report on grade level of students, because students who used digital math software multiple years have multiple grade levels. Grade level was not used as a control variable in longitudinal regression models.

2. We divided digital math software users within vendors into quartiles based on the average amount of time they spent using digital math software each month of use. Within each vender, each quartile contains 25% of users of that vendor's software. Quartile 1 contains the users with the lowest averages. Quartile 2 contains the users

with the second lowest averages. Quartile 3 contains users with the second highest averages. Quartile 4 contains users with the highest averages. Note that quartiles were repeated measures. Each student was assigned a quartile for each year the student used digital math software.

3. For each user with more than one month of data, we reported the coefficient of variation (COV) as an indicator of consistency of use. The COV is calculated using the mean and standard deviation of minutes of use per month according to the following formula:

$$C_v = \frac{\sigma_{Period\ Usage}}{\mu_{Period\ Usage}}$$

   Note that a high COV indicates less consistent use, and a low COV indicates more consistent use. We reported average COV for each vendor for each use quartile. COV, like quartile, was calculated for each year a student used digital math software.

4. For longitudinal analyses we used the Generalized Estimation Equation (GEE), with linear and logistic regression. GEE, in interpretation, is similar to generalized linear models. Unlike generalized linear models, GEE accommodates for repeated measures or year over year data for individuals. Because our data are longitudinal, we want to include multiple years of data for individuals. In the general linear model, including repeated measures on individuals violates the assumption of independence, or the assumption that outcomes of individuals do not influence other outcomes. A students' SAGE math scores are highly related and not independent of their SAGE math scores from previous years. By using GEE, we are able to use SAGE scores from the same students from multiple years as outcomes, providing a more comprehensive and accurate view of the true effects of digital math software use.

   We used two sets of models. The first set of models included digital software users and propensity-score matched non-users. The second set of models included only digital math software users. Each set of models included 12 models, one for each of the three outcome indicators for all digital math software users and one for each of the three software vendors. Variables included in the models are shown in Table 2.

Table 2. Variables Used in GEE Regression Models

Student Characteristics	School Characteristics	Use Variables (user only models)
Gender	Proportion of Low Income	Years of Use
Race or Ethnicity	Proportion of Mobile	Use Quartiles
Qualify for Free and Reduced Lunch	Proportion of Chronic Absence	Consistency of Use
Mobility Status		
Rural Status		
Chronic Absence Status		

Outcome Indicators

For longitudinal models outcomes, our primary outcome of interest was performance on Student Assessment of Growth and Excellence (SAGE) Math tests for each year of student data. We used three related but distinct indicators calculated from SAGE scores:

1. Proficiency
2. Percentile rank estimated from standardized scores
3. SGP

These outcomes capture the variance in performance.

Proficiency

Proficiency on SAGE shows how participants scored relative to a pre-defined benchmark. More than 200 educators, education experts, and other stakeholders participated in a week long workshop on standard setting to determine proficiency levels.[6] The outcome we use for proficiency is the dichotomous proficient (1) or not proficient (0). However, for average proficiency, we reported the levels of proficiency provided by the USBE as: Below Proficiency, Approaching Proficiency, Proficient, and Highly Proficient. Based on guidelines for interpreting SAGE scores,[6] a score of proficient or highly proficient indicates a student is on track in terms of college and career readiness. A score below proficient or approaching proficient indicates a student is not on track in terms of college and career readiness.

Percentile Rank

We calculated standardized scores from student math SAGE scores. Standardized scores tell us how well a student performed on a test in units of standard deviations from the mean score. An advantage to using standardized scores is that we can compare all students regardless of which grade level SAGE math test they completed. A disadvantage to using standard scores is that they are not easy to interpret. To make results easier to interpret, we converted standardized scores into percentile ranks.

The percentile rank allows us to know how students performed relative to other students who took the same test. The higher the percentile rank, the better the student performed. For example, a student who took the 8th grade math test and scored in the 56th percentile performed better than 56% of other students who took the 8th grade math test.

Student Growth Percentile (SGP)

SGP shows student growth or improvement from the previous year SAGE math score relative to similar students. SGP takes into account performance and past performance. A student with an SGP of 52% showed more growth than 52% of other students who performed similar to them in the past.

[6] https://www.uintahonline.com/uploads/2/3/1/0/23109436/overviewof_whatissage.pdf

Digital Math Software User and Non-User Information

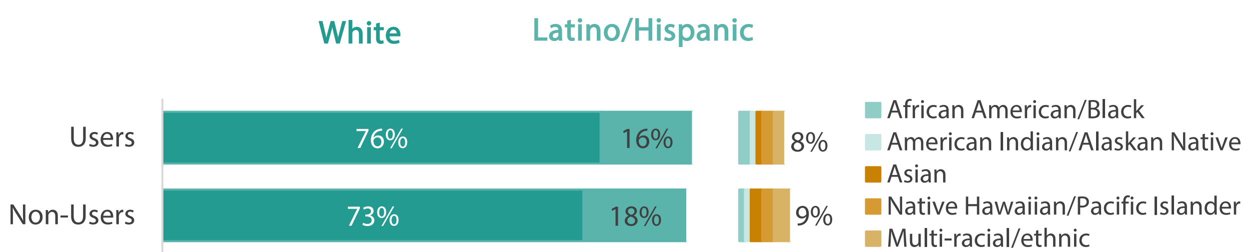
This section of the report provides descriptive information about all users and non-users. The sample used for descriptive analyses includes software users and non-users statewide in grades 3-12. The sample in later sections is limited to software users with SAGE math test scores and propensity score matched non-users, but this section describes all software users and non-users in grades 3-12 statewide.

How do Digital Math Software Users Differ from Non-Users in Terms of Demographic Characteristics?

Using descriptive statistics, this section examines the demographic attributes of digital math software users and non-users. Digital math software users and non-users are disaggregated by race and ethnicity, rurality, gender, eligibility for free or reduced lunch, mobility, and chronic absenteeism status. The software user and the non-user group consisted of students in grades 3-12. We do not report frequencies of students by grade level, because multiple years of data are included for many students, meaning that many students have multiple grade levels. This section reports on all digital math software users and all non-users.

Findings

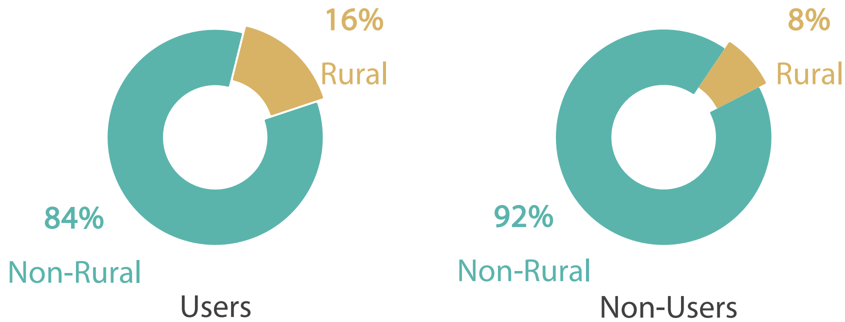
Figure 1. Race and Ethnicity of Software Users and Non-Users



Data sources: USBE and Digital Math Software Vendors

USBE reports students in the following race and ethnicity categories—White, Black or African American, Asian, American Indian and Alaskan Native, Native Hawaiian and Pacific Islander, or multiple races. Additionally, USBE determines ethnicity by whether a student is of Hispanic origin or not. This study utilized the same categories for race and ethnicity as USBE. As depicted in Figure 1. Race and Ethnicity of Software Users and Non-Users above, White students accounted for the largest share of digital math software users (76%) and non-users (73%) as compared to their representation of 74% among students in the schools included in this study. Additionally, students of color, which included students identified as African American/Black, American Indian/Alaskan Native, Asian, Hispanic/Latino, Multi-race/ethnicity, and Native Hawaiian/Pacific Islander, accounted for a lesser fraction of users and non-users of digital math software than their representation in the general student population. Moreover, these students are more represented among non-users of digital math software (27%) than users (24%), and collectively account for 26% of students in the schools included in the study.

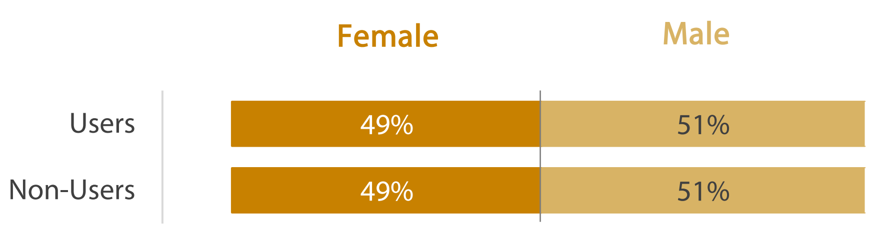
Figure 2. Rural and Non-Rural Software Users and Non-Users



Data sources: USBE and Digital Math Software Vendors

Students were also identified by USBE according to their school's locale, which includes four designations—rural, city, suburb, or town. Students whose schools were designated as rural were categorized as rural in the current report. Additionally, students whose schools were described as located in a city, suburb, or town were categorized in this report as non-rural. Findings shown in Figure 2 suggest that non-rural students comprised the majority of digital math software users (84%) and non-users (92%), while rural students were in the minority in both populations (16% and 8%). Rural students, however, were slightly overrepresented among digital math software users (16%) in view of their 10% representation among students in the schools included in this study.

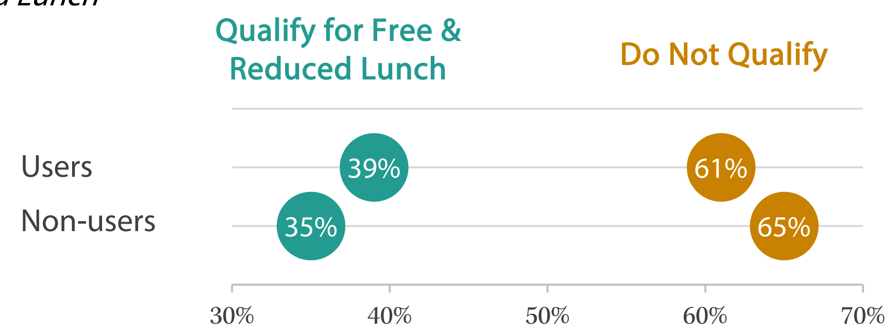
Figure 3. Gender of Software Users and Non-Users



Data sources: USBE and Digital Math Software Vendors

In the current report, we defined gender, similarly to USBE, as including two categories—male and female. As illustrated in Figure 3, female and male students are near evenly represented among digital math software users and non-users. Among digital math software users, female students accounted for 49% of students, while male students accounted for 51%. The same gender breakdown also held for non-users of digital math software and the larger sample from which both digital math software users and non-users were drawn.

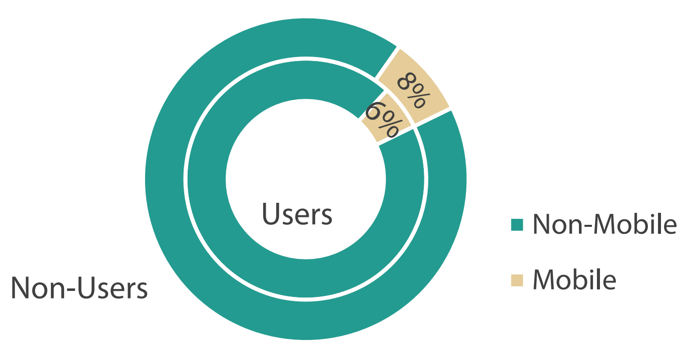
Figure 4. Digital Math Software Users and Non-Users and Whether they Qualify for Free and Reduced Lunch



Data sources: USBE and Digital Math Software Vendors

Economically disadvantaged status, according to USBE, is determined by whether or not a student qualifies for free or reduced lunch. In the current report, rather than using the term economically disadvantaged, we report on students who qualified for or were eligible for free and reduced lunch. As Figure 4 depicts, 39% of students who use digital math software were eligible for free or reduced lunch, as compared to 35% of non-users. Students eligible for free or reduced lunch accounted for 36% of students in the schools included in the study, a slightly lower percent than among digital math software users.

Figure 5. Mobility of Software Users and Non-Users

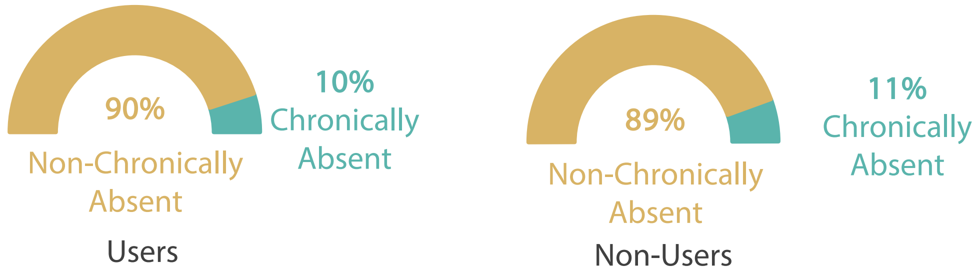


Data sources: USBE and Digital Math Software Vendors

Consistent with USBE's use of mobility, this evaluation determined student mobility by whether a student was enrolled in a particular school for the entire school year. Thus, we classified a student as mobile, if the student attended more than one school in a given school year, or non-mobile if they attended only one school in a given school year. According to Figure 5, non-mobile students comprised the majority of digital math software users (94%) and non-users (92%). Mobile students, while accounting for a lesser percentage of both populations, were slightly more represented among non-users (8%) of digital math software than users (6%).

Among students in the school included in this study, 7% were identified as mobile, and 93% were identified as non-mobile.

Figure 6. Chronic Absence of Software Users and Non-Users



Data sources: USBE and Digital Math Software Vendors

Figure 6 provides digital math software users and non-users disaggregated by chronic absenteeism status. Consistent with the USBE definition, we determined chronic absenteeism status by whether a student was absent for 10% or more of their total membership days in the school in which they had the highest number of attendance days. Among students in the schools included in the study, 11% were classified as chronically absent as compared to 10% of digital math software users and 11% of non-users. Additionally, most digital math software users (90%) and non-users (89%) were non-chronically absent students.

Summary

In summary, the sample from which digital math software users and non-users were drawn was composed, primarily, of White students, male students, students who not eligible for free and reduced lunch, non-mobile students, non-rural students, and non-chronically absent students. As the figures above illustrate, the compositions of the digital math software user and non-user populations were very similar to that of the overall student sample. The largest differences between digital math software users and non-users and the overall student sample were shown in Figure 2, which demonstrates rural students were slightly overrepresented among digital math software users, and in Figure 4, which shows students eligible for free or reduced lunch were slightly overrepresented among digital math software users.

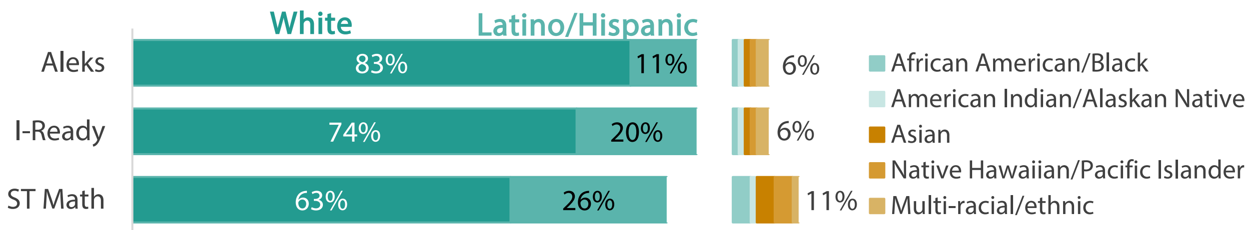
How do Digital Math Users Vary Across Software Vendors?

This section extends the prior section's findings on the demographic characteristics of digital math software users by further disaggregating these students based on the type of digital math software they utilized. ALEKS, i-Ready, and ST Math users are the focus of this section. These three groups of digital math software users, as in the prior section, are differentiated by race and ethnicity, regional locale, gender, eligibility for free or reduced lunch, mobility, and chronic absence. Just as with our description of all users and non-users, we do not report counts of student grade level in our comparison of software vendor users, because students with multiple years of data have multiple grade levels. ALEKS software users included students in grades 3-

12. i-Ready software users included students in grades 3-8. ST Math software users were in grades 3-9.

Findings

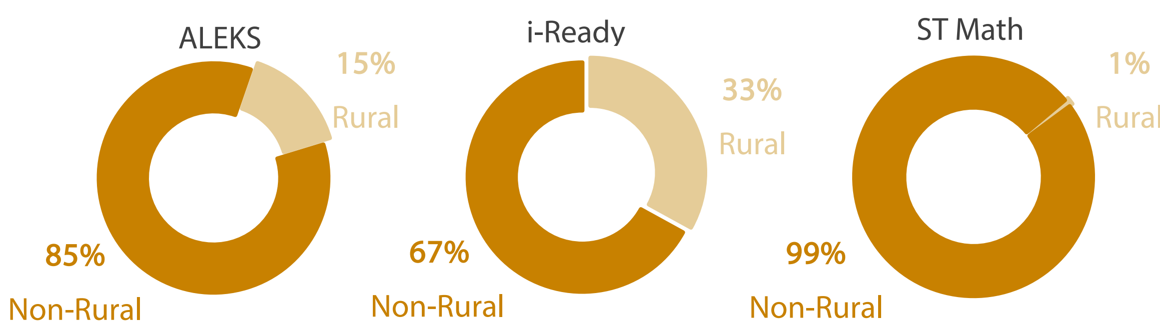
Figure 7. Race and Ethnicity of Software Users in Each Vendor



DATA SOURCES: USBE AND DIGITAL MATH SOFTWARE VENDORS

The student sample in the current study was 74% White, 2% Black or African American, 2% Asian, 1% American Indian and Alaskan Native, 2% Native Hawaiian and Pacific Islander, and 3% multiple races. As Figure 7 indicates, the vast majority of digital math software users, irrespective of vendor, were White students. ALEKS and i-Ready, however, had a higher percentage of White users (83% and 74%) than ST Math (63%). Latino/Hispanic students were the second most represented group of users across the three Digital Math Software Vendors, accounting for 26% of ST Math users, 20% of i-Ready users, and 11% of ALEKS users. Additionally, students of color, were most represented among ST Math users (37%), followed by i-Ready (26%), and lastly ALEKS (17%).

Figure 8. Rural Status of Software Users in Each Vendor



Data sources: USBE and Digital Math Software Vendors

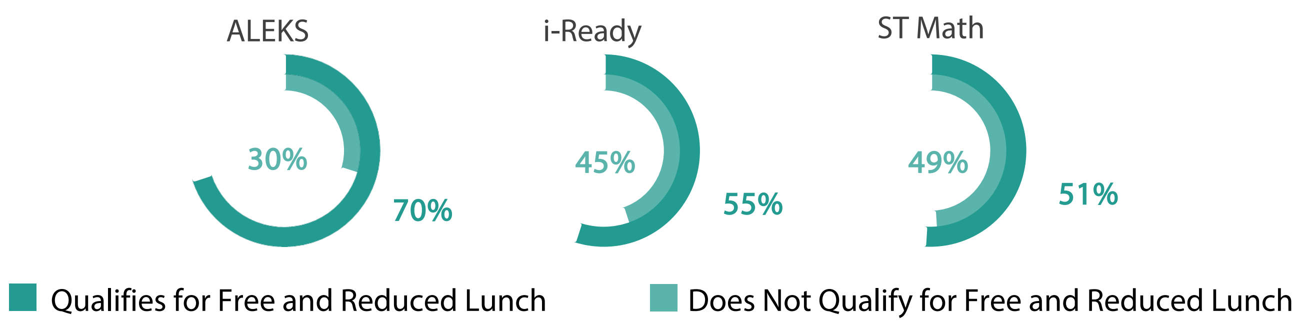
As seen in Figure 8, rural and non-rural students accounted for 10% and 90% of students, respectively, in the schools included in this study. As Figure 8 illustrates, most users of ALEKS (85%), i-Ready (67%), and ST Math (99%) were non-rural students. Rural students accounted for a lesser percentage of users across vendors. However, these students are more represented among i-Ready users (33%) than ALEKS (15%) and ST Math (1%).

Figure 9. Gender of Software Users in Each Vendor

Data sources: USBE and Digital Math Software Vendors

When disaggregated by gender, students in the schools included in this study were 49% female and 51% male. As Figure 9 depicts, ALEKS users were evenly distributed by gender. Among ST Math and i-Ready users, however, male students (53% and 52%) were slightly more represented than female students (47% and 48%).

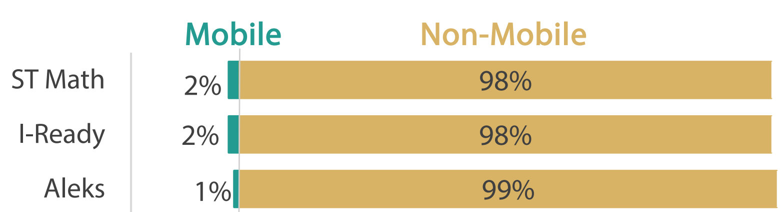
Figure 10. Student who Qualify for Free and Reduced Lunch in Each Software Vendor



Data sources: USBE and Digital Math Software Vendors

Students eligible for free and reduced lunch comprised 36% of the student sample in this study, and those who did not qualify for free and reduced lunch accounted for 64% of students. As Figure 10 depicts, students who were not eligible for free and reduced lunch accounted for more than half of ALEKS (70%), i-Ready (55%), and ST Math (51%) users, and were most represented among ALEKS users. Students who were eligible for free and reduced lunch, on the other hand, are most represented among ST Math users, at 49%, and least represented among ALEKS users, at 30%.

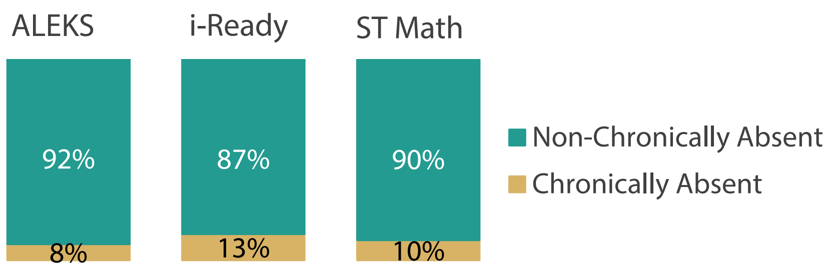
Figure 11. Mobility Status of Software Users in Each Vendor



Data sources: USBE and Digital Math Software Vendors

As seen in Figure 5, mobile students accounted for 7% of students in the schools included in this study. Findings shown in Figure 11 indicate students who were mobile were underrepresented among ALEKS, i-Ready, and ST-Math users, as they accounted for 1%, 2%, and 2%, respectively, of users within their software vendors. Non-mobile students who made up 93% of students in this study, also accounted for the majority of ALEKS (99%), i-Ready (98%), and ST Math (98%) users.

Figure 12. Chronic Absence of Digital Math Software Users in Each Vendor



Data sources: USBE and Digital Math Software Vendors

The student sample in this study was 11% chronically absent and 89% non-chronically absent. Similar to the study sample, digital math software users were mostly comprised of non-chronically absent students. Figure 12 shows that 92% of ALEKS users, 87% of i-Ready users, and 90% of ST Math users were not chronically absent. Chronically absent students, who accounted for a minority of digital math software users across vendors, were slightly more represented among i-Ready users (13%) than ST Math (10%) and ALEKS (8%).

Summary

Similar to the prior section's findings, ALEKS, i-Ready, and ST Math users were composed very similarly to the overall student sample for this study. Like the overall student sample, ALEKS, i-Ready, and ST Math users were mostly White, non-rural, non-chronically absent, non-mobile, and ineligible for free or reduced lunch. While i-Ready and ST Math users were mostly male like the general student sample, ALEKS users were equally distributed by gender. Important deviations from the composition of the overall student sample can be seen in Figure 7, in which Latino students were overrepresented among i-Ready and ST Math users, in Figure 8, in which rural students were overrepresented among i-Ready and ALEKS users, and Figure 10, in which students who were eligible for free or reduced lunch were overrepresented among ST Math users.

Digital Math Software Use Information

How Much and How Consistently Do Students Use Math Software?

This section examines the length of time that students used digital math software per week and the consistency with which students used digital math software. We report the length of time students used digital math software by dividing students into quartiles based on their average minutes of use per week. Students were grouped into quartiles for each year they used a software; this means that if a student used a software for multiple years they are counted multiple times in the use quartiles. Software users were counted in multiple quartiles to allow individuals use to vary over years.

The degree of consistency—how similar students were in the amount of time they used digital math software from month to month with which students used digital math software—was determined using a coefficient of variation (COV). Alternatively, a lower COV indicates lower variation or a greater degree of consistency among students in their use of digital math software.

Findings

Within each vendor, digital math software users were grouped into quartiles based on the average time they spent using digital math software per week. Quartile 1 consists of the 25% of digital math users who spent the least amount of time using the software per week. Quartile 2 consists of the 25% of students who spent the second least amount of time using the software per week. Quartile 3 consists of the 25% of students who spent the second most time using software per week, and Quartile 4 consists of the students who spent the most time using digital math software per week.

Table 3. Range of Minutes of Digital Math Software Use Per Week for Each Quartile of Student Users and for Each Vendor

	ALEKS n=157,301	*i-Ready* n=27,766	*ST Math* n=39,838
	Minutes of use per week		
Quartile 1	≤41	≤42	≤27
Quartile 2	41 – 60	42 – 55	27 – 40
Quartile 3	61 – 92	56 – 70	41 – 64
Quartile 4	≥93	≥71	≥65

Data sources: USBE and Digital Math Software Vendors

Table 3 provides the breakdown of minutes per week for each use quartile for each of the three vendors included in this evaluation. ST Math had the lowest amount for the first use quartile, which was 27 or fewer minutes per week. ALEKS had the highest amount for use in the fourth quartile, which was 93 minutes or greater per week.

For a comparison, we discuss digital math vendor use recommendations. ALEKS does not currently provide a recommendation for minutes of use per week. ALEKS does post information regarding implementation strategies from their customers which include weekly expected use. Some implementation strategies call for 2 hours of use per week.[7] Other strategies call for 5 hours per week.[8] i-Ready currently recommends students complete 30-49 minutes on software per week.[9] ST Math recommends students complete 90 minutes per week on digital math software.[10]

Table 4. Count of Students in Years for Each Quartile of Digital Math Software Users and for Each Vendor

	ALEKS	*i-Ready*	*ST Math*
	Number of Observations		
Quartile 1	39,326	6,944	9,984
Quartile 2	39,325	6,943	9,990
Quartile 3	39,325	6,942	9,980
Quartile 4	39,325	6,937	9,974
Total	157,301	27,766	39,838

Note that students were included in quartiles for each year they used a digital math software, so students with multiple years of software use are counted multiple times in Table 4.

Data sources: USBE and Digital Math Software Vendors

Data from Table 4 demonstrates that ALEKS had the greatest number of users, followed by ST Math, and i-Ready. Within vendor, each quartile had approximately 25% of users for that vendor.

[7] Implementation Strategies: https://www.ALEKS.com/k12/implementations/popup?_form_=true&parse_list=e*258&parse_request=true&cmscache=parse_list:parse_request#:~:text=Students%20will%20be%20expected%20to,minutes%2C%20four%20days%20per%20week.

[8] Implementation Strategies: https://www.ALEKS.com/k12/implementations/index?_form_=true&parse_request=true&parse_list=h*323&cmscache=parse_list:parse_request

[9] i-Ready Success in Action: https://www.curriculumassociates.com/products/i-ready/how-it-works

[10] T Math Implementation Guide: https://dlassets.stmath.com/pdfs/massachusetts/MA-Implementation-Guide-EN-176.pdf

Table 5. Consistency of Digital Math Software Use by Use Quartile of Student Users for Each Vendor

	ALEKS	*i-Ready*	*ST Math*
	Consistency in use measured by coefficient of variation		
Quartile 1	.62	.60	.64
Quartile 2	.56	.52	.61
Quartile 3	.54	.44	.58
Quartile 4	.53	.41	.60

Data sources: USBE and Digital Math Software Vendors

For each software vendor, we calculated the average of all students COV to assess the degree of consistency with which students in each quartile used digital math software. The methodology section provides a full explanation of how we calculated the COV. The COV is an indicator of the consistency of duration of use from month to month. For example, two students on average may use software 8 hours per month, but one may consistently use it 8 hours each month and the other might use it 4 hours one month and 12 hours another month. Although both students have the same monthly average duration of use, the consistency with which they use the software is different. As previously explained, a higher COV indicates higher variation or a lower degree of consistency of use of digital math software. Alternatively, a lower COV indicates lower variation or a greater consistency of use of digital math software.

As Table 5 shows, across all three software vendors, students in Quartile 1, the quartile with lowest use per week, had the lowest degree of consistency in their use of digital math software (i.e., these students had the highest coefficient of variation). Among ALEKS and i-Ready users, consistency in use of digital math software increases with each quartile; students in Quartile 4 exhibited the highest degree of consistency in their software use. For ST Math users, students in Quartile 3 demonstrated the greatest consistency in using the software. Students in i-Ready in the 4th use quartile had the lowest COV or were the most consist users across all four software vendors.

Summary

In summary, the length and consistency of digital math software use varies across students and vendors. With the exception of ST Math users, students who used the software the most, that is, students in Quartile 4, also had the lowest average COV, showing that they use digital math software more consistently from month to month compared to users in lower percentiles.

Digital Math Software Users and Non-Users Math Performance

Do Software Users Perform Better than Non-Users?

To assess differences between users and non-users on SAGE math tests, we examined averages and general estimating equation regression results for proficiency, student growth percentile (SGP), and percentile rank. First, we report averages on these outcomes for users and propensity-score matched non-users. Then we present results of regression analyses that calculate the difference in outcomes for digital math software users compared to non-users.

Table 6 shows that digital math software users and propensity-score matched non-users had similar average proficiency levels, SGP, and percentile rank. The averages of digital math software users were slightly above non-users. In previous reports, Digital math software users had higher average SGP than non-users

3 Outcomes of Interest

1. Proficiency. Measures student performance relative to a predefined benchmark.
2. Percentile Rank. An indicator of students performed relative to other students who took the same test.
3. Student Growth Percentile (SGP). A statistical estimate of student growth relative to students who had similar performance in the past.

See Appendix A. Methodology for additional Information about outcome measures.

Findings

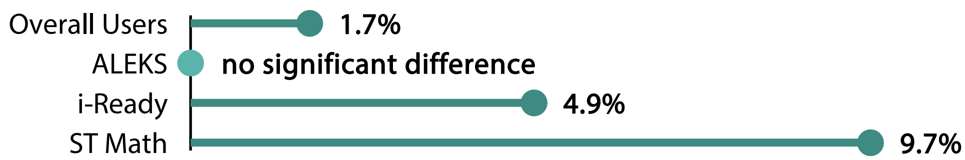
Table 6. Average Proficiency Level, Student Growth Percentile, and Percentile Rank for Users and Propensity-Score Matched Non-Users

	Proficiency (1-4)		Percentile Rank		Student Growth Percentile (SGP)	
	Average	SD	Average	SD	Average	SD
Users	2.33	1.12	49.96	24.20	50.91	28.73
Propensity Score Matched Non-users	2.32	1.13	48.48	23.71	49.72	28.98

Data sources: USBE and Digital Math Software Vendors

Regression analyses provide more robust tests of the relationship between software use and performance, because they control for other characteristics that may be related to performance. In the regression analysis, we controlled for several student characteristics, including gender, race or ethnicity, free and reduced lunch status, mobility, and chronic absenteeism. In addition to student characteristics, we controlled for school-level variables, including rates of low income, mobility, and chronic absence. Results of student and school-level variables included in regression models are presented in the next section. The focus of this section is regression results estimating the difference between digital math software users and propensity-score matched non-users on the outcomes of interest: proficiency, percentile rank, and SGP.

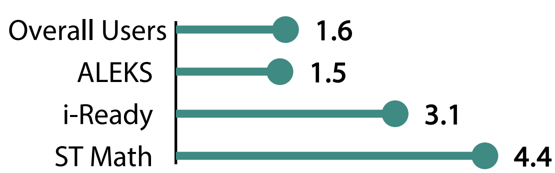
Figure 13. Difference in Probability of Proficiency for Digital Math Software Users Compared to Propensity-Score Matched Non-Users



Data sources: USBE and Digital Math Software Vendors

Figure 13 shows the regression models' estimated difference in the probability of students meeting proficiency for users and propensity-score matched non-users. The model estimated that digital math software users across the three years of use had a 1.7% higher probability of being proficient compared to propensity-score matched non-users. When we consider results by software vendor, ALEKS users were not statistically significantly more or less likely to be proficient compared to matched non-users, but i-Ready users had 4.9% higher probability of proficiency, and students using ST Math had 9.7% higher probability of proficiency compared to non-users. Next we present regression results for the outcome of percentile rank.

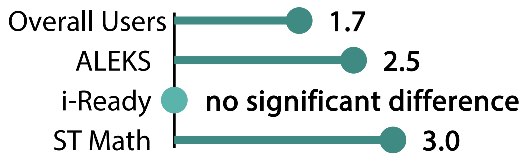
Figure 14. Difference in Percentile Rank of Proficiency for Digital Math Software Users Compared to Propensity-Score Matched Non-Users



Data sources: USBE and Digital Math Software Vendors

As shown in Figure 14, regression models estimated the difference in percentile rank between digital math software users and propensity-score matched non-users. The model for all digital math software users estimated that software users on average had 1.6 higher percentile ranks than propensity-score matched non-users. To illustrate this finding, if a student who did not use digital math software scored better than 68% of her peers, we would expect a similar student who did use digital math software to score better than 69.6% of her peers. When considering individual software vendors, regression models estimated ALEKS users had 1.5 higher percentile ranks than matched non-users, i-Ready users had percentile ranks 3.1 higher than matched non-users, and ST math users had percentile ranks 4.4 higher than matched non-users. Next we present regression estimates of SGP for digital math software users and non-users.

Figure 15. Difference in SGP for Digital Math Software Users Compared to Propensity-Score Matched Non-Users



Data sources: USBE and Digital Math Software Vendors

Figure 15 shows the regression models estimates of the difference in SGP for digital math software users and propensity-score matched non-users. The model for all digital math software users estimated that on average, users' SGPs were 1.7 points higher than non-users. Considering users of the vendors separately, regression models estimated ALEKS users' average SGP was 2.5 points higher than non-users, but regression results showed i-Ready users did not have statistically significantly different SGP compared to propensity-score matched non-users. The regression model estimated that ST Math users on average had 3 point higher SGP than matched non-users. In the next section, we present regression results showing how student and school level variables are related to the three outcomes of interest. See Appendix B: Regression Results for Digital Software Users and Non-Users for full results of the regression models for the three outcome indicators for each vendor.

Summary

Findings presented in this section address the question of whether digital math software users performed better than propensity-score matched non-users on SAGE tests across multiple years. Performance indicators include proficiency, percentile rank, and SGP. This analysis suggest digital math software users performed slightly better than propensity-score matched non-users.

- Digital math software users average proficiency level, percentile rank and SGP were only slightly above averages of propensity-score matched non-users.
- Regression models estimated overall digital math software users and i-Ready and ST Math users were a little more likely to be proficient compared to propensity-score matched non-users.
- Regression models estimated overall digital math software users and users of all three vendors had higher percentile ranks than propensity-score matched non-users.
- Regression models estimated overall digital math software users and ALEKS and ST Math users had higher SGP than propensity-score matched non-users.
- The size of effects varied across vendors.

Student and School Characteristics and Performance

What Student and School Characteristics are Related to Performance?

In the previous section, we presented results that showed software users performed better than non-users in terms of proficiency, percentile, and SGP. In our GEE analyses we controlled for several student and school-level characteristics. In this section, we report the relationship between those control variables and performance.

Findings

Table 7 provides estimated difference (Δ) in the three outcome indicators based on the student and school characteristics. Table 7 also indicates the direction of the relationship. A positive relationship, indicated by an arrow pointing up, means that students with the characteristic performed better than students without the characteristic. A negative relationship, which is indicated by an arrow pointing down, means that the students with the characteristic performed worse than students without the characteristic. Arrows pointing left and right indicate that students with the characteristic performed better on one or more indicator, but worse on another one or more indicator than students without the characteristic. We reported n.s. in place of model estimates which were not statistically significant.

Table 7. GEE Results for Student and School Characteristics

Characteristic	Δ in Probability of Proficiency	Δ in Percentile	Δ in SGP	Direction of Relationship	
Gender					
Male	1.3%	-0.9	-1.7	Mixed	←→
Race or Ethnicity					
Asian	3.1%	2.4	4.5	Pos	↑
Multiple Races	-3.9%	-3.4	n.s.	Neg	↓
Pacific Islander	-16.9%	-12.4	n.s.	Neg	↓
Hispanic/Latino	-20.8%	-17.2	-2.2	Neg	↓
American Indian	-23.8%	-18.4	n.s.	Neg	↓
African American	-26.5%	-25.3	-3.7	Neg	↓
Additional Student Characteristics					
Rural	1.1%	1.1	1.0	Pos	↑
Mobile	-10.9%	-9.6	-3.6	Neg	↓
Free and Reduced Lunch	-14.0%	-12.5	-1.9	Neg	↓
Chronic Absent	-15.3%	-13.5	-5.6	Neg	↓
School-Level Variables					
Mobile	-0.6%	-0.5	-0.2	Neg	↓
Free and Reduced Lunch	-0.1%	-0.1	0.0	Neg	↓
Chronic Absence	0.3%	0.1	0.2	Pos	↑

Data sources: USBE and Digital Math Software Vendors

Gender, race or ethnicity, additional student characteristics, and school characteristics were statistically significantly related to outcomes. Gender was the only student characteristic that was associated with both improved and worse performance, depending on the indicator. Male students were just over 1% more likely to be proficient compared to female students, but on average had lower scale scores and lower SGP. The most likely explanation for these findings is that whereas a slightly higher percent of male students met proficiency, there were a number of male students with very low scores, which decreased the average percentile rank and SGP for male students.

Compared to White students, Asian students performed better on all three indicators, probability of proficiency, percentile rank, and SGP. Students with multiple race or ethnicity, Hispanic or Latino students, American Indian students, and African American students on average did not perform as well as White students across the indicators. Pacific Islanders did not perform as well as White students on the proficiency outcome and the percentile outcome, but were not statistically significantly different compared to White students on SGP. The effects for Hispanic/Latino, American Indian, African American and Pacific Islander were of greater magnitude than other student or school characteristics.

On all three indicators, probability of proficiency, percentile rank, and SGP, rural students tended to perform a little better compared to non-rural students. Students characteristics of being mobile, qualifying for free and reduced lunch and being chronically absent were related to lower scores on the three indicators. Similarly, students who attended schools with high rates of mobile and low-income, students did not perform as well as students in other schools. Surprisingly, students in schools with high levels of chronic absence performed slightly better. See the full model for all users in Appendix B: Regression Results for Digital Software Users and Non-Users. See the full models for each vendor in Appendix C. Vendor Specific Regression Results For Digital Math Software Users and Non-Users.

Summary

Findings presented in this section address the question of what student and school-level characteristics were related to performance indicators. Multiple student and school characteristics were significantly related to performance indicators. Student characteristics related to outcome indicators included gender, race and ethnicity, rural status, mobility, whether students qualify for free and reduced lunch, and chronic absence. At the school level, overall rates of mobility, students who qualify for free and reduced lunch, and chronic absence were related to outcome indicators.

- Gender had the only mixed relationship, with male students being more likely to be proficient, but also having overall lower average percentile rank and SGP.
- Asian students on average performed better than White students across all indicators.
- Students of multiple race or ethnicity, Pacific Islander, Hispanic or Latino, American Indian, and African American students did not perform as well as White students across the three indicators.
- Rural students performed slightly better than non-rural students across all three indicators.

- On all three indicators, mobile students, students who qualify for free and reduced lunch, and chronically absent students did not perform as well as students who respectively were not mobile, did not qualify for free and reduced lunch, and were not chronically absent.
- Students in schools with higher rates of mobility and students who qualify for free and reduced lunch did not perform as well as students in schools with lower rates of mobile students and students who qualify for free and reduced lunch.
- Students in schools with higher rates of chronic absence performed better than students in schools with lower rates of chronic absence.

Amount and Consistency of Digital Math Software Use and Performance

How Does the Way Students Use Math Software Relate to Performance?

In this section of the report, we examine how student use of digital math software related to performance across the indicators of probability of proficiency, percentile rank, and SGP. In this section we report on all digital math software users. See regression results for the individual vendors in Appendix E. Vendor Specific Regression Results For Digital Math Software Users Only. The variables of interest for software use include:

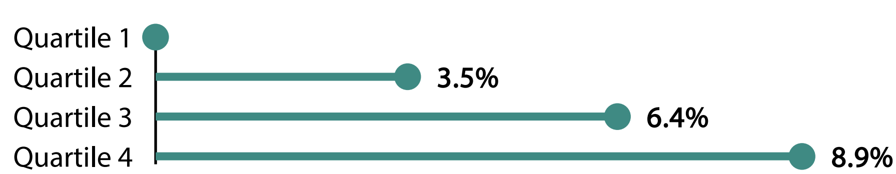
1. Overall use as measured by use quartiles
2. Consistency of use as measured by the coefficient of variance
3. Years of software use within vendor

Because this section is concerned with how students used digital math software, the regression analyses we report on in this section included digital math software users and did not include the propensity-score matched comparison group. The regression models reported on here controlled for student and school-level characteristics reported on in the last section, but we only report on use variables in this section. See results of the full model for all users in Appendix D. Regression Results for Digital Software Users Only.

Findings

First, we present findings on how overall minutes of use per month was related to performance. We used the use quartiles reported on previously in this report as predictors in models. Quartile 1 consists of the 25% of students with the lowest use. Quartile 2 two consists of the 25% of students with the next lowest use. Quartile 3 consists of the 25% of students with the second highest use, and Quartile 4 consists of the 25% of students with the highest use. Note that the range of minute per month included in each quartile varied from vendor to vendor.

Figure 16. Difference in Probability of Proficiency for Use Quartiles



Data sources: USBE and Digital Math Software Vendors

We used Quartile 1 as our baseline for comparison so we could compare the difference in outcome indicators between Quartile 1 and Quartiles 2-4. Results shown in Figure 16 indicate that students who use digital math software more were more likely to be proficient. Users in

Quartiles 2-4 had respectively 3.5%, 6.4%, and 8.9% higher probabilities of proficiency compared to users in the Quartile 1.

Figure 17 shows that similar to proficiency, students who used digital math software more had higher percentile ranks. Compared to Quartile 1, students in Quartiles 2-4 had respectively 3.27, 6.48, and 8.97 higher average percentile ranks. To illustrate this finding, if a student in Quartile 1 has a percentile rank of 60, he scored higher than 60% of other test takers. A similar student in Quartile 4 would have a percentile rank of 69, indicating he scored higher than 69% of other test takers.

Figure 17. Difference in Percentile Rank for Use Quartiles

Data sources: USBE and Digital Math Software Vendors

As shown in Figure 18, similar to findings for proficiency and percentile rank, students who used digital math software more had higher SGP. Compared to digital math software users in Quartile 1, users in Quartiles 2, 3, and 4 respectively, had 2.88, 5.11, and 7.45 higher SGP. To illustrate, if a Quartile 1 student had SGP of 53, she would have more growth or greater improvement than 53% of test takers who scored similar to her the previous year. We would expect a similar Quartile 4 student to have an SGP of 60, indicating that she would have more growth or greater improvement than 60% of test takers who scored similar to her the previous year.

Figure 18. Difference in SGP for Use Quartiles

Data sources: USBE and Digital Math Software Vendors

In addition to overall use, we included consistency of use and years of use in the model to test their relationship to performance. The coefficient of variation is an indicator of how consistent or inconsistent a student used digital math software. We calculated the coefficient of variation for each student across all years of use. Table 8 shows results for consistency of use and years of use.

Table 8. Difference in Outcomes of Interest Given a One-Unit Increase in the Coefficient of Variation and an Additional Year of Use

Use Variable	Difference in Probability of Proficiency	Difference in Percentile	Difference in SGP
Coefficient of Variation	-2%	-2.1	-1.9
Years of Use	-3%	-.1	-1.2

Data sources: USBE and Digital Math Software Vendors

Students who were more consistent in their use of digital math software performed better on all three outcome indicators. The coefficient of variation is a measure of how inconsistently students use software; the higher the coefficient of variation, the more variation in the length of time students used the software for each month. The regression estimates that a student with a 1% higher coefficient of variation was 2% less likely to be proficient, had a 2.1 lower percentile rank, and a 1.9% lower SGP.

In this analysis, for each additional year of digital math software use, students were 3% less likely to be proficient (See Tables 8-11). Specifically, they had a .1 lower percentile rank, and a 1.2 lower SGP. Interpreting the results of the years of software use variable should be done cautiously, and certainly should not be used for a summative judgment regarding the effectiveness or utility of digital math software. Instead, given the contradictory nature of this finding to previous empirical research of the benefits of technology use in math and science classes in middle and high schools (Middleton & Murray 1999; Wenglinksy 1998), further examination is necessary. In particular, we suggest that this finding raises additional question regarding the impact, if any, of student course taking patterns and engagement and success with the math curriculum prior to exposure and use of the digital math platforms. Moreover, this longitudinal outcomes analysis does not account for variations in teacher characteristics (e.g., content expertise, professional learning in STEM) or instructional methods (e.g. variations in use of technology), which is an area for further exploration (DeCoito & Richardson, 2018; Rahman, Krishnan, & Kapila, 2017). For a more detailed and extensive view as to how Digital Math software users vary from non-users longitudinally see Appendix F.

Summary

In this section, we looked at how the way students used digital math software related to the outcome indicators of probability of proficiency, percentile rank, and SGP. Findings suggest that overall amount of use and consistency of use of digital math software were related to the three indicators of performance. In a full model of the data that included mixed populations of elementary, middle, and high school students served by different vendors for different years, the number of years in the data was indicative of a negative relation to SAGE math performance (Appendix F), but results likely varied based on digital math software vendor and more specifically based on the populations those vendors served. This variation can be seen by taking a panoramic view of the results from vendor specific models found in Appendices C, E, and F, and considering the disparate populations they treat.

- Students in higher use quartiles had higher probability of proficiency, percentile ranks, and SGP, meaning that more use was related to better performance.
- Students with higher coefficients of variation had lower probability of proficiency, percentile ranks, and SGP, indicating students who used digital math software more consistently performed better than students who had less consistent use.
- For years of use, vendor specific modeling results were mixed. For example, Table 29 shows i-Ready SGP regression results had a non-significant positive effect for years of use as compared to Table 26 which shows Aleks SGP regression results had a significant negative association. This indicates that while the boost from using the software is overwhelmingly positive there is still a negative trend when viewing math scores across multiple years as students advance in the content rigor (Appendix F).

Summary of Findings

Here we provide a summary of the overall evaluation findings. In this evaluation we compared digital math users to non-users across the state. We also analyzed use, including how much and how consistently students used the digital math software. We compared users and non-users on SAGE math test outcome indicators of probability of proficiency, percentile rank, and SGP. We also explored which student and school-level characteristics are related to performance indicators and finally how use of digital math software is related to SAGE performance indicators. Findings in all of these areas are summarized below.

Digital Math Software User and Non-User Information

Digital math software users and non-users statewide had similar rates of students in each race and ethnicity, gender, and similar rates of mobile students and students who were chronically absent. Digital math software users had slightly higher rates of students in rural areas and slightly higher rates of students who qualify for free and reduced lunch.

Comparing users across Digital Math Software Vendors, students using each vendor's software appear similar in terms of most student characteristics. However, compared to ALEKS, i-Ready and ST Math digital software users had higher rates of Latino students. Compared to ST Math, i-Ready and ALEKS users had higher rates of rural students. ST Math software users had a higher percent of students eligible for free and reduced lunch.

Digital Math Use and Consistency of Use

The amount of time students spent using digital math software varied between students within and across software vendors. Similarly, how consistently students used digital math software varied between students within and across software vendors. In general, consistency of use increased as time spent using digital math software increased.

Digital Math Software Users and Non-Users Math Performance

Average proficiency level, percentile rank, and SGP were similar in digital math software users and non-users. With the exceptions noted below, regression results suggested digital math software users performed slightly better than non-users in probability of proficiency, percentile rank, and SGP. Exceptions include ALEKS users were not statistically significantly more likely to be proficient than propensity-score matched non-users, and i-Ready users did not have significantly higher SGP than propensity score matched non-users.

Student and School Characteristics and Performance

Compared to female students, male students were slightly more likely to be proficient, but had lower average percentile ranks and SGP. Race and ethnicity were related to performance. In general, Asian students performed better than White students, and other students of color did not perform as well as White students. Rural students performed slightly better than non-rural students across the three outcome indicators. Mobile students, students who qualify for free and reduced lunch, and students who were chronically absent did not perform as well as students without those attributes. Lastly, students from schools with higher levels of mobile students and students who qualify for free and reduced lunch did not perform as well as students from schools with lower rates of mobility and students who qualify for free and reduced lunch, and students from schools with higher rates of chronic absence performed better than students from schools with lower rates of chronic absence.

Amount and Consistency of Digital Math Software Use and Performance

Students who used digital math software more minutes per week, based on use quartile, were more likely to be proficient, had higher percentile ranks and higher SGP. Students who used digital math software more consistently (had less variation in the length of use from month to month) were more likely to be proficient, had higher percentile ranks and higher SGP. Finally, students who used digital math software for multiple years followed the general population (e.g., nonusers) trends of decreased proficiency (Appendix F) as represented by lower percentile ranks, and SGP. However, students who used digital math software still fared better than those who did not use the math software in the outcomes of proficiency, percentile ranks, and SGP.

Causality and Quality of Use

Two issues of interest that are not settled by this evaluation are whether use of math software causes improved performance and with what quality teachers use digital math software and integrate software into curriculum. Consistent with previous evaluations and research on technology in mathematics education (Murphy, 2016; Cheung & Slavin, 2013; Young, Gorumek, & Hamilton, 2018), this evaluation found that software users performed better than non-users. The outcome of interest for this evaluation was multiple years of SAGE math test proficiency, percentile rank, and SGP. The analyses reported here, and previous years of the evaluation, have been observational and correlational in nature. These types of studies are important. Yet, they do not demonstrate causation. In the absence of experimental designs—randomly assigning students and schools to use or not use digital math software, an evaluation cannot definitively speak to whether the software caused the improved performance in users, and such conclusions should be avoided. However, the additional analyses using propensity score matching strengthens the causal argument, as we have controlled for preexisting differences between users and non-users. However, it is important to note that propensity score matching only accounts for characteristics we included in the propensity score matching. Additional student and school characteristics may influence performance, and certainly school policies and teacher practices, which were not addressed at all in these analyses impact performance.

This analyses also does not address the quality of use and how teachers integrate digital math software and curriculum. However, in subsequent evaluations, informed by the SAMR model (Puentedura, 2013) and the TPACK framework (Mishra & Koehler, 2006), we explore student and teacher perceptions of how digital math software is being used in classrooms. The UEPC has collected survey data from students and teachers as well as teacher interviews to better understand how personalized math software is used in teaching and learning. However, to date, the use of these surveys are not permitted to be administered in a way that would permit the data between sources—surveys, teacher- and student-level data, and observations—to be used in tandem.

Considerations for Improving the K-12 Math Personalized Learning Software Grant

We conclude this report with some considerations for K-12 Math Personalized Learning Software Grant. These considerations are based on evaluation findings and research on technology and education. The considerations we present address efforts to improve outcomes by increasing use and consistency of use of digital math software, expanding high quality integration of digital math software into teaching and learning, and providing additional supports for students.

The K-12 Math Personalized Learning Software Grant seeks to improve student learning in mathematics literacy. We found students who use digital math software more and students who use digital math software with greater consistency outperform students who use the software less and use software with less consistency. Research suggests that distributing practice consistently across time can be more effective than mass practice at one time (Nazari & Ebersback, 2019; Schutte et al., 2015).

Next, this evaluation demonstrates better outcomes for students who used the software more and students who used software more consistently. However, there is more to achieving successful outcomes than amount and consistency of use. Research on educational technology underscores the importance of effective integration of technology into curriculum (Puentedura, 2013; Mishra and Koehler, 2006), including the quality of technology integration.

To address both the quality and quantity of digital software integration, there are several recommendations. First, consider creating a digital math integration repository that illustrates how teachers are both integrating the software in their mathematics lessons and how they are finding the balance between consistent and meaningful use of the digital math software. Next, increase opportunities for learning for educators to model and practice technology integration within the mathematics program that addresses increased and consistent use of the digital math software as a complement to, and not a replacement for, their mathematics instruction. This professional learning could include addressing how teachers may leverage available software reports of student use and performance to address student needs. Taken together, these opportunities would provide a venue for teachers to share their professional practice, success stories and strategies to overcome barriers or obstacles to successful integration of digital math software into math curriculum.

Many students of color, students who qualify for free and reduced lunch, mobile students, and students who were chronically absent were less likely to be proficient and had lower percentile ranks and SGP. Issues relating to multicultural education and inequities in education cannot be solved by technology alone and must be addressed systemically. However, addressing inequities in technology access and use is necessary to address these larger issues, including pedagogy, educator and student beliefs, and access (Gorski, 2009; Dotterer, Hedges, & Parker, 2016). One aim of the digital math software is to increase opportunities in mathematics. In order to increase access and improve student outcomes in mathematics literacy for student groups with lower performance, there are several considerations that may be beneficial. First, explore how access and use of the software may differ for student groups based on observed classroom-level practices. Next, provide intentional development opportunities for educators to maximize culturally relevant pedagogy for students and increase access to the software in ways that again complement other instructional techniques. Finally, further consideration may be needed regarding the availability and access to the digital math software.

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Appendix A. Methodology

Data Collection Channel

The UEPC set up a dedicated secure file transfer protocol server for software vendors. All data exchanges between the UEPC and the vendors, schools, school districts, and USBE were compliant with FERPA and other federal and local privacy and confidentiality laws and regulations.

Data Disposition

This is a longitudinal study. All data that the UEPC received and derived from the received data will be used solely for this project and will be kept until the project ends. The UEPC will not share the linked data to any third party under any circumstances. The UEPC will not share any data components to any third party without formal written authorization by those who own the data components along with documentation of IRB approval from the third party's institution.

Once the project ends, all data will be sanitized and destroyed following the guideline of the University of Utah (http://regulations.utah.edu/it/guidelines/G4-004N1.pdf) and the Federal regulations (http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-88r1.pdf, pp 22-23).

Data Source Security

All data were securely encrypted, transmitted, and stored according to industry and University of Utah standards.

Data Sources

Vendor Data

Three math learning platforms were included in the evaluation, including ALEKS, i-Ready, and ST Math. Mathspace was not included in this analysis because for the years required to do a longitudinal view they were still a pilot program, and therefore didn't have the data necessary for this analysis. Imagine Math was not included in this analysis because of issues in data that made matching across platforms (i.e. vendor provided data to SAGE data) inaccessible. Usual yearly evaluation reports can still be expected per usual arrangement. Student usage from vendors was requested every month for longitudinal analyses starting in September 2014 and going through November 2019.

USBE Data

In accordance with the existing data-sharing agreement, the USBE data needed for the evaluation of the software were transferred to the UEPC via the USBE's secure FTP server.

Data Storage

The Utah Education Policy Center (UEPC) considers the security and protection of data to be of the utmost importance. Encrypted data are stored on secure hardware, maintained by highly trained computer professionals, and safeguarded by the University of Utah's network security, Virtual Private Network (VPN), and firewall. The UEPC protects data in compliance with the

Family Educational Rights and privacy Act, 20 U.S. Code §1232g and 34 CFR Part 99 ("FERPA"), the Government Records and Management Act U.C.A. §62G-2 ("GRAMA"), U.C.A. §53A-1-1401 et seq, 15 U.S. Code §§ 6501-6506 ("COPPA") and Utah Administrative Code R277-487 ("Student Data Protection Act").

The UEPC limits and restricts data access to leaders in charge of the day-to-day operations of the research, and professional and technically qualified staff who conduct research. All UEPC staff receive FERPA and CITI trainings and certification, which cover issues of data privacy, security, and protections, and ethics of data management and use. UEPC employees who have access to data are required to sign a Non-Disclosure Agreement. Access to data is controlled by password protection, encryption, dual authentication, and/or similar procedures designed to ensure that data cannot be accessed by unauthorized individuals.

The UEPC maintains a data sharing agreement (DSA) with the Utah State Board of Education (USBE) wherein the USBE shares data with the UEPC for the purposes of state, district, and federal evaluations.

Data Samples

The sample used for the analyses included all students whose data from the five vendors matched with the USBE database. Students were in grades 3 through 12 because those grades completed SAGE testing. Samples in the analyses varied depending on the outcomes of interest. Those outcomes included SAGE standardized scores, standardized growth percentiles (SGPs), and proficiency level. The largest sample was for proficiency, because it included the least amount of missing values compared to the other outcomes. The analysis of SAGE raw scores included a subset of the full population because it only included students who had SAGE math test scores. The SGP analysis was smaller still because it only included students in grade four or above who took the SAGE math test in at least one previous year.

Some students used more than one software program. Because these students represented less than 1% of the total students who used the software, we did not think they would affect the outcome of the analyses. For the analyses of the combined vendors, students were counted only once per year and their number of minutes on the software was combined across the software programs they used.

Sample sizes reported in this analysis are complex due to the nature of analysis related to repeated measures. Sample sizes throughout various analyses were different due to a number of factors such as missing data among different variables, reporting of observations vs reporting distinct individuals, and construction of different variables.

Data Analyses

Data Matching Methods

We linked the vendor data with USBE data using multiple criteria. First, we collapsed the students in the Vendor data to single rows based on the student login and school year, and removed the 2019 and 2020 school years because they contained testing from RISE instead of the SAGE for the outcome. Second, we matched the USBE and Vendors data based on the same full name, state school id, and school year which was appropriate because it yielded a large enough sample for analysis. Third, we identified what schools were associated with each vendor and which schools were not associated with a vendor, and for each individual vendor we performed a propensity score match based on proportions of school-level characteristics with those identified as not having a vendor.

Statistical Analyses

The following statistical methods were used in the analysis:

1. Proportions were reported to compare race, gender, low income status, mobility, rural status, and chronic absenteeism for users and non-users, and between vendors by school year.
2. Consistent with our previous evaluation reports, we considered usage greater than 3600 minutes in a single month, or approximately 14 hours a week, to be unrealistic. Therefore, if a student had a monthly usage greater than 3600 minutes were dropped; this constituted less than 1% of all individuals. Students in the vendor data who had zero minutes of reported usage and zero logins were considered non-users, and were also filtered out of the analysis.
3. Quartiles, which by definition are when you divide the data of interest into 4 equal sized groups, were created by software usage in minutes per week for each vendor independently. This helps to compare low to high usage groups in an interpretable way in the modeling.
4. Proportions for race, mobility status, rural status, those who tested below grade level, chronic absenteeism, and gender were made on the school level in order to perform propensity score match between schools of each vendor individually and non-user schools. This was done to get a more appropriate comparison group for the analysis of users to non-users.
5. All the models used in this analysis accounted for the following variables to help address potential confounding and answer research questions of interest: Years in vendor, Student gender, race, low income status, mobility status, rural status, and chronically absent status; some school level variables were also incorporated in the models such as proportion of low income, mobile, and chronically absent students. It should also be noted that since SAGE testing does not have raw scores that are comparable from one test to another we created standardized test scores to use in our analysis.
6. Generalized Estimating Equation (GEE) with logistic regression was used to compare individual vendor users and combined vendor users to non-users on proficiency with an exchangeable correlation structure. GEE was necessary in this analysis to control for within subject variation because we have repeated measures across years of the same subjects which influences the independence assumption. GEE is similar to its commonly used counterpart generalized linear model in interpretation. In order to have a more balanced model we took a random sample of the USBE non-users that was twice as large as the user group, so the ratio for the non-user comparison group to users would be 2:1.
7. GEE with linear regression was used to compare SGPs and Standardized test scores of individual vendor users and combined vendor users to non-users using an exchangeable

correlation structure. In order to have a more balanced model we took a random sample of the USBE non-users that was twice as large as the user group, so the ratio for the non-user comparison group to users would be 2:1.

8. In order to account for the effect consistency of software use from one month to another on outcomes we generated a coefficient of variation, using the following formula: $C_v = \frac{\sigma_{Period\ Usage}}{\mu_{Period\ Usage}}$, to include in our other within vendor models.
9. GEE with logistic regression was used to determine how the number of minutes per week, divided into quartiles, using the math software influences their proficiency. An exchangeable correlation structure was used to address the within subject variation, and odds ratios comparing the lowest quartile of use to the other three quartiles, 95% confidence intervals of odds ratios, and p-values were reported.
10. GEE with linear regression was used to determine how the number of minutes per week, divided into quartiles, using the math software influences Standardized test scores and SGP. An exchangeable correlation structure was used to address the within subject variation, and coefficients of program use, 95% confidence intervals, and p-values were reported.
11. Appendix F contains additional analysis that redefined the years of use variable into a years of observation variable; all other variables are defined the same as in previous models. The difference between these variables is "years of use" variable defines a non-software user as 0 where as "years of observation" variable is the number of years the non-software user is observed in the data. The software user subjects remain constant between the two variables, and both provide useful information that is outlined in the report.

Limitations

1. Name spelling variations and typos in the data may impact matching.

2. The SAGE testing takes place starting in 3rd grade, but some of the math vendors begin as early as kindergarten. This means that students who started earlier do not have the year over year data included to account for their full participation in the software.

3. Data on student usage were reported for the entire school year from September to June, including usage that may have taken place after SAGE testing. Program use that took place after a student took the math SAGE test would have no relationship to SAGE results. Therefore, there was some amount of use data included in the analyses that were not relevant to the outcome variables.

4. Student usage amounts may be slightly biased if students remained signed into the program while it was not in use. This influences the maximum values of the software usage quantiles to appear unrealistic in relation to ALEKS and ST Math. These extreme values made up 0.4 % and 0.8 % of the vendor specific samples respectively. Analysis was done to assess the influence of these extreme values, and they were found to be not significantly, or meaningfully, impactful thus by virtue of commonly accepted statistical

practice they were left in the analysis. The recommendation to control this issue in the future is extended to the vendors to remain vigilant in controlling for unrealistic time amounts through methods such as monitoring inactivity, setting a plausibility threshold for usage amounts, and/or ex post facto data cleaning.

Appendix B: Regression Results for Digital Software Users and Non-Users

Table 9. Probability of Proficiency Regression Results for Digital Math Users (All Vendors) and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.461	0.008	3395.862	<.001	1.586	.613
Years of use	-0.121	0.006	366.499	<.001	0.886	.470
Software user	0.067	0.010	40.970	<.001	1.069	.517
Gender – Male	0.052	0.006	77.571	<.001	1.054	.513
Black/African American	-1.182	0.031	1500.625	<.001	0.307	.235
American Indian	-1.034	0.033	983.091	<.001	0.356	.262
Asian	0.125	0.022	31.051	<.001	1.133	.531
Hispanic/Latino	-0.884	0.009	8694.064	<.001	0.413	.292
Multiple Races	-0.156	0.019	66.056	<.001	0.855	.461
Pacific Islander	-0.706	0.026	717.790	<.001	0.494	.331
Low Income	-0.577	0.007	6826.196	<.001	0.561	.360
Mobile	-0.442	0.014	1021.859	<.001	0.642	.391
Rural	0.045	0.010	20.599	<.001	1.046	.511
Chronically Absent	-0.633	0.011	3402.546	<.001	0.531	.347
Free and Reduced Lunch	-0.005	0.000	857.095	<.001	0.995	.499
Mobile (school)	-0.025	0.001	701.891	<.001	0.975	.494
Chronically Absent (school)	0.011	0.001	266.161	<.001	1.011	.503

Data sources: USBE and Digital Math Software Vendors

Table 10. Standardized Score Regression Results for Digital Math Users (All Vendors) and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.423	0.003	15828.748	<.001
Years of use	-0.036	0.002	272.203	<.001
Software user	0.040	0.004	97.027	<.001
Gender – Male	-0.023	0.003	72.595	<.001
Black/African American	-0.685	0.012	3243.132	<.001
American Indian	-0.478	0.012	1549.326	<.001
Asian	0.060	0.011	30.694	<.001
Hispanic/Latino	-0.445	0.004	12137.640	<.001
Multiple Races	-0.086	0.009	93.258	<.001
Pacific Islander	-0.316	0.010	906.969	<.001
Low Income	-0.319	0.003	10059.242	<.001
Mobile	-0.244	0.006	1796.459	<.001
Rural	0.028	0.004	44.069	<.001
Chronically Absent	-0.344	0.005	5746.692	<.001
Free and Reduced Lunch	-0.003	0.000	1752.894	<.001
Mobile (school)	-0.013	0.000	1240.132	<.001
Chronically Absent (school)	0.002	0.000	25.147	<.001

Data sources: USBE and Digital Math Software Vendors

Table 11. SGP Regression Results for Digital Math Users (All Vendors) and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	53.263	0.118	202719.757	<.001
Years of use	-0.742	0.121	37.498	<.001
Software user	1.726	0.197	76.911	<.001
Gender – Male	-1.715	0.087	388.548	<.001
Black/African American	-3.726	0.380	95.973	<.001
American Indian	0.691	0.409	2.861	.091
Asian	4.450	0.352	160.204	<.001
Hispanic/Latino	-2.215	0.130	288.570	<.001
Multiple Races	-0.034	0.303	0.013	.911
Pacific Islander	-0.157	0.358	0.191	.662
Low Income	-1.902	0.106	320.654	<.001
Mobile	-3.584	0.245	214.779	<.001
Rural	0.964	0.144	45.074	<.001
Chronically Absent	-5.645	0.162	1212.652	<.001
Low Income (school)	-0.028	0.003	104.266	<.001
Mobile (school)	-0.249	0.016	244.647	<.001
Chronically Absent (school)	0.155	0.010	234.853	<.001

Data sources: USBE and Digital Math Software Vendors

Appendix C. Vendor Specific Regression Results For Digital Math Software Users and Non-Users

ALEKS

Table 12. Probability of Proficiency Regression Results for ALEKS Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.270	0.006	1869.752	<.001	1.311	.567
Years of use	-0.140	0.007	349.178	<.001	0.870	.465
Software user	0.004	0.012	0.107	0.707	1.004	.501
Gender – Male	0.028	0.007	15.618	<.001	1.028	.507
Black/African American	-1.457	0.043	1154.697	<.001	0.233	.189
American Indian	-1.166	0.040	836.910	<.001	0.312	.238
Asian	0.027	0.029	0.887	0.346	1.028	.507
Hispanic/Latino	-1.045	0.012	7982.371	<.001	0.352	.260
Multiple Races	-0.206	0.023	77.901	<.001	0.814	.449
Pacific Islander	-0.916	0.036	654.497	<.001	0.400	.286
Free and Reduced Lunch	-0.645	0.008	6711.841	<.001	0.525	.344
Mobile	-0.533	0.017	979.690	<.001	0.587	.370
Rural	0.123	0.011	122.415	<.001	1.131	.531
Chronically Absent	-0.685	0.013	2730.966	<.001	0.504	.335

Data sources: USBE and Digital Math Software Vendors

Table 13. Standardized Score Regression Results for ALEKS Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.286	0.003	11532.363	<.001
Years of use	-0.050	0.003	342.680	<.001
Software user	0.037	0.005	60.501	<.001
Gender – Male	-0.038	0.003	145.613	<.001
Black/African American	-0.782	0.016	2393.942	<.001
American Indian	-0.549	0.015	1383.177	<.001
Asian	0.004	0.014	0.063	.802
Hispanic/Latino	-0.528	0.005	12170.283	<.001
Multiple Races	-0.116	0.011	113.459	<.001
Pacific Islander	-0.411	0.014	839.915	<.001
Free and Reduced Lunch	-0.360	0.004	10252.499	<.001
Mobile	-0.289	0.007	1607.998	<.001
Rural	0.054	0.005	128.325	<.001
Chronically Absent	-0.375	0.005	4670.919	<.001

Data sources: USBE and Digital Math Software Vendors

Table 14. SGP Regression Results for ALEKS Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	52.348	0.092	320374.698	<.001
Years of use	-1.000	0.145	47.727	<.001
Software user	2.471	0.226	119.946	<.001
Gender – Male	-1.996	0.101	386.634	<.001
Black/African American	-4.907	0.492	99.325	<.001
American Indian	0.778	0.484	2.588	.108
Asian	3.421	0.449	58.124	<.001
Hispanic/Latino	-2.920	0.152	366.613	<.001
Multiple Races	-0.421	0.360	1.369	.242
Pacific Islander	-2.338	0.472	24.496	<.001
Free and Reduced Lunch	-2.101	0.116	326.624	<.001
Mobile	-4.012	0.290	191.454	<.001
Rural	1.683	0.161	109.792	<.001
Chronically Absent	-5.797	0.191	923.902	<.001

Data sources: USBE and Digital Math Software Vendors

I-Ready

Table 15. Probability of Proficiency Regression Results for i-Ready Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.315	0.016	369.374	<.001	1.370	.578
Years of use	-0.019	0.024	0.606	0.436	0.981	.495
Software user	0.197	0.035	30.751	<.001	1.217	.549
Gender – Male	0.106	0.018	33.280	<.001	1.112	.527
Black/African American	-1.223	0.089	188.978	<.001	0.294	.227
American Indian	-1.008	0.116	75.902	<.001	0.365	.267
Asian	0.021	0.070	0.085	0.770	1.021	.505
Hispanic/Latino	-0.936	0.028	1109.424	<.001	0.392	.282
Multiple Races	-0.164	0.057	8.304	0.004	0.849	.459
Pacific Islander	-0.798	0.081	96.932	<.001	0.450	.310
Free and Reduced Lunch	-0.739	0.020	1314.997	<.001	0.478	.323
Mobile	-0.496	0.040	153.930	<.001	0.609	.379
Rural	0.027	0.028	0.928	0.335	1.027	.507
Chronically Absent	-0.479	0.030	262.953	<.001	0.619	.382

Data sources: USBE and Digital Math Software Vendors

Table 16. Standardized Score Regression Results for i-Ready Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.243	0.007	1133.008	<.001
Years of use	-0.006	0.008	0.599	.439
Software user	0.078	0.013	34.607	<.001
Gender – Male	0.022	0.008	6.492	0.011
Black/African American	-0.787	0.038	439.732	<.001
American Indian	-0.526	0.045	137.531	<.001
Asian	0.056	0.035	2.495	.114
Hispanic/Latino	-0.501	0.013	1584.794	<.001
Multiple Races	-0.075	0.027	7.711	.005
Pacific Islander	-0.390	0.035	126.553	<.001
Free and Reduced Lunch	-0.430	0.010	1932.482	<.001
Mobile	-0.262	0.017	230.679	<.001
Rural	0.077	0.012	40.786	<.001
Chronically Absent	-0.278	0.013	461.138	<.001

Data sources: USBE and Digital Math Software Vendors

Table 17. SGP Regression Results for i-Ready Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	53.242	0.262	41394.926	<.001
Years of use	0.406	0.521	0.607	.436
Software user	-0.501	0.769	0.424	.515
Gender – Male	-1.062	0.287	13.739	<.001
Black/African American	-3.768	1.182	10.155	.001
American Indian	-1.670	1.487	1.261	.261
Asian	5.042	1.176	18.376	<.001
Hispanic/Latino	-2.532	0.414	37.348	<.001
Multiple Races	0.429	0.960	0.200	.655
Pacific Islander	-1.751	1.165	2.261	.133
Free and Reduced Lunch	-3.109	0.326	91.053	<.001
Mobile	-5.730	0.707	65.706	<.001
Rural	-0.363	0.417	0.759	.384
Chronically Absent	-3.830	0.471	66.264	<.001

Data sources: USBE and Digital Math Software Vendors

ST Math

Table 18. Probability of Proficiency Regression Results for ST Math Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.358	0.013	799.671	<.001	1.430	.589
Years of use	-0.111	0.013	68.611	<.001	0.895	.472
Software user	0.394	0.023	282.635	<.001	1.483	.597
Gender – Male	0.111	0.014	64.596	<.001	1.117	.528
Black/African American	-1.124	0.049	532.874	<.001	0.325	.245
American Indian	-1.072	0.064	282.494	<.001	0.342	.255
Asian	-0.018	0.040	0.200	.655	0.982	.496
Hispanic/Latino	-0.853	0.019	2072.836	<.001	0.426	.299
Multiple Races	-0.008	0.042	0.035	.851	0.992	.498
Pacific Islander	-0.663	0.044	230.429	<.001	0.515	.340
Free and Reduced Lunch	-0.831	0.015	2983.237	<.001	0.436	.303
Mobile	-0.522	0.028	346.654	<.001	0.593	.372
Rural	-0.353	0.038	87.217	<.001	0.703	.413
Chronically Absent	-0.577	0.024	574.262	<.001	0.562	.360

Data sources: USBE and Digital Math Software Vendors

Table 19. Standardized Score Regression Results for ST Math Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.300	0.005	3004.355	<.001
Years of use	-0.008	0.004	3.556	0.059
Software user	0.111	0.009	152.395	<.001
Gender – Male	0.003	0.006	0.268	0.604
Black/African American	-0.695	0.021	1092.595	<.001
American Indian	-0.576	0.024	578.382	<.001
Asian	-0.001	0.020	0.002	0.967
Hispanic/Latino	-0.445	0.008	2815.583	<.001
Multiple Races	0.000	0.020	0.000	0.994
Pacific Islander	-0.290	0.018	272.870	<.001
Free and Reduced Lunch	-0.483	0.007	4553.799	<.001
Mobile	-0.308	0.012	717.562	<.001
Rural	-0.178	0.016	126.819	<.001
Chronically Absent	-0.328	0.010	1091.104	<.001

Data sources: USBE and Digital Math Software Vendors

Table 20. SGP Regression Results for ST Math Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	52.854	0.197	72008.003	<.001
Years of use	-1.038	0.260	15.874	<.001
Software user	3.012	0.488	38.029	<.001
Gender – Male	-0.932	0.209	19.885	<.001
Black/African American	-3.869	0.692	31.278	<.001
American Indian	-0.010	0.851	0.000	.991
Asian	4.175	0.647	41.673	<.001
Hispanic/Latino	-2.494	0.279	79.692	<.001
Multiple Races	1.111	0.695	2.557	.110
Pacific Islander	1.951	0.621	9.873	.002
Free and Reduced Lunch	-3.686	0.243	229.857	<.001
Mobile	-3.938	0.568	48.046	<.001
Rural	-0.846	0.537	2.481	.115
Chronically Absent	-4.662	0.377	152.582	<.001

Data sources: USBE and Digital Math Software Vendors

Appendix D. Regression Results for Digital Software Users Only

Table 21. Probability of Proficiency Regression Results for Digital Math Users Only (All Vendors)

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.481	0.019	614.651	<.001	1.617	0.618
Years of use	-0.138	0.006	548.902	<.001	0.871	0.465
Use 2nd quartile	0.139	0.011	154.734	<.001	1.149	0.535
Use 3rd quartile	0.256	0.011	506.322	<.001	1.291	0.564
Use 4th quartile	0.360	0.012	906.040	<.001	1.433	0.589
Coefficient of variation	-0.108	0.015	50.918	<.001	0.898	0.473
Gender – Male	0.030	0.010	8.058	<.01	1.030	0.507
Black/African American	-1.117	0.051	488.693	0	0.327	0.247
American Indian	-0.915	0.055	280.176	0	0.401	0.286
Asian	0.081	0.042	3.794	.051	1.085	0.520
Hispanic/Latino	-0.853	0.017	2546.151	<.001	0.426	0.299
Multiple Races	-0.141	0.035	16.491	<.001	0.869	0.465
Pacific Islander	-0.578	0.046	157.996	<.001	0.561	0.359
Free and Reduced Lunch	-0.492	0.011	1896.241	<.001	0.611	0.379
Mobile	-0.340	0.022	237.958	<.001	0.712	0.416
Rural	0.124	0.013	93.541	<.001	1.132	0.531
Chronically Absent	-0.444	0.016	757.570	<.001	0.641	0.391
Free and Reduced Lunch (school)	0.000	0.000	0.289	.591	1.000	0.500
Mobile (school)	-0.040	0.002	393.247	<.001	0.961	0.490
Chronically Absent (school)	-0.010	0.001	106.633	<.001	0.990	0.497

Data sources: USBE and Digital Math Software Vendors

Table 22. Standardized Score Regression Results for Digital Math Users Only (All Vendors)

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.315	0.008	1617.574	<.001
Years of use	-0.015	0.002	52.477	<.001
Use 2nd quartile	0.082	0.004	372.486	<.001
Use 3rd quartile	0.163	0.004	1410.912	<.001
Use 4th quartile	0.227	0.005	2482.406	<.001
Coefficient of variation	-0.051	0.006	78.658	<.001
Gender – Male	-0.029	0.005	37.935	<.001
Black/African American	-0.656	0.020	1034.358	<.001
American Indian	-0.423	0.021	404.159	<.001
Asian	0.048	0.020	5.587	.018
Hispanic/Latino	-0.427	0.007	3471.924	<.001
Multiple Races	-0.085	0.016	28.291	<.001
Pacific Islander	-0.273	0.019	203.763	<.001
Free and Reduced Lunch	-0.255	0.005	2679.427	<.001
Mobile	-0.177	0.009	394.542	<.001
Rural	0.066	0.005	146.309	<.001
Chronically Absent	-0.231	0.007	1241.774	<.001
Free and Reduced Lunch (school)	-0.001	0.000	30.042	<.001
Mobile (school)	-0.021	0.001	631.233	<.001
Chronically Absent (school)	-0.005	0.000	155.034	<.001

Data sources: USBE and Digital Math Software Vendors

Table 23. SGP Regression Results for Digital Math Users Only (All Vendors)

Feature	Estimate	Std err	Wald	*p*
(Intercept)	55.144	0.322	29281.489	<.001
Years of use	-1.214	0.114	114.076	<.001
Use 2nd quartile	2.878	0.200	206.293	<.001
Use 3rd quartile	5.109	0.200	651.706	<.001
Use 4th quartile	7.449	0.202	1359.843	<.001
Coefficient of variation	-1.875	0.270	48.273	<.001
Gender – Male	-2.080	0.138	227.505	<.001
Black/African American	-3.183	0.616	26.728	<.001
American Indian	1.143	0.677	2.852	.091
Asian	4.961	0.604	67.510	<.001
Hispanic/Latino	-1.573	0.213	54.629	<.001
Multiple Races	-0.318	0.500	0.404	.525
Pacific Islander	1.114	0.614	3.297	.069
Free and Reduced Lunch	-1.958	0.165	141.175	<.001
Mobile	-2.608	0.437	35.645	<.001
Rural	1.185	0.181	43.067	<.001
Chronically Absent	-4.924	0.260	359.736	<.001
Free and Reduced Lunch (school)	-0.017	0.005	13.369	<.001
Mobile (school)	-0.379	0.030	156.232	<.001
Chronically Absent (school)	-0.026	0.014	3.613	.057

Data sources: USBE and Digital Math Software Vendors

Appendix E. Vendor Specific Regression Results For Digital Math Software Users Only

ALEKS

Table 24. Probability of Proficiency Regression Results for ALEKS Users Only

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.513	0.024	448.893	<.001	1.671	.626
Years of use	-0.173	0.007	594.580	<.001	0.841	.457
Use 2nd quartile	0.153	0.014	125.138	<.001	1.165	.538
Use 3rd quartile	0.291	0.014	436.180	<.001	1.338	.572
Use 4th quartile	0.385	0.015	680.725	<.001	1.469	.595
Coefficient of variation	-0.087	0.019	21.906	<.001	0.917	.478
Gender – Male	-0.006	0.013	0.214	0.644	0.994	.499
Black/African American	-1.489	0.082	333.115	<.001	0.226	.184
American Indian	-1.018	0.069	215.420	<.001	0.361	.265
Asian	-0.011	0.059	0.037	0.848	0.989	.497
Hispanic/Latino	-1.018	0.023	2032.952	<.001	0.361	.265
Multiple Races	-0.278	0.044	39.132	<.001	0.758	.431
Pacific Islander	-0.790	0.067	140.923	<.001	0.454	.312
Free and Reduced Lunch	-0.466	0.014	1175.549	<.001	0.628	.386
Mobile	-0.344	0.029	141.339	<.001	0.709	.415
Rural	0.217	0.015	206.212	<.001	1.242	.554
Chronically Absent	-0.510	0.021	608.834	<.001	0.601	.375
Free and Reduced Lunch (school)	-0.002	0.000	27.218	<.001	0.998	.499
Mobile (school)	-0.052	0.003	245.868	<.001	0.949	.487
Chronically Absent (school)	-0.011	0.001	88.129	<.001	0.989	.497

Data sources: USBE and Digital Math Software Vendors

Table 25. Standardized Score Regression Results for ALEKS Users Only

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.329	0.010	1154.307	<.001
Years of use	-0.042	0.003	267.481	<.001
Use 2nd quartile	0.099	0.005	345.699	<.001
Use 3rd quartile	0.195	0.005	1290.850	<.001
Use 4th quartile	0.262	0.006	2100.455	<.001
Coefficient of variation	-0.034	0.007	22.330	<.001
Gender – Male	-0.051	0.006	81.688	<.001
Black/African American	-0.790	0.029	763.516	<.001
American Indian	-0.435	0.025	293.330	<.001
Asian	-0.026	0.028	0.844	.358
Hispanic/Latino	-0.493	0.009	2997.694	<.001
Multiple Races	-0.160	0.020	63.008	<.001
Pacific Islander	-0.361	0.027	179.547	<.001
Free and Reduced Lunch	-0.237	0.006	1652.244	<.001
Mobile	-0.169	0.012	208.777	<.001
Rural	0.096	0.006	226.322	<.001
Chronically Absent	-0.255	0.008	929.174	<.001
Free and Reduced Lunch (school)	-0.002	0.000	151.155	<.001
Mobile (school)	-0.019	0.001	318.689	<.001
Chronically Absent (school)	-0.004	0.001	74.253	<.001

Data sources: USBE and Digital Math Software Vendors

Table 26. SGP Regression Results for ALEKS Users Only

Feature	Estimate	Std err	Wald	*p*
(Intercept)	55.857	0.383	21272.114	<.001
Years of use	-1.661	0.135	152.254	<.001
Use 2nd quartile	3.158	0.233	183.334	<.001
Use 3rd quartile	5.836	0.233	625.282	<.001
Use 4th quartile	8.113	0.236	1177.467	<.001
Coefficient of variation	-2.325	0.318	53.479	<.001
Gender – Male	-2.450	0.160	235.632	<.001
Black/African American	-4.400	0.805	29.865	<.001
American Indian	1.398	0.800	3.056	.080
Asian	3.606	0.785	21.117	<.001
Hispanic/Latino	-2.025	0.253	63.930	<.001
Multiple Races	-1.268	0.590	4.624	.032
Pacific Islander	-2.125	0.822	6.687	.010
Free and Reduced Lunch	-1.550	0.189	67.411	<.001
Mobile	-2.532	0.530	22.839	<.001
Rural	2.713	0.207	172.096	<.001
Chronically Absent	-5.390	0.312	298.386	<.001
Free and Reduced Lunch (school)	-0.061	0.006	116.801	<.001
Mobile (school)	-0.292	0.042	48.364	<.001
Chronically Absent (school)	0.052	0.016	10.093	.001

Data sources: USBE and Digital Math Software Vendors

I-Ready

Table 27. Probability of Proficiency Regression Results for i-Ready Users Only

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.490	0.064	58.845	<.001	1.632	.620
Years of use	0.031	0.021	2.248	.134	1.031	.508
Use 2nd quartile	0.267	0.033	64.619	<.001	1.306	.566
Use 3rd quartile	0.403	0.035	133.975	<.001	1.496	.599
Use 4th quartile	0.598	0.037	256.565	<.001	1.819	.645
Coefficient of variation	-0.003	0.062	0.002	.960	0.997	.499
Gender – Male	0.115	0.029	15.165	<.001	1.122	.529
Black/African American	-0.977	0.145	45.454	<.001	0.377	.274
American Indian	-0.653	0.162	16.291	<.001	0.520	.342
Asian	0.177	0.137	1.660	.198	1.193	.544
Hispanic/Latino	-0.711	0.043	279.556	<.001	0.491	.329
Multiple Races	-0.097	0.094	1.054	.305	0.908	.476
Pacific Islander	-0.620	0.151	16.935	<.001	0.538	.350
Free and Reduced Lunch	-0.579	0.034	283.448	<.001	0.560	.359
Mobile	-0.297	0.055	29.140	<.001	0.743	.426
Rural	-0.036	0.035	1.048	.306	0.965	.491
Chronically Absent	-0.335	0.040	70.756	<.001	0.716	.417
Free and Reduced Lunch (school)	0.004	0.001	21.019	<.001	1.004	.501
Mobile (school)	-0.069	0.004	307.480	<.001	0.933	.483
Chronically Absent (school)	-0.017	0.003	41.037	<.001	0.983	.496

Data sources: USBE and Digital Math Software Vendors

Table 28. Standardized Score Regression Results for i-Ready Users Only

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.267	0.025	114.767	<.001
Years of use	0.069	0.006	121.434	<.001
Use 2nd quartile	0.111	0.012	85.550	<.001
Use 3rd quartile	0.224	0.013	314.550	<.001
Use 4th quartile	0.314	0.014	539.720	<.001
Coefficient of variation	0.023	0.022	1.005	.316
Gender – Male	0.035	0.013	7.061	<.001
Black/African American	-0.550	0.059	87.556	<.001
American Indian	-0.345	0.066	26.946	<.001
Asian	0.071	0.062	1.312	.252
Hispanic/Latino	-0.368	0.019	372.641	<.001
Multiple Races	-0.036	0.042	0.750	.386
Pacific Islander	-0.303	0.066	21.156	<.001
Free and Reduced Lunch	-0.298	0.014	427.028	<.001
Mobile	-0.139	0.021	43.499	<.001
Rural	0.070	0.014	23.533	<.001
Chronically Absent	-0.180	0.016	134.246	<.001
Free and Reduced Lunch (school)	0.001	0.000	9.244	.002
Mobile (school)	-0.033	0.002	350.053	<.001
Chronically Absent (school)	-0.013	0.001	118.228	<.001

Data sources: USBE and Digital Math Software Vendors

Table 29. SGP Regression Results for i-Ready Users Only

Feature	Estimate	Std err	Wald	*p*
(Intercept)	55.567	1.201	2140.022	<.001
Years of use	0.781	0.450	3.016	.082
Use 2nd quartile	3.296	0.633	27.139	<.001
Use 3rd quartile	4.986	0.653	58.212	<.001
Use 4th quartile	9.451	0.672	197.778	<.001
Coefficient of variation	0.944	1.150	0.673	.412
Gender – Male	-1.714	0.431	15.832	<.001
Black/African American	-1.027	1.886	0.296	.586
American Indian	0.257	2.260	0.013	.909
Asian	5.035	2.187	5.299	.021
Hispanic/Latino	-0.571	0.628	0.828	.363
Multiple Races	1.963	1.489	1.739	.187
Pacific Islander	0.701	2.029	0.119	.730
Free and Reduced Lunch	-2.992	0.533	31.525	<.001
Mobile	-0.846	1.091	0.602	.438
Rural	-3.226	0.531	36.916	<.001
Chronically Absent	-3.126	0.684	20.879	<.001
Free and Reduced Lunch (school)	0.021	0.012	2.979	.084
Mobile (school)	-0.818	0.064	163.849	<.001
Chronically Absent (school)	-0.276	0.042	42.527	<.001

Data sources: USBE and Digital Math Software Vendors

ST Math

Table 30. Probability of Proficiency Regression Results for ST Math Users Only

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	1.069	0.047	514.063	<.001	2.913	.744
Years of use	-0.091	0.013	46.815	<.001	0.913	.477
Use 2nd quartile	0.080	0.027	9.046	.003	1.083	.520
Use 3rd quartile	0.129	0.027	23.246	<.001	1.137	.532
Use 4th quartile	0.285	0.028	103.595	<.001	1.329	.571
Coefficient of variation	-0.180	0.032	31.169	<.001	0.835	.455
Gender – Male	0.107	0.026	17.434	<.001	1.113	.527
Black/African American	-0.851	0.076	126.372	<.001	0.427	.299
American Indian	-0.510	0.113	20.264	<.001	0.601	.375
Asian	0.085	0.070	1.450	.228	1.088	.521
Hispanic/Latino	-0.579	0.036	257.203	<.001	0.560	.359
Multiple Races	0.203	0.075	7.277	.007	1.225	.551
Pacific Islander	-0.398	0.074	29.217	<.001	0.672	.402
Free and Reduced Lunch	-0.595	0.029	416.248	<.001	0.552	.356
Mobile	-0.360	0.046	61.361	<.001	0.697	.411
Rural	-0.696	0.049	203.234	<.001	0.498	.333
Chronically Absent	-0.431	0.037	134.871	<.001	0.650	.394
Free and Reduced Lunch (school)	-0.002	0.001	7.546	.006	0.998	.499
Mobile (school)	-0.061	0.006	102.248	<.001	0.941	.485

Data sources: USBE and Digital Math Software Vendors

Table 31. Standardized Score Regression Results for ST Math Users Only

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.564	0.018	1010.086	<.001
Years of use	0.019	0.004	20.070	<.001
Use 2nd quartile	0.040	0.009	20.771	<.001
Use 3rd quartile	0.069	0.009	56.468	<.001
Use 4th quartile	0.128	0.010	176.401	<.001
Coefficient of variation	-0.076	0.011	46.625	<.001
Gender – Male	0.009	0.011	0.586	.444
Black/African American	-0.517	0.033	242.828	<.001
American Indian	-0.271	0.046	34.684	<.001
Asian	0.111	0.032	11.957	.001
Hispanic/Latino	-0.275	0.016	291.287	<.001
Multiple Races	0.086	0.034	6.500	.011
Pacific Islander	-0.166	0.030	31.229	<.001
Free and Reduced Lunch	-0.303	0.012	590.054	<.001
Mobile	-0.199	0.018	128.592	<.001
Rural	-0.283	0.021	189.331	<.001
Chronically Absent	-0.203	0.014	209.056	<.001
Free and Reduced Lunch (school)	-0.001	0.000	12.909	<.001
Mobile (school)	-0.034	0.002	225.196	<.001
Chronically Absent (school)	-0.006	0.001	20.713	<.001

Data sources: USBE and Digital Math Software Vendors

Table 32. SGP Regression Results for ST Math Users Only

Feature	Estimate	Std err	Wald	*p*
(Intercept)	54.017	0.860	3946.022	<.001
Years of use	-0.606	0.263	5.314	.021
Use 2nd quartile	1.841	0.530	12.073	.001
Use 3rd quartile	3.119	0.530	34.591	<.001
Use 4th quartile	5.435	0.543	100.299	<.001
Coefficient of variation	-1.431	0.648	4.876	.027
Gender – Male	-0.586	0.371	2.493	.114
Black/African American	-2.131	1.111	3.681	.055
American Indian	2.549	1.636	2.428	.119
Asian	6.791	1.073	40.081	<.001
Hispanic/Latino	-0.471	0.524	0.805	.370
Multiple Races	1.735	1.242	1.951	.162
Pacific Islander	5.084	1.036	24.095	<.001
Free and Reduced Lunch	-3.283	0.462	50.377	<.001
Mobile	-3.493	1.137	9.443	.002
Rural	-5.117	0.682	56.239	<.001
Chronically Absent	-4.091	0.657	38.790	<.001
Free and Reduced Lunch (school)	0.030	0.012	6.300	.012
Mobile (school)	-0.454	0.083	29.599	<.001
Chronically Absent (school)	-0.041	0.043	0.920	.337

Data sources: USBE and Digital Math Software Vendors

Appendix F. Regression Results Demonstrating Years of Observation with User Interaction

All Users Combined

Table 33. Probability of Proficiency Regression Results for Digital Math Users (All Vendors) and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.355	0.008	1765.639	<.001	1.427	0.588
Years of Observation	-0.102	0.005	367.254	<.001	0.903	0.474
Software user	-0.013	0.012	1.132	0.287	0.987	0.497
Gender – Male	0.041	0.006	42.785	<.001	1.042	0.51
Black/African American	-1.293	0.032	1633.863	<.001	0.275	0.215
American Indian	-1.166	0.034	1148.026	<.001	0.312	0.238
Asian	0.07	0.023	8.773	0.003	1.072	0.517
Hispanic/Latino	-0.974	0.01	9748.9	<.001	0.378	0.274
Multiple Races	-0.149	0.02	55.145	<.001	0.861	0.463
Pacific Islander	-0.757	0.028	745.772	<.001	0.469	0.319
Low Income	-0.622	0.007	8437.567	<.001	0.537	0.349
Mobile	-0.423	0.013	1127.615	<.001	0.655	0.396
Rural	0.077	0.01	63.967	<.001	1.08	0.519
Chronically Absent	-0.531	0.01	2677.513	<.001	0.588	0.37
Years of Obs * Software User Interaction	-0.014	0.008	2.971	0.085	0.986	0.496

Data sources: USBE and Digital Math Software Vendors

Table 34. Standardized Score Regression Results for Digital Math Users (All Vendors) and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.317	0.003	9295.466	<.001
Years of Observation	-0.028	0.002	222.883	<.001
Software user	0.019	0.005	17.619	<.001
Gender – Male	-0.032	0.003	122.602	<.001
Black/African American	-0.758	0.013	3561.919	<.001
American Indian	-0.594	0.013	2136.413	<.001
Asian	0.03	0.012	6.388	0.011
Hispanic/Latino	-0.517	0.004	15154.5	<.001
Multiple Races	-0.085	0.009	81.766	<.001
Pacific Islander	-0.376	0.011	1117.849	<.001
Low Income	-0.344	0.003	12511.23	<.001
Mobile	-0.23	0.005	1961.562	<.001
Rural	0.039	0.004	90.33	<.001
Chronically Absent	-0.279	0.004	4479.067	<.001
Years of Obs * Software User Interaction	-0.004	0.003	2.221	0.136

Data sources: USBE and Digital Math Software Vendors

Table 35. SGP Regression Results for Digital Math Users (All Vendors) and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	51.655	0.156	110296.4	<.001
Years of Observation	0.724	0.102	50.641	<.001
Software user	3.054	0.236	167.275	<.001
Gender – Male	-1.884	0.087	469.839	<.001
Black/African American	-3.63	0.384	89.501	<.001
American Indian	0.366	0.398	0.843	0.358
Asian	4.319	0.353	149.902	<.001
Hispanic/Latino	-2.549	0.128	398.303	<.001
Multiple Races	0.065	0.304	0.045	0.832
Pacific Islander	-0.85	0.36	5.576	0.018
Low Income	-2.545	0.1	649.387	<.001
Mobile	-4.249	0.245	299.968	<.001
Rural	1.541	0.14	121.525	<.001
Chronically Absent	-5.424	0.161	1133.563	<.001
Years of Obs * Software User Interaction	-1.571	0.158	98.692	<.001

Data sources: USBE and Digital Math Software Vendors

Aleks

Table 36. Probability of Proficiency Regression Results for ALEKS Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.36	0.01	1303.418	<.001	1.434	0.589
Years of Observation	-0.109	0.006	312.895	<.001	0.896	0.473
Software user	-0.116	0.014	66.641	<.001	0.89	0.471
Gender – Male	0.022	0.008	8.159	0.004	1.022	0.505
Black/African American	-1.453	0.045	1040.563	<.001	0.234	0.19
American Indian	-1.182	0.043	762.88	<.001	0.307	0.235
Asian	0.074	0.031	5.641	0.018	1.077	0.518
Hispanic/Latino	-1.053	0.013	7088.084	<.001	0.349	0.259
Multiple Races	-0.194	0.024	63.053	<.001	0.824	0.452
Pacific Islander	-0.858	0.037	526.431	<.001	0.424	0.298
Low Income	-0.596	0.008	5403.966	<.001	0.551	0.355
Mobile	-0.425	0.015	755.744	<.001	0.654	0.395
Rural	0.124	0.011	134.197	<.001	1.132	0.531
Chronically Absent	-0.567	0.012	2105.227	<.001	0.567	0.362
Years of Obs * Software User Interaction	-0.023	0.01	5.931	0.015	0.977	0.494

Data sources: USBE and Digital Math Software Vendors

Table 37. Standardized Score Regression Results for ALEKS Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.331	0.004	7290.88	<.001
Years of Observation	-0.033	0.002	225.069	<.001
Software user	-0.006	0.005	1.213	0.271
Gender – Male	-0.044	0.003	163.678	<.001
Black/African American	-0.781	0.017	2202.699	<.001
American Indian	-0.578	0.016	1368.695	<.001
Asian	0.037	0.015	5.646	0.017
Hispanic/Latino	-0.539	0.005	10993.47	<.001
Multiple Races	-0.111	0.011	96.927	<.001
Pacific Islander	-0.392	0.015	696.033	<.001
Low Income	-0.317	0.004	7754.736	<.001
Mobile	-0.219	0.006	1177.556	<.001
Rural	0.046	0.005	101.491	<.001
Chronically Absent	-0.292	0.005	3351.775	<.001
Years of Obs * Software User Interaction	-0.01	0.003	9.234	0.002

Data sources: USBE and Digital Math Software Vendors

Table 38. SGP Regression Results for ALEKS Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	51.703	0.183	80124.16	<.001
Years of Observation	0.69	0.119	33.748	<.001
Software user	3.136	0.275	130.325	<.001
Gender – Male	-2.112	0.101	433.728	<.001
Black/African American	-4.274	0.495	74.695	<.001
American Indian	0.748	0.476	2.465	0.116
Asian	4.014	0.454	78.225	<.001
Hispanic/Latino	-2.695	0.154	304.514	<.001
Multiple Races	-0.238	0.358	0.443	0.506
Pacific Islander	-1.59	0.473	11.311	0.001
Low Income	-2.181	0.117	349.579	<.001
Mobile	-4.08	0.292	195.561	<.001
Rural	1.8	0.156	132.81	<.001
Chronically Absent	-5.869	0.191	941.946	<.001
Years of Obs * Software User Interaction	-1.691	0.187	81.638	<.001

Data sources: USBE and Digital Math Software Vendors

I-Ready

Table 39. Probability of Proficiency Regression Results for I-Ready Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.322	0.029	124.435	<.001	1.38	0.58
Years of Observation	-0.086	0.021	16.919	<.001	0.918	0.479
Software user	0.148	0.042	12.127	<.001	1.159	0.537
Gender – Male	0.114	0.019	34.795	<.001	1.12	0.528
Black/African American	-1.212	0.096	160.957	<.001	0.298	0.229
American Indian	-1.215	0.101	145.849	<.001	0.297	0.229
Asian	-0.044	0.073	0.354	0.552	0.957	0.489
Hispanic/Latino	-0.923	0.029	994.83	<.001	0.397	0.284
Multiple Races	-0.26	0.059	19.403	<.001	0.771	0.435
Pacific Islander	-0.7	0.092	58.184	<.001	0.496	0.332
Low Income	-0.683	0.021	1054.262	<.001	0.505	0.336
Mobile	-0.448	0.039	131.309	<.001	0.639	0.39
Rural	0.088	0.029	9.237	0.002	1.092	0.522
Chronically Absent	-0.456	0.03	230.009	<.001	0.634	0.388
Years of Obs * Software User Interaction	0.064	0.032	4.115	0.043	1.066	0.516

Data sources: USBE and Digital Math Software Vendors

Table 40. Standardized Score Regression Results for I-Ready Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.278	0.011	659.382	<.001
Years of Observation	-0.017	0.007	5.602	0.018
Software user	0.048	0.016	9.669	0.002
Gender – Male	0.008	0.009	0.859	0.354
Black/African American	-0.743	0.039	357.796	<.001
American Indian	-0.618	0.038	259.006	<.001
Asian	0.009	0.036	0.069	0.793
Hispanic/Latino	-0.501	0.013	1471.732	<.001
Multiple Races	-0.108	0.027	15.54	<.001
Pacific Islander	-0.407	0.041	98.577	<.001
Low Income	-0.386	0.01	1558.288	<.001
Mobile	-0.246	0.016	225.717	<.001
Rural	0.096	0.012	58.618	<.001
Chronically Absent	-0.246	0.012	403.336	<.001
Years of Obs * Software User Interaction	0.008	0.01	0.573	0.449

Data sources: USBE and Digital Math Software Vendors

Table 41. SGP Regression Results for I-Ready Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	52.814	0.571	8547.062	<.001
Years of Observation	0.383	0.42	0.834	0.361
Software user	0.005	0.921	≈ 0	0.996
Gender – Male	-1.44	0.283	25.801	<.001
Black/African American	-1.79	1.248	2.059	0.151
American Indian	1.204	1.26	0.913	0.339
Asian	4.761	1.159	16.876	<.001
Hispanic/Latino	-2.377	0.409	33.843	<.001
Multiple Races	1.076	0.949	1.286	0.257
Pacific Islander	-1.98	1.264	2.454	0.117
Low Income	-3.699	0.324	130.349	<.001
Mobile	-5.298	0.721	53.964	<.001
Rural	1.374	0.43	10.213	0.001
Chronically Absent	-4.189	0.474	77.962	<.001
Years of Obs * Software User Interaction	-0.183	0.667	0.075	0.784

Data sources: USBE and Digital Math Software Vendors

ST Math

Table 42. Probability of Proficiency Regression Results for ST Math Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*	Odds Ratio	Probability
(Intercept)	0.4	0.02	413.37	<.001	1.492	0.599
Years of Observation	-0.073	0.012	35.05	<.001	0.929	0.482
Software user	0.328	0.027	142.886	<.001	1.388	0.581
Gender – Male	0.077	0.015	27.92	<.001	1.08	0.519
Black/African American	-1.175	0.052	509.282	<.001	0.309	0.236
American Indian	-1.022	0.071	207.363	<.001	0.36	0.265
Asian	0.011	0.042	0.072	0.789	1.011	0.503
Hispanic/Latino	-0.848	0.02	1813.592	<.001	0.428	0.3
Multiple Races	0.036	0.044	0.675	0.411	1.037	0.509
Pacific Islander	-0.687	0.047	216.786	<.001	0.503	0.335
Low Income	-0.772	0.016	2420.764	<.001	0.462	0.316
Mobile	-0.449	0.026	289.749	<.001	0.638	0.39
Rural	-0.426	0.037	131.726	<.001	0.653	0.395
Chronically Absent	-0.495	0.024	442.891	<.001	0.609	0.379
Years of Obs * Software User Interaction	-0.032	0.018	3.189	0.074	0.968	0.492

Data sources: USBE and Digital Math Software Vendors

Table 43. Standardized Score Regression Results for ST Math Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	0.299	0.008	1507.74	<.001
Years of Observation	-0.013	0.004	9.093	0.003
Software user	0.11	0.01	113.398	<.001
Gender – Male	-0.012	0.007	3.253	0.071
Black/African American	-0.709	0.023	986.358	<.001
American Indian	-0.564	0.028	415.752	<.001
Asian	0.026	0.021	1.496	0.221
Hispanic/Latino	-0.451	0.009	2515.918	<.001
Multiple Races	0.018	0.021	0.74	0.39
Pacific Islander	-0.329	0.019	292.228	<.001
Low Income	-0.435	0.007	3475.806	<.001
Mobile	-0.251	0.011	559.099	<.001
Rural	-0.166	0.016	115.081	<.001
Chronically Absent	-0.256	0.009	780.503	<.001
Years of Obs * Software User Interaction	0.001	0.006	0.042	0.838

Data sources: USBE and Digital Math Software Vendors

Table 44. SGP Regression Results for ST Math Users and Propensity-Score Matched Comparison Students

Feature	Estimate	Std err	Wald	*p*
(Intercept)	50.908	0.357	20360.87	<.001
Years of Observation	1.051	0.226	21.619	<.001
Software user	4.924	0.572	74.014	<.001
Gender – Male	-1.195	0.21	32.491	<.001
Black/African American	-2.914	0.699	17.376	<.001
American Indian	-1.012	0.886	1.305	0.253
Asian	4.777	0.645	54.887	<.001
Hispanic/Latino	-2.004	0.282	50.667	<.001
Multiple Races	0.586	0.72	0.662	0.416
Pacific Islander	0.748	0.626	1.427	0.232
Low Income	-3.583	0.244	215.883	<.001
Mobile	-4.254	0.584	53.071	<.001
Rural	-0.314	0.506	0.385	0.535
Chronically Absent	-4.478	0.384	135.688	<.001
Years of Obs * Software User Interaction	-2.106	0.345	37.377	<.001

Data sources: USBE and Digital Math Software Vendors

THE UNIVERSITY OF UTAH
UTAH EDUCATION POLICY CENTER

FOR RELEASE JULY 30, 2020

Advancing STEM Teaching And Learning In Utah

An Evaluation of the Impact of the Professional Learning Grant 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 STEM professional learning in the United States. The review addresses topics including the quality of the United States' STEM K-12 teacher workforce; the state of STEM professional development and learning in the United States; STEM professional learning in high-performing nations in science and mathematics; the attributes of effective STEM professional learning; and the impact of effective STEM professional learning on teacher and student outcomes. In Part One, the report also provides an overview of the Professional Learning Grant Program, the evaluation's methods, and the report's organization.

Setting the Context

The Quality of the United States' STEM K-12 Teacher Workforce

The urgent need to address the declining performance and interest of U.S. K-12 students in science and mathematics has led to an increased focus on the quality of the nation's science, engineering, mathematics, and technology (STEM) teacher workforce (Chiyaka, Kibirige, Sithole, McCarthy, & Mupinga, 2017; Fulton & Britton, 2011; Rogers, Winship, & Sun, 2016). As researchers have unequivocally noted, most in-service STEM K-12 educators in the United States, whether in computer science, mathematics, or the life sciences, do not hold degrees in the very subject areas they teach (Hossain & Robinson, 2012; Leyzberg & Moretti, 2017; Swars, Smith, Smith, Carothers, & Myers, 2016). Resultantly, K-12 schools across the nation are having to grapple with the grave effects on student learning, proficiency, and interest in STEM brought on by systemic inadequacies in STEM teacher education and teachers who, by and large, lack the requisite knowledge of content and pedagogy needed to teach science and mathematics effectively (Berry III, Ellis, & Hughes, 2014; Jensen, Roberts-Hall, Magee, & Ginnivan, 2016a; Joshi & Jain, 2018; Onuma, 2017).

The State of STEM Professional Development and Learning in the United States

To rectify the ill-preparation of STEM K-12 teachers, as well as further the expertise and instructional practices of those who received adequate training in their subject areas, schools across the nation are increasingly relying on conventional interventions such as professional development and, in some cases, professional learning communities (Burrows, 2015; Chiyaka et al., 2017; Fulton & Britton, 2011; Hudley & Mallinson, 2017). While these supplementary training opportunities for STEM teachers have been ongoing in the United States for a decade or more, scholars have become more vocal about the deficiencies in the nation's approach to STEM professional development. In recent years, some scholars have described STEM professional development approaches in the United States as largely piece-meal in nature, fragmented, and ineffective (Hiebert & Stigler, 2017; Maltese, Lung, Potvin, & Hochbein, 2013; Onuma, 2017; Rogers et al., 2016). Additionally, national bodies such as the National Commission on Teaching and America's Future (NCTAF) have reported that "countries that persistently rank at the top of international measures of science and mathematics achievement do things [with regard to STEM professional development and learning] differently [than the United States]" (Fulton & Britton, 2011, p. 4).

STEM Professional Learning in High-Performing Nations in Science and Mathematics

In line with NCTAF's assertion, researchers have noted that a long-standing tradition of school systems that are high-performing in mathematics and science, such as those in mainland China, Hong Kong, and Taiwan, is to provide STEM teachers with discipline-specific, or subject-based, professional development (Onuma, 2017). This form of professional development involves collaborative learning with a group of teachers who provide instruction in the same subject area. And in mainland China, master teachers—who account for less than 0.5% of the nation's teachers, possess upwards of 10 years of teaching experience in the subject area, and have published widely on teaching and learning—oversee these subject-based professional learning communities (Jensen et al., 2016a; Onuma 2017; Jensen, Sonnemann, Roberts-Hull, & Hunter, 2016b). Moreover, every new mathematics or science teacher in mainland China is provided a mentor who is not only an expert on the subject but is experienced in cultivating the expertise of new teachers (Jensen et al., 2016a; Onuma, 2017). In the United States, however, an antithetical system exists in which teachers neither receive adequate support from school leaders to seek out relevant professional development nor are provided with discipline-specific professional development in their schools (Chiyaka et al., 2017; Jensen et al., 2016a). The convention, rather, in the United States is to offer large-scale workshops or training sessions led by experts, with the expectation, whether implicit or made crystal clear, that teachers use the knowledge, if any, they acquire from these sessions to inform their practice (Jensen et al., 2016a; Maltese et al., 2013). Regrettably, research suggests that this form of professional development has provided little benefit, if any, to teaching quality in the United States (Hiebert & Stigler, 2017).

The Attributes of Effective STEM Professional Learning

In response to the shortfall of STEM professional development in the United States, researchers and national bodies alike have attempted to identify the qualities that make for effective professional development and learning. As Fulton and Britton (2011) posit, STEM learning communities are effective when they are undergirded by six principles which include *shared values and goals*, *leadership support*, *time (continuity)*, *use of student data and work*, *collective responsibility*, *good facilitation*, *trust*, and *focus on a single school subject*. Still, other researchers such as Rogers and colleagues (2016) have noted that STEM professional development is only effective in improving student learning outcomes and interest in as much as they facilitate teachers' ability to create "authentic" STEM learning experiences in their classrooms. To this end, Rogers and colleagues (2016) posit that effective STEM professional development is one that increases teachers' awareness of the various STEM careers available, provides them with opportunities to experience real-world STEM applications such as in STEM facilities, builds their STEM knowledge through intensive mentoring programs, and provides them with hands-on experiences in STEM teaching and learning.

The Impact of Effective STEM Professional Learning on Teacher and Student Outcomes

When professional development and learning takes on the aforementioned attributes posited by Fulton and Britton (2011) and Rogers and colleagues (2016), researchers tend to observe increased interest among teachers in teaching STEM or integrating STEM content in their lessons, increased use of inquiry-based and problem-solving approaches in STEM instruction, increased collaboration and shared learning among STEM teachers, increased content knowledge and pedagogical content knowledge in STEM subjects, increased self-efficacy and confidence among educators to teach STEM, and increased career satisfaction (Burrows, 2015; Chiyaka et al., 2017; Fulton & Britton, 2011; Nadelson et al., 2013; Nathan, Atwood, Prevost, Phelps, & Tan, 2011; Onuma, 2017; Webb, 2015). Moreover, teachers who participate in effective STEM professional learning communities have been found to be better able to improve and sustain the learning, achievement, and interest of their students in STEM subjects (Capraro et al., 2016; Estapa & Tank, 2017; Fulton & Britton, 2011; Jensen et al., 2016a).

Merits of the Current Evaluation

Despite the positive findings about the impact of effective professional development on teacher and student outcomes, scholars have noted the need for more research on "naturally occurring" STEM professional learning communities as most research studies (e.g., Baker & Galanti, 2017; Estapa & Tank, 2017; Nadelson et al., 2013; Nathan et al., 2011) have tended to examine quasi-experimental professional learning communities—that is, professional learning communities that were created as part of the research study.

The current report extends the existing bodies of knowledge on STEM professional development and learning in the United States in its evaluation of the *Professional Learning Grant Program* established in Utah to advance STEM teaching and learning. The next section of this introduction provides a broad overview of the program. More specifically, it discusses how the grant program was created and how it is supporting the formation of "naturally occurring" STEM professional learning communities in local education agencies in Utah.

Overview of the Professional Learning Grant Program

In 2014, House Bill 150 (H.B. 150)[1], passed in the Utah State Legislature, amended and enacted provisions related to the Science, Technology, Engineering, and Mathematics (STEM) Action Center. Among the bill's new provisions was a mandate that the STEM Action Center provide high quality STEM education professional learning to K-12 educators. Concerning the STEM education professional learning provision (also referred to as the *Professional Learning Grant Program*[2]), H.B. 150 proposed that the STEM Action Center either provides an online professional learning platform for teachers or creates a hybrid format that supports both online professional learning and face-to-face applied learning. The online application chosen for the professional learning, as the bill further elaborated, must undergo rigorous vetting and meet high-quality standards developed by the Utah State Board of Education. Additionally, it must 1) provide teachers with access to automatic tools, resources, and strategies, 2) allow teachers to work in online learning communities, 3) provide video examples of highly effective STEM education teaching, 4) permit additional STEM education video content to be uploaded, 5) track and report data on usage of the application's components, and 6) allow the Utah State Board of Education, school district, or school to track results of the professional learning.

Program Implementation

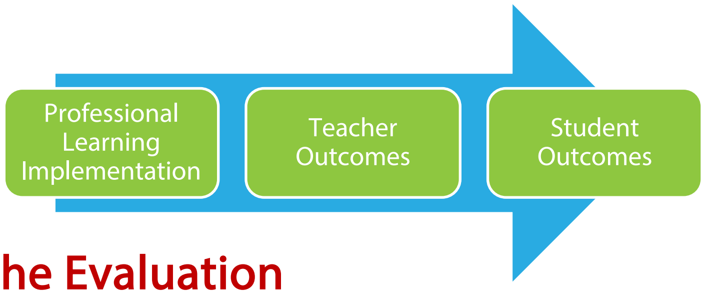
As the administrator of the Professional Learning Grant Program, the STEM Action Center selects the online application to be used in providing STEM education professional learning to teachers as well as the schools that participate in the grant program. Based on criteria specified in H.B. 150, the STEM Action Center selected Edivate, an online professional learning application provided by the School Improvement Network (SINET), for the Professional Learning Grant Program. Participating schools, according to the STEM Action Center, are selected on the basis of identified needs associated with STEM learning and are provided with

[1] https://le.utah.gov/~2014/bills/static/hb0150.html
[2] https://stem.utah.gov/grants/professional-learning-grant/

one-year or three-year grants to implement professional learning to address their needs. Additionally, as a requirement of participation, teachers involved in grant-funded professional learning activities must upload videos of themselves that will be used for self-reflection and also to receive feedback from peers.

The Professional Learning Grant Program is intended to impact three keys areas of STEM education as illustrated in Figure 1.

Figure 1. Expected Impact of the Professional Learning Grant Program



Purpose of the Evaluation

The current evaluation seeks to investigate the effectiveness of the Professional Learning Grant Program in meeting its stated objectives to impact professional learning implementation, teacher outcomes, and student outcomes.

Methods

Evaluation Questions

The purpose of the evaluation is addressed through the following questions:

1. What are the demographics of teachers and administrators in schools that receive grant funding?
2. How is professional learning implemented in schools that receive grant funding?
3. What impact does participating in professional learning have on teacher outcomes?
4. What impact does teacher participation in professional learning have on student outcomes?

Survey Design

To address the evaluation questions, a survey was designed for teachers and administrators in schools that received funding from the Professional Learning Grant Program. Teachers were asked to respond to questions about their demographics, how professional learning was implemented at their schools, their outcomes, and those of students. Administrators, similarly, were asked to report on their demographics, how professional learning was implemented at their schools, and teacher and student outcomes. Survey questions were intentionally developed to provide insight into the evaluation questions. As such, they can be grouped into four broad categories—demographics, professional learning implementation, teacher outcomes, and student outcomes. They can also be further organized into sub-categories, as illustrated in Figure 2. Both close-ended and open-ended question formats were included in the survey.

Figure 2. Survey Foci

Demographics	STEM Professional Learning Implementation	Teacher Outcomes	Student Outcomes

• School district
• School
• Role in school
• *For teachers only:*
  • Grade levels taught
  • STEM areas taught
  • Endorsments earned
	• Degree of enforcement
	• Level of teacher participation
	• Nature and quality of activities provided
	• Level of satisfaction with provisions
	• General feedback
		• Interest in STEM professional learning
		• STEM skills, knowledge, and confidence
		• STEM instructional practices
		• General instructional practices
		• Job attiudes
			• Learning outcomes in STEM
			• STEM interest
			• STEM engagement

Survey Administration

The survey was launched late-April 2020 and closed mid-June 2020. In advance of the survey launch, the Utah Education Policy Center (UEPC) shared the survey link with the STEM Action Center, who in turn, disseminated the link to teachers and administrators in schools that received grant funding. The survey garnered a total of 1,941 responses, including 1,861 from teachers and 80 from administrators.

Data Analysis

Close-ended responses were analyzed using descriptive statistics, such as frequencies and percentages and open-ended responses were analyzed using inductive coding, which is 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).

Where possible, findings covered in this report were compared to those discussed in the report from the previous year (2019). In the instances where comparisons were not made, the question was either not included in the 2019 survey or was altered from its original wording in a way that precludes comparison to prior data. To provide an example of a consequential change made to the wording of a survey question, the 2019 survey had asked administrators to specify the extent to which they agree or disagree that "my district strongly encouraged teachers to use *video-based* STEM professional learning." In the 2020 survey, the statement was modified to read as "my district strongly encouraged teachers to participate in STEM professional learning." In cases such as the example provided above, where the meaning of the question was effectively changed, a comparison between 2019 and 2020 findings was not provided.

Report Organization

This introduction constitutes the first of six sections of this report. The second section of the report, *Demographics,* provides demographic information on the teachers and administrators who participated in the survey. *Professional Learning Implementation,* the report's third section, explores the implementation of STEM professional learning in schools that participated in the grant program. The fourth section of the report, *Teacher Outcomes,* investigates the outcomes of teachers from participating in STEM professional learning. *Student Outcomes,* the fifth section of the report, address the effects of teacher participation in STEM professional learning on students. Finally, the sixth section of the report, *Conclusions and Considerations,* provides a summary of the report's findings as well as considerations for the Professional Learning Grant Program.

PART TWO:

DEMOGRAPHICS

A total of 1,941 teachers and administrators, from schools that received grant funding, participated in the survey that informed this report. Discussed in this section are key demographic information about these teachers and administrators.

Key Findings on Survey Participant Demographics

Teachers and Administrators Who Participated in the Survey Were Affiliated with A Variety of Local Education Agencies

Teachers and administrators who responded to the survey were asked to identify the local education agencies to which they belong. As Table 1 illustrates, most teachers and administrators (*n* = 1,773) were affiliated with public school districts, while a few others (*n* = 168) worked for charter schools. Of the local education agencies represented, Alpine District (*n* = 287), Davis District (*n* = 280), and Provo District (*n* = 276) accounted for the highest numbers of teacher and administrator respondents.

Table 1. Local Education Agencies and Number of Survey Respondents

LEA	Number of Survey Respondents
Alpine District	287
Box Elder District	3
Cache District	52
Davis District	280
Emery District	11
Granite District	124
Iron District	11
Jordan District	93
Juab District	4
Millard District	22
Morgan District	4
Murray District	24
Nebo District	43
Ogden City District	2
Park City District	1
Piute District	17
Provo District	276
Rich District	2
Salt Lake District	76
San Juan District	49
Sevier District	3
South Sanpete District	113
Tooele District	98
Wasatch District	9
Washington District	169
Charter or Other	168
Total	**1,941**

More Teachers Than Administrators Participated in the Survey

Survey respondents were asked to specify their roles within their schools by indicating whether they were teachers or administrators. As Figure 3 suggests, 96% of respondents identified themselves as teachers, and 4% indicated that they were administrators.

Figure 3. Teacher and Administrator Representation Among Survey Respondents

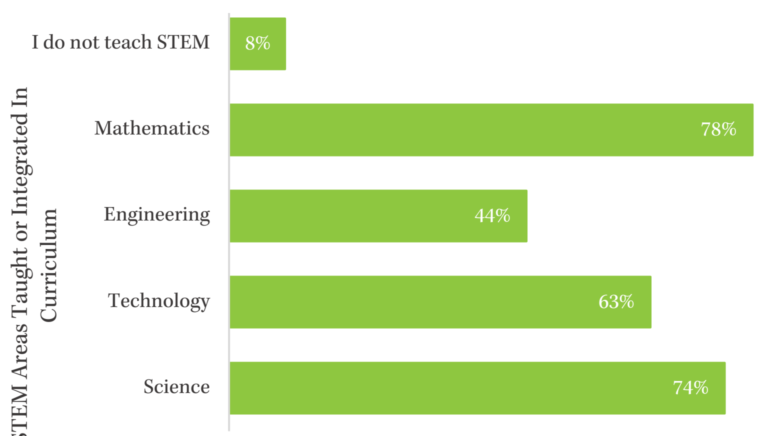
1861 Teachers (96%)
80 Administrators (4%)

Survey Respondents

Teachers Who Participated in STEM Professional Learning Teach or Integrate a Variety of STEM Areas in Their Curricula, Although Mathematics is The Most Popular STEM Area Taught or Integrated

Teachers who participated in STEM professional learning were asked to select the various STEM areas they teach or integrate into their curricula. As Figure 4 suggests, each STEM area (science, technology, engineering, and mathematics) was taught or integrated by some percent of teachers. However, mathematics (78%) was the most popular STEM area taught or integrated by teachers, followed closely by science (74%). These findings parallel those from the 2019 survey in which teachers most often indicated that they taught or integrated mathematics into their curricula (65%), followed by science (63%).

Figure 4. STEM Areas Taught by Teachers or Integrated into Curricula

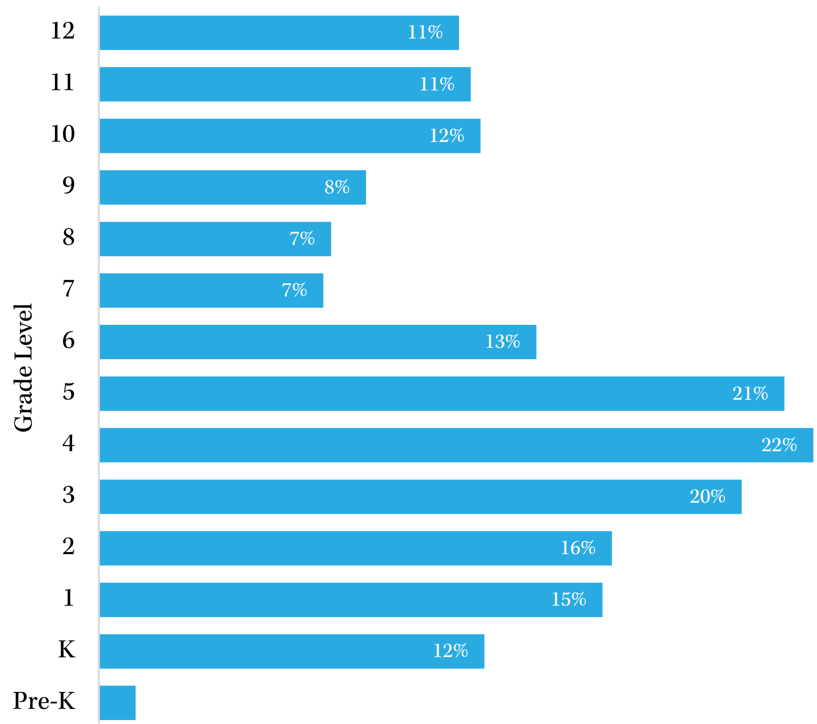


Note: Values do not sum to 100% because respondents could select more than one option. n=1839

Teachers Who Participated in STEM Professional Learning Teach Various Grade Levels, Although the 3rd, 4th, and 5th Grades Were the Most Frequently Reported Grade Levels Taught

Teachers who participated in STEM professional learning were asked to select all the grade levels they teach. As Figure 5 suggests, teachers who participated in STEM professional learning teach a variety of grade levels, spanning pre-kindergarten to grade 12, although they most often indicated teaching grades 3 (20%), 4 (22%), and 5 (21%).

Figure 5. Grade Levels Taught by Teachers

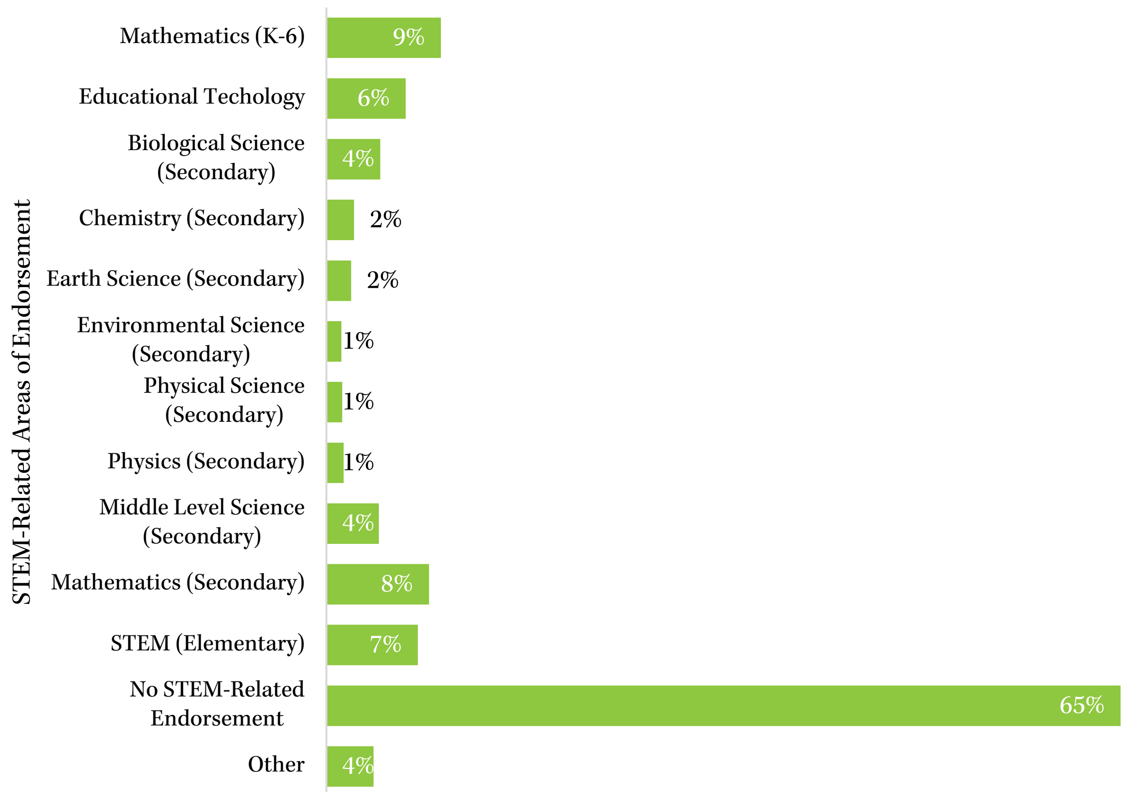


Note: Values do not sum to 100% because respondents could select more than one option. n=1680

Most Teachers Who Participated in STEM Professional Learning Do Not Have A STEM-Related Endorsement

Teachers were asked in the survey to identify the STEM-related endorsements they had earned. They were also permitted to indicate that they had either earned “other” endorsements or do not have a STEM-related endorsement. As Figure 6 illustrates, the majority of teachers (63%) indicated that they do not have a STEM-related endorsement.

Figure 6. STEM-Related Endorsements Possessed by Teachers

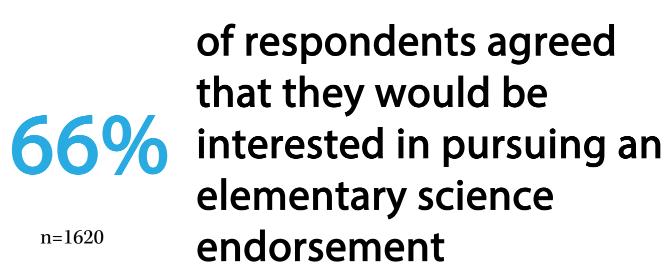


Note: Values do not sum to 100% because respondents could select more than one option. n=1680

Most Teachers Agree That They Would Be Interested in Pursuing an Elementary Science Endorsement If One Were Offered

When asked if they would be interested in pursuing an elementary science endorsement if one were offered, the majority of teachers (66%) strongly agreed or somewhat agreed that they would be interested (Figure 7). Thirty-four percent of teachers, however, somewhat disagreed or strongly disagreed that they would be interested.

Figure 7. Percent of Teachers Interested in Pursuing an Elementary Science Endorsement



PART THREE:

PROFESSIONAL LEARNING IMPLEMENTATION

This section explores the implementation of STEM professional learning in schools that participated in the grant program. More specifically, it reviews findings from the evaluation about the enforcement of STEM professional learning in participating schools, teacher participation and experiences with STEM professional learning, the nature and quality of STEM professional learning opportunities provided, teacher and administrator satisfaction with STEM professional learning, and feedback from administrators and teachers about the STEM professional learning opportunities provided and whether or not they would recommend participation to others.

Key Findings on STEM Professional Learning Enforcement

An Overwhelming Majority of Administrators and Teachers Strongly Agree or Somewhat Agree That STEM Professional Learning Was Enforced at their Schools and School Districts

Administrators were asked in the survey to specify the extent to which they agree that their school districts encouraged teachers to participate in professional learning. They were also asked to indicate the extent to which they agree that they personally encouraged teachers to participate in STEM professional learning and to video their teaching for use in peer or self-reflection. As Figure 8 suggests, between 96% to 98% of administrators, depending on the question, strongly agreed or somewhat agreed to the enforcement of STEM professional learning in their school districts and schools. Comparison of administrators' responses from the current survey and 2019 survey concerning the statement "I encouraged teachers to video themselves teaching and engage in peer or self-reflection" shows that the same percentage of administrators (96%) indicated that they somewhat agreed or strongly agreed.

Similar to administrators, teachers were asked to assess the enforcement of STEM professional learning at their schools. More specifically, they were asked to indicate the extent to which they agree that their "school or district encouraged teachers to participate in STEM professional learning" and their "school administrators supported my engagement with STEM professional learning." As Figure 9 illustrates, 96% and 97% of teachers respectively (up from 92% and 93% in 2019), strongly agreed or somewhat agreed that their "school or district encouraged participation in STEM professional learning" and that their "school administrators supported their engagement with STEM professional learning."

Figure 8. Administrator Reponses to Questions Regarding STEM Professional Learning Enforcement

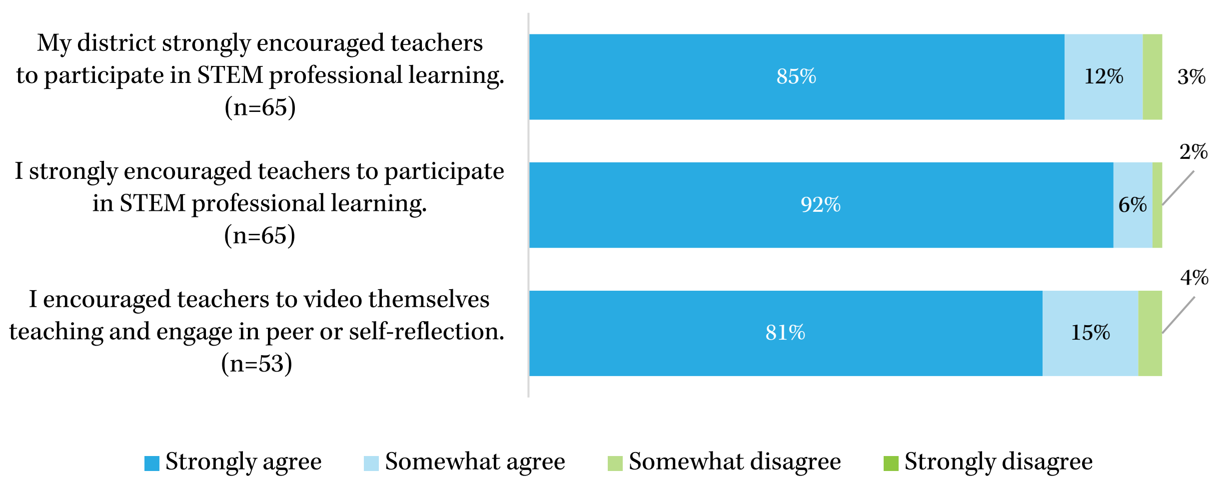
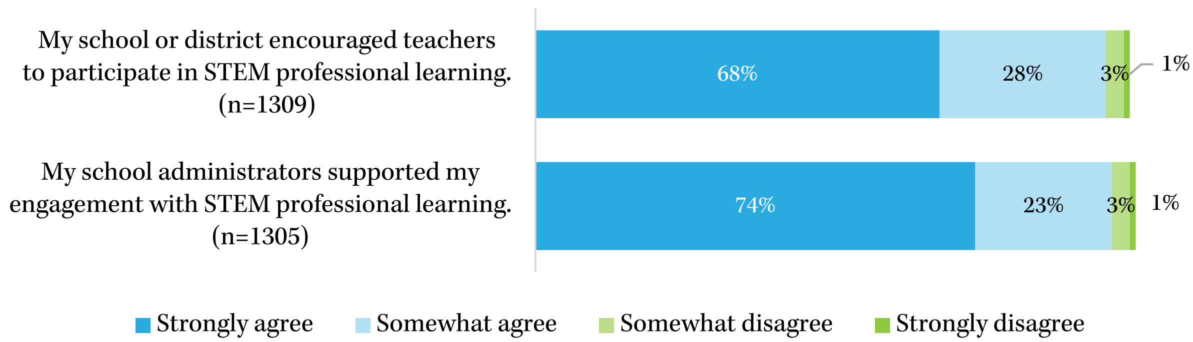


Figure 9. Teacher Reponses to Questions Regarding STEM Professional Learning Enforcement

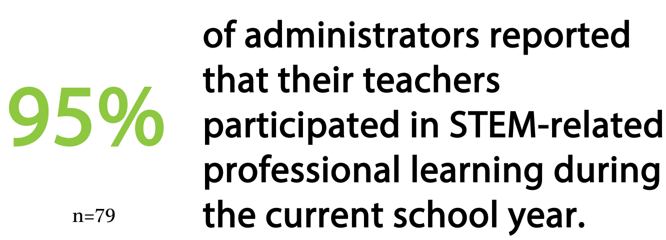


Key Findings on Teacher Participation in STEM Professional Learning

Nearly All Administrators Indicated That Teachers in their Schools Participated in STEM Professional Learning During the School Year

When asked whether teachers at their schools participated in STEM professional learning during the school year, 95% of administrators responded affirmatively (by indicating "yes," Figure 10).

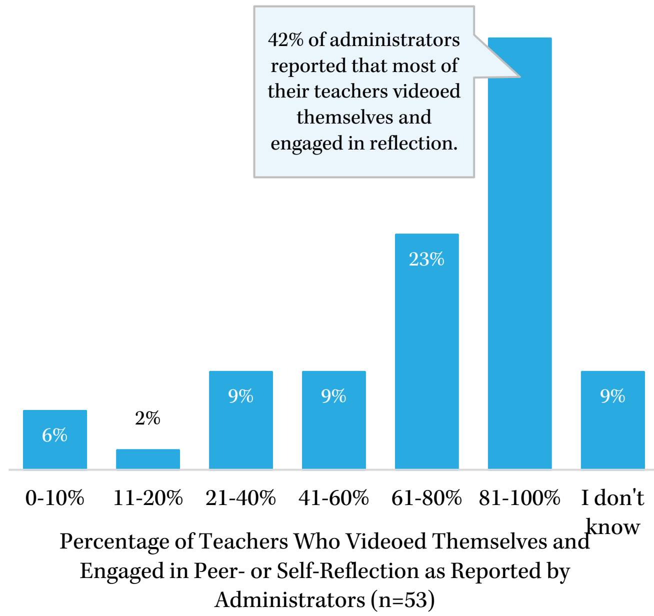
Figure 10. Percent of Administrators That Indicated "Yes" to Question Regarding Teachers' Participation in STEM Professional Learning



Administrators Were More Likely to Indicate That the Majority, If Not All, Of Their Teachers Engaged in Peer- or Self-Reflection

Administrators were asked in the survey to estimate the percentage of teachers at their school who recorded videos of themselves for use in peer- or- self-reflection. To answer this question, they were provided with the following options: "0-10%," "11-20%," "21-40%," "41-60%," "61-80%," "81-100%," and "I don't know." As Figure 11 illustrates, the highest percent of administrators (42%) indicated that 81% to 100% of teachers at their schools recorded videos of themselves for use in peer- or self-reflection.

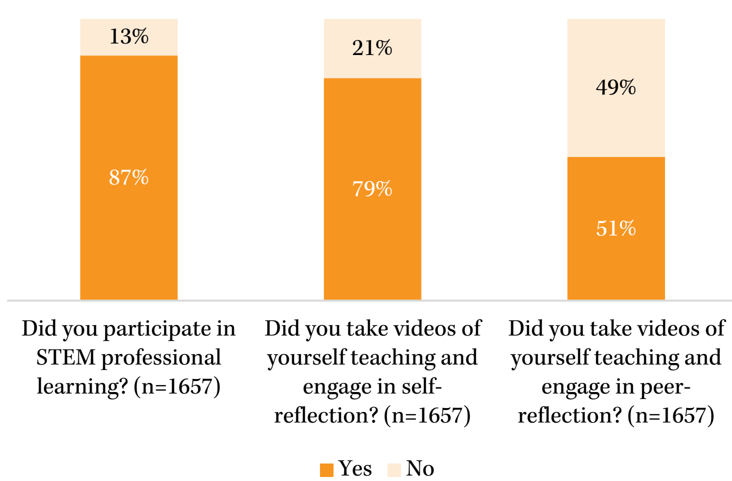
Figure 11. Administrators' Estimation of the Percent of Teachers Who Videoed Themselves and Engaged in Self- or Peer-Reflection



An Overwhelming Majority of Teachers Noted That They Participated in STEM Professional Learning. However, A Higher Majority of Them Used Videos of Their Teaching for Self- Than Peer-Reflection

Like administrators, teachers were asked a series of questions regarding their participation in STEM professional learning. More specifically, they were asked to respond with a "yes" or "no" about if they participated in STEM professional learning, if they recorded videos of themselves for use in self-reflection, and if they recorded videos of themselves for use in peer-reflection. As Figure 12 suggests, the vast majority of teachers (87%, down from 94% in 2019) who responded to the survey indicated that they participated in STEM professional learning. At the same time, however, teachers were more likely to affirm that they recorded videos of their teaching for self-reflection (79%) as compared to peer-reflection (51%).

Figure 12. Teachers' Responses to Questions About Their Participation in STEM Professional Learning



Key Findings About Teacher Experiences with STEM Professional Learning

Teachers were asked about why they do or do not intend to make videos of themselves for self- or peer-reflection. Table 2 suggests that teachers intend to continue making videos of themselves because it improves their instructional practices, promotes group learning among teachers, and encourages self-reflection. As Table 3 illustrates, teachers were unable, or do not intend, to make videos of themselves because of several issues including, but not limited to, the time-intensive nature of the practice, their discomfort with recording themselves, technological issues, and their perception that the practice is unbeneficial.

Table 2. Teachers' Reasons for Why They Intend to Continue Recording Videos of Themselves Teaching

Theme	Example Quotes
Improves Teachers' Instructional Practices	"To help myself become a better teacher." "The videos help me improve on my teaching." "Videos is one main tool I use for reflection and improvement of my teaching." "One of the best ways I have known what improvements/changes to make." "I felt like making SWIVEL videos of myself teaching was extremely beneficial. I intend to continue making them because it really helped me to see where I could improve." "The videos help me see what I need to improve when interacting with students." "It is an easy and powerful way to learn how to become a better teacher!" "I understand the value of using video to help improve my teaching."
Promotes Group Learning and Support Among Teachers	"It is a good way to focus on one area and share with my team mates." "I think it helps with self-reflection and team building." "I learn from watching myself and getting feedback from my peers." "I learn from watching myself and getting feedback from my peers." "It's a great way to see you style of teaching, and get feedback." "It helps us get ideas from one another."
Permits Self-Reflection and Improvement	"Every time I watch it back I notice something new." "I learn a lot when I make videos of myself or my peers." "I learned from watching myself and I want to improve." "I think that I learned lots from watching myself teach." "Self- or peer- reflection is an effective tool to bettering my own skills." "I do intend to make more videos because they are eye-opening and informative." "I think they really help and allow for self-reflection and peer advise." "It helps me reflect and make my teaching better." "I think this is a good way to analyze and self-reflect on teaching practices." "For self-reflection and improvement!"

Table 3. Teachers' Reasons for Why They Were Unable, or Do Not Intend, to Record Videos of Themselves Teaching

Theme	Example Quotes
Time Intensive	"It can be time consuming!" "I don't have time." "It takes a lot of time that I could spend instructing." "It is time consuming. I do not like to watch myself teach." "I am busy and don't feel I have time to video and get peer review." "I know I should, but it just takes more time and I hate watching myself." "I honestly don't have time to take and then reflect on videos."

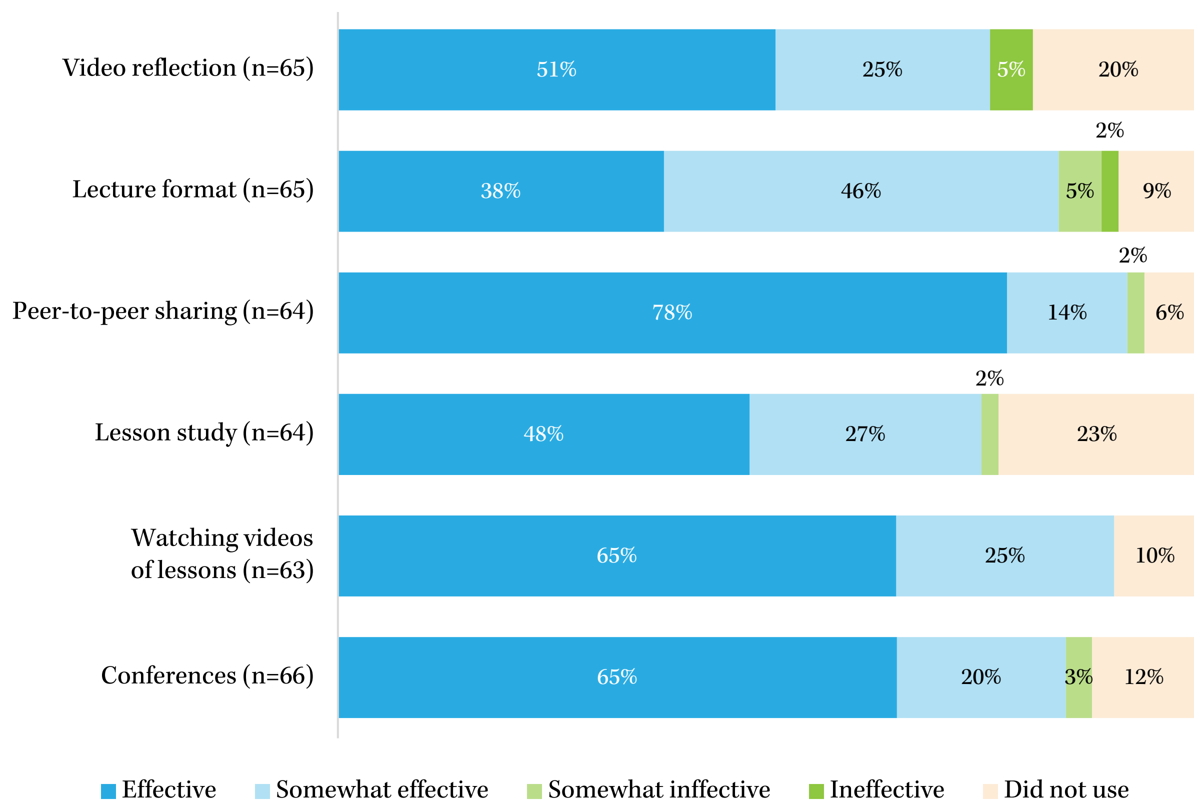
	"It is time consuming and I can see things in real time." "I feel it is a useful tool, however it takes time and preparation to do so." "I usually don't film myself because it takes time to set up."
Lack of Technology	"No technology available." "Lack of equipment to do so easily." "Not sure about equipment available." "School lacks the equipment to do so." "Not having access to recording devices." "Technology resources are unavailable to continue." "Honestly, sometimes it's hard to access the technology needed."
Unnecessary or Unbeneficial	"It was good to see what others see, but it does not change how I teach." "I can reflect on a lesson without needing to video tape myself." "I can reflect on a lesson without needing to video tape myself." "Because of the quarantine I wasn't able to." "I doubt the value of this experience." "I don't think it was helpful enough to justify the time." "I don't feel like it brought new insights into my teaching." "I really don't get much out of watching myself on video."
Competing Priorities	"There is already too much to do as a teacher." "It is one more thing to remember and do and I am too busy as it is." "Too many other things going on the classroom to take the time to do it." "It's on the to-do list, but hasn't hit the top of the priority list yet." "I need to - just trying to stay afloat of everything else I have to do."
Distracting For Students	"A little distracting to the class and I don't enjoy watching myself teach." "I think it is helpful but it is also very distracting." "It is currently not required and I do not want to disrupt my teaching." "Kids tend to act up when being videod." "It's VERY distracting to kinders." "Student distractions." "Kids act differently."
Discomfort with Practice	"I'm less at ease when a video is running." "I think it's a bit of a pain and embarrassing." "It's uncomfortable. But I see value in it, so I do it." "Videoing myself is intimidating and I don't like to do it." "I will make videos as needed. I am uncomfortable doing this." "It was too uncomfortable and I didn't really learn anything from it." "The videos can be helpful but uncomfortable for myself and others." "Videos make me look fatter than I am and I already have eating issues." "I will if it is a requirement but honestly I am not a fan of being videoed." "I don't like watching myself and don't want others videoing me either."
Overly Involved	"Too complicated." "Too much time/effort." "It is tedious." "A lot of fuss and bother."
Disrupted by School Closures Due to COVID-19	"I intended to and then COVID soft closure happened." "We are not currently teaching in our classrooms because of Covid-19." "I intended to this year, but COVID hindered me from having time to do it." "Learning methods changed with the online learning format due to the virus." "I am not working with students due to COVID-19." "Because of the quarantine I wasn't able to."

Key Findings About the Nature and Quality of STEM Professional Learning Opportunities Provided

Administrators Were More Likely to Rate Peer-to-Peer Sharing, Watching Videos of Lessons, and Conferences as "Effective" in Comparison to Other STEM Professional Learning Activities Offered

Administrators were asked to assess the effectiveness of the various STEM professional learning opportunities provided to teachers at their schools. They were also allowed to indicate that their schools "did not use" a particular professional learning format where applicable. As Figure 13 suggests, STEM professional learning activities rank in the following order based on the percent of administrators who indicated that they were "effective": peer-to-peer sharing (78%), watching videos of lessons (65%), conferences (65%), video reflection (51%), lesson study (48%), and lecture format (38%). Additionally, administrators were more likely to indicate that their schools "did not use" lesson study (23%) and video reflection (20%), in comparison to other STEM professional learning activities. Similar to the current survey's results, administrators in 2019 were most likely to rate peer-to-peer sharing (71%) and watching videos of lessons (48%) as effective. However, unlike this year's results, conferences (16%) and lesson study (16%) were the two primary formats that administrators indicated that they "did not to use" in 2019.

Figure 13. Administrators' Evaluation of the Nature and Quality of STEM Professional Learning Formats Provided

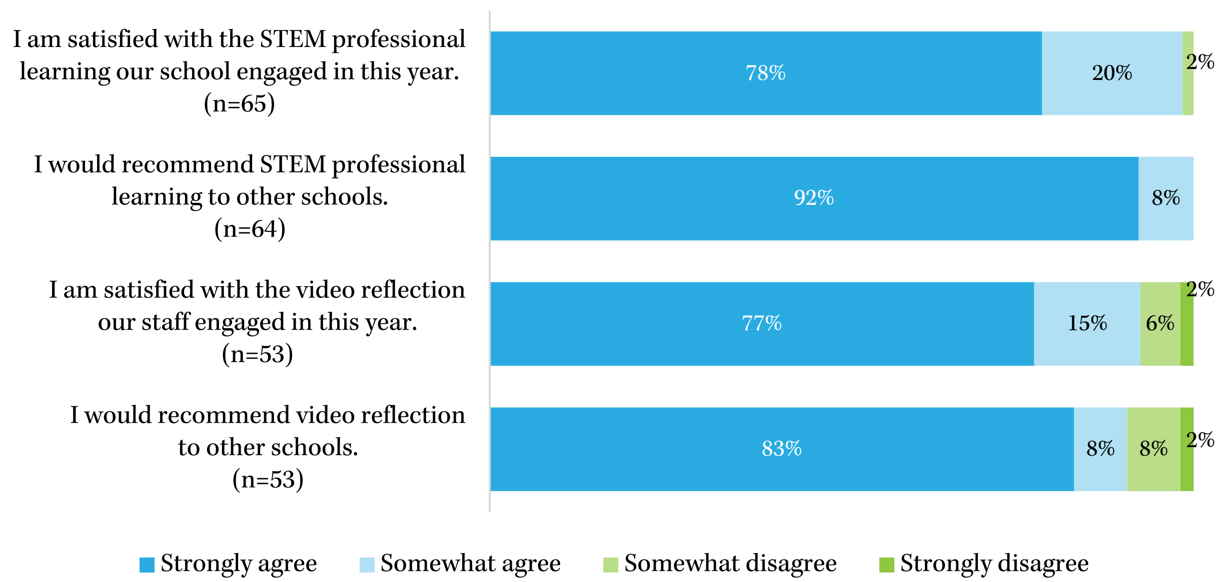


Keys Findings About Administrator and Teacher Satisfaction with STEM Professional Learning

The Vast Majority of Administrators Strongly Agree or Somewhat Agree with Indicators of Satisfaction with Professional Learning

Administrators were asked to evaluate their satisfaction with the STEM professional learning opportunities provided to teachers at their schools. To facilitate their assessment, they were asked to indicate the extent to which they agree with the following four statements: 1) “I am satisfied with the STEM professional learning our school engaged in this year;” 2) “I would recommend STEM professional learning to other schools;” 3) “I am satisfied with the video reflection our staff engaged in this year;” and 4) “I would recommend video reflection to other schools.” As Figure 14 illustrates, the overwhelming majority of administrators expressed satisfaction with the STEM professional learning provided at their schools, with 98%, 100%, 92%, and 91% of administrators respectively (compared to 95%, 97%, 85%, and 96% in 2019), indicating that they “strongly agree” or “somewhat agree” to the four aforementioned statements.

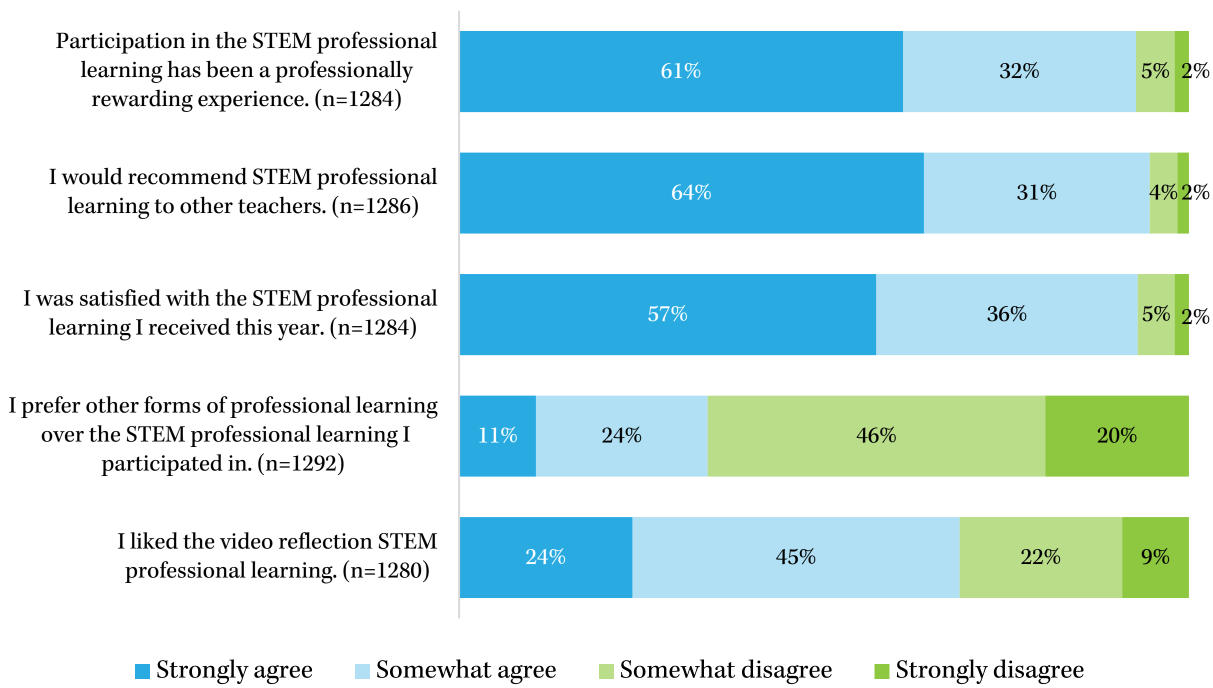
Figure 14. Administrators’ Responses to Questions About Their Satisfaction with STEM Professional Learning



The Majority of Teachers Affirm Their Satisfaction with The STEM Professional Learning Provided at Their Schools

Teachers, like administrators, were queried about their satisfaction with the STEM professional learning provided at their schools. More specifically, they were asked to specify the extent to which they agree with the following statements: 1) “Participation in the STEM professional learning has been a professionally rewarding experience;” 2) “I would recommend STEM professional learning to other teachers;” 3) “I was satisfied with the STEM professional learning I received this year;” 4) “I prefer other forms of professional learning over the STEM professional learning I participated in; and 5) I liked the video reflection STEM professional learning. As Figure 15 shows, the vast majority of teachers (93%, 95%, and 93% respectively, compared to 93%, 94% and 93% in 2019) strongly agreed or somewhat agreed to the first three indicators of satisfaction with STEM professional learning. Concerning the fourth statement, which was intentionally worded *negatively*, the majority of teachers (76%, up from 37% in 2019) strongly *disagreed* or somewhat *disagreed*; this response can be interpreted, positively, to mean that most teachers preferred the STEM professional learning they participated in over other forms of professional learning that could be provided. This finding provides additional evidence that teachers were mostly satisfied with their STEM professional learning experiences. Finally, with regard to the fifth indicator of satisfaction with STEM professional learning, the majority of teachers (69%, down from 71% in 2019) strongly agreed or somewhat agreed to liking "the video reflection format of STEM professional learning." It is important, however, to note that teachers who responded affirmatively concerning this indicator were much more likely to indicate that they "somewhat agree" as opposed to "strongly agree," which was unlike their responses to the other positively-worded indicators.

Figure 15. Teachers' Responses to Questions About Their Satisfaction with STEM Professional Learning



Administrator and Teacher Feedback About STEM Professional Learning and Whether or Not They Recommend It

Administrators and teachers were asked about whether or not they would recommend STEM professional learning to other schools. As Tables 4 and 5 illustrate, administrators and teachers held similar sentiments about why they would recommend STEM professional learning to other schools. More specifically, they discussed the benefit of STEM professional learning for increasing student knowledge and engagement, increasing teachers' content knowledge, facilitating teachers' acquisition of new skills, and improving teachers' instructional practices to name a few. As Tables 6 and 7 suggest, some administrators and teachers would not recommend STEM professional learning to other schools because they perceived it as unbeneficial, time intensive or consuming, unorganized, providing insufficient coverage of grade-level specific topics, and providing insufficient examples of detailed lesson plans and videos.

Table 4. Administrators' Reasons for Why They Would Recommend STEM Professional Learning to Other Schools

Theme	Example Quotes
Increased Student Knowledge	"Expands teacher and student knowledge for better understanding in today's advancing technological world." "This process has helped my teachers engage their students more in learning activities that increase the students' ability to retain what they have learned." "Providing opportunities for students to create videos is very educational and they learn the material at a much greater depth when they have to produce a video on an explanation of a topic."
Increased Student Engagement & Interest	"Our students love their STEM explorations and other class or grade level STEM learning activities. They look forward to these activities and even the most difficult-to-engage students are generally fully immersed in STEM learning. Students cannot have these learning opportunities without teachers having the knowledge and skills to present them in the best way to students." "The STEM profession learning is essential as curricular content for 21st century skills and to cultivate students' engagement." "We have seen students' interest levels in STEM rise significantly." "It's a great tool for teachers to improve instruction and student engagement..."
Provided General Student Benefits	"The strategies learned through the professional development series impacted both teacher ability and student progress." "It is very helpful to engage with others and learn new skills. Students will benefit from the learning."
Increased Teacher Content Knowledge	"Having grade levels meet to collaborate on curriculum, engage in lesson studies, and use video reflection not only builds teachers' STEM knowledge and practices, but builds their understanding of what effective professional development should look like, in general." "Expands teacher and student knowledge for better understanding in today's advancing technological world." "I would definitely recommend the STEM professional learning & video reflection. The teachers were excited to learn & then use their new knowledge." "It has been fantastic PD and our teachers have learned a lot."
Increased Teacher Interest in STEM	"STEM professional learning really gave our faculty a boost. It re-energized them and helped them really jump in and love teaching STEM related topics. It provided a "can do" attitude for our faculty." "The teachers left every session energized and excited."
Improved Teachers' Instructional Practices	"The STEM professional learning has had outstanding results in our school and community as more and more teachers have included STEM practices in their teaching and been willing to take more risks with their own learning." "The hands on approach and intense training was undeniably an asset for our faculty…Teachers were willing to participate and engage in practicing lessons learned." "Teachers really changed their teaching practices after reviewing their teaching videos." "STEM professional learning and video reflection have provided teachers with multiple ways to present lessons and improve instructional practices. "

Promoted Group Learning and Support Among Teachers	“Yes, I would highly recommend the STEM professional learning and video reflection to other schools. The professional learning opportunities have been cutting edge and designed for teachers to engage and collaborate throughout.” “It is very helpful to engage with others and learn new skills. Students will benefit from the learning.” “This year’s professional development was very useful. Teachers enjoyed working with their grade level teams to create something very authentic. They enjoyed sharing that with other grade levels of teachers and students. I feel that this was a wonderful addition to our schools professional development.”
Provided Hands-On Training and Other Resources	‘The hands on approach and intense training was undeniably an asset for our faculty.” “We really appreciated the material and strategies that were presented in our professional development sessions and the opportunity to use the strategies we learned.” “It is a great way to learn about yourself, get new ideas, learn from others, and learn how to improve.” “It creates a venue that allows self-reflection and professional interaction and feedback receiving.” “When video reflection is done in a team setting as we encourage with grade-level PLCs, our teams assist each other to start where they are, and then rise together as more effective professionals.”

Table 5. Teachers’ Reasons for Why They Would Recommend STEM Professional Learning to Other Schools

Theme	**Example Quotes**
Increased Student Engagement	“STEM has brought my class to a new level of engagement.” “I have seen that STEM learning is highly engaging to the students.” “Better understanding and more student engagement.”
Increased Teacher Content Knowledge	“It helps me understand my content area better.” “It really broke down the concepts and standards.” “I learned a lot through the professional learning.” “The videos are good at explaining technology to teachers.” “I am new to science so I got a lot of good information to help me.” “It makes teachers more knowledgeable about the subjects.” “I have a greater understanding of STEM and how to implement it in my classroom.”
Facilitated Teachers’ Acquisition of New Skills	“I love how it develops problem solving skills.” “I would recommend. It’s always good to grow your skills.” “I was able to learn new skills to help me become a better teacher.” “I have new ideas to use in the classroom.” “I love the ideas and strategies generated in the STEM professional learning.”
Improved Teachers’ Instructional Practices	“It has helped me improve my teaching skills for STEM.” “There were a lot of simple practices to add to daily instruction.” “I like getting ideas on how to improve my practice.” “I learned a lot that I could directly integrate into my teaching.” “It's a great refresher on best practices to use in the classroom.” “The professional learning helps me be a better teacher.” “Recording yourself can help improve your practice.” “It will enhance lesson planning and experiences for the kids!” “It helped me create lessons that were fun and meaningful to me and my students.”
Increased Teachers’ Confidence	“It helped get me more confident in teaching science.” “It really helped my confidence as a teacher in these areas!” “I feel more confident to teach the new standards.” “I have more confidence in teaching the new SEED Science Standards.” “I feel more confident in what I am doing so my job satisfaction increases.”

	"It helped me become more confident in what I am supposed to be teaching."
Promoted Group Learning and Support Among Teachers	"It's always helpful to hear from other teachers." "It was great to get together with other teachers to learn." "It is awesome to collaborate with other teachers and get new ideas." "Great to meet and collaborate with other teachers." "Collaborating with other STEM teachers is inspiring and motivating."
Provided Needed Training and Other Resources	"It provided hands-on training and collaboration." "It gave me a lot of good ideas and resources." "Learned new tools to use and different ways to teach." "I like the resources that were presented." "More tools to utilize."
Effective Facilitators, Activities, and Presentations	"Excellent, knowledgeable instructors." "The presentations I saw were well thought out and interesting." "The content and professor was amazing." "I like the way Jaimie structured the class." "Kris Cunningham is an incredible mentor."
Increased Interest in Professional Development	"I just hope it continues to be available." "More please more time, more hands on etc." "Keep providing it in as many ways possible." "Keep this going for teachers in the same way." "MORE PLEASE!" "Let's do it more!"

Table 6. Administrators' Reasons for Why They Would Not Recommend STEM Professional Learning to Other Schools

Theme	Example Quotes
Ineffective for Improving Teaching Practice	"Teachers did not appreciate the filming component and we experienced little effectiveness from the filming sessions." "The video reflection was not as universally useful…Those 1 or 2 videos that some teachers made were useful, but did not create a great context for professional learning."
Need for More Detailed Lesson Plans and Videos	"I would have liked to see lesson plans with a very clear framework and to have videos of someone actually teaching the lessons."
Slow and Repetitive	"The only negative feedback was that it was slow moving at time and repeated itself during the sessions."
Ineffective Organization	"It is hard when everyone is at different levels of comfort of STEM. "
Time Intensive	"Video reflection works really well but it takes time to implement effectively."
Need for Additional Professional Development	"Need additional PD for teachers."

Table 7. Teachers' Reasons for Why They Would Not Recommend STEM Professional Learning to Other Schools

Theme	Example Quotes
Unbeneficial	"Waste of time. No benefit. Still confused." "It took time away from teaching to film myself and wasn't worth the stress." "Not all the sessions were useful."
Overwhelming	"It's a great deal of change. And there is always too much change at once."

	“It was overwhelming.” “Fun and interesting ideas, but very overwhelming.”
Time Consuming	“Sometimes I felt that they were too long to hold my attention.” “It takes me out of my classroom too much.” “The classes took too much time away from my classroom.” “I felt a decrease in interest because the time commitment was overwhelming.”
Unorganized Sessions	“The first session was a bit unorganized. “ “Taught in a very confusing and incohesive way.”
Insufficient Hands-On Professional Development	“Just hoping to be hands on next time.” “More hands on lessons that we can take back.” “More hands on manipulatives related to engineering.”
Need for Grade-Level Specific Professional Development	“It does not target the curriculum in the grade I teach.” “More 1/2 -day Kindergarten focus, please.” “More organized by grades would be great.”
Unhelpful Facilitators	“The trainers were not very helpful or interesting.”

PART FOUR:

TEACHER OUTCOMES

This section explores teachers' outcomes from participating in STEM professional learning. More specifically, it addresses the impact of STEM professional learning on teachers' interest in professional learning, teachers' skills, knowledge, and confidence to teach STEM content, teachers' STEM instructional practices, teachers' general instructional practices, and teachers' job attitudes.

Key Findings on Teachers' Interest in Professional Learning

A Majority of Administrators and Teachers Agree That Participating in STEM Professional Increased Teachers' Interest in Professional Learning

Administrators were asked in the survey to specify the extent to which they agree or disagree that "teachers' interest in professional learning increased after STEM professional learning" (Figure 16). In turn, teachers were themselves asked to self-evaluate their interest in professional learning post-participation in STEM professional learning. More specifically, they were asked to indicate the extent to which their interest in professional increased or decreased following their participation in STEM professional learning (Figure 17). Additionally, they were asked to specify the extent to which they agree or disagree that they engage in, or intend to engage in, professional learning activities because of their participation in STEM professional learning (Figure 18). As Figure 16 illustrates, the vast majority of administrators (97%, down from 99% in 2019) "strongly agree" or "somewhat agree" that participating in STEM professional learning increased teachers' interest in professional learning. Teachers' views were a little less positive than those of administrators, with a lower majority of them (67%, down from 71% in 2019) indicating that participation in STEM professional learning "greatly increased" or "somewhat increased" their interest in professional learning (Figure 17). Finally, most teachers, as illustrated in Figure 18, "strongly agree" or "somewhat agree" that they engage in, or intend to engage in, professional learning because of their participation in STEM professional learning; concerning teachers' responses to this group of questions, however, the highest majority of teachers (93%, up from 57% in 2019) strongly agreed or somewhat agreed that they "intend to take videos of myself for peer-or self-reflection" and the lowest majority (56%), down from 92% in 2019) affirmed that they have "engaged in more self-reflection of my teaching."

Figure 16. Percent of Administrators Who Agreed That Teachers' Interest in Professional Learning Increased After Participation in STEM Professional Learning

97% **of administrators agreed that their teachers' interest in professional learning increased after STEM professional learning.**

Figure 17. Teachers' Assessment of their Interest in Professional Learning After Participating in STEM Professional Learning

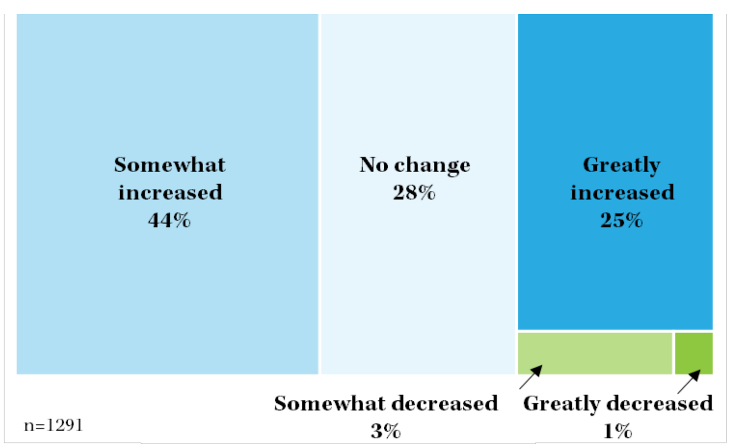
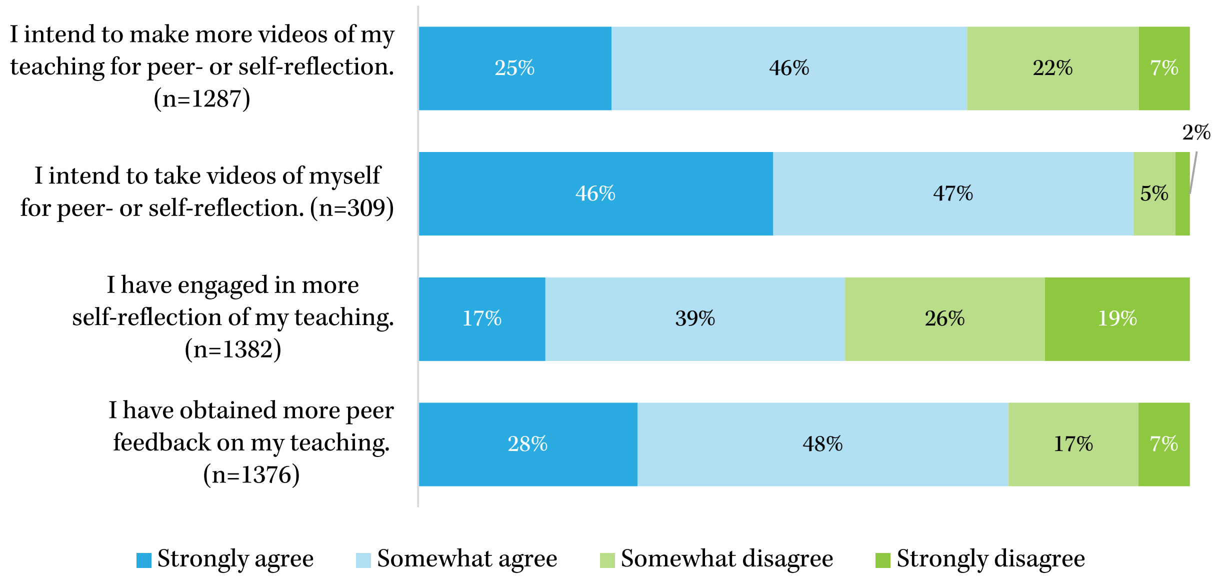


Figure 18. Teachers' Responses to Additional Questions About Their Interest in STEM Professional Learning



Key Findings on Teachers' STEM Skills, Knowledge, and Confidence

Most Administrators and Teachers Agree That Participating in STEM Professional Learning Increased Teachers Skills, Knowledge, and Confidence to Teach STEM Content

Administrators were asked in the survey to indicate the extent to which they agree or disagree that STEM professional learning was effective in "developing teachers' skills in STEM," "increasing teachers' STEM content knowledge," and "developing teachers' confidence to teach STEM content" (Figure 19). Teachers were also posed the very same set of questions as illustrated in Figure 20. Additionally, they were asked to evaluate how confident they were in teaching and creating STEM lessons before and after participating in STEM professional learning (Figure 21). As Figure 19 illustrates, 99%, 97%, and 100% of administrators respectively (compared to 100%, 92%, and 93% in 2019), "strongly agree" or "somewhat agree" that STEM professional learning was effective in develop teachers' skills in STEM, content knowledge, and confidence to teach STEM content. Teachers also expressed similarly positive sentiments with 95%, 92%, and 91% (up from 93%, 89%, and 90% in 2019) indicating that they "strongly agree" or "somewhat agree" that STEM professional learning was effective at increasing their skills in STEM, content knowledge, and confidence to teach STEM content (Figure 20). Concerning teachers' confidence to teach and create STEM lessons before and after participating in STEM professional learning, Figure 21 shows that teachers were much more likely to indicate that they were "strongly confident" or "somewhat confident" to "teach elementary math standards," "teach elementary science standards," "teach STEM lessons," and "create STEM lessons" *after* participating in STEM professional learning; this was also the case in 2019. It is important to note, however, that teachers were least likely to indicate that they were confident with creating STEM lessons both before (51%) and after (88%) participating in STEM professional learning.

Figure 19. Administrators' Responses to Questions About the Impact of STEM Professional Learning on Teachers' STEM Skills, Content Knowledge, and Confidence

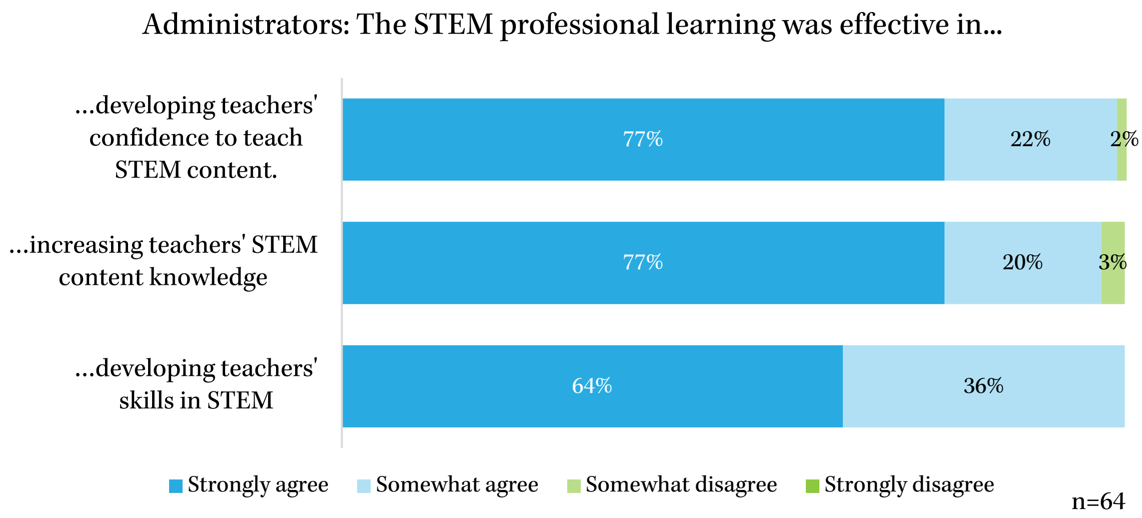


Figure 20. Teachers' Responses to Questions About the Impact of STEM Professional Learning on Their STEM Skills, Content Knowledge, and Confidence

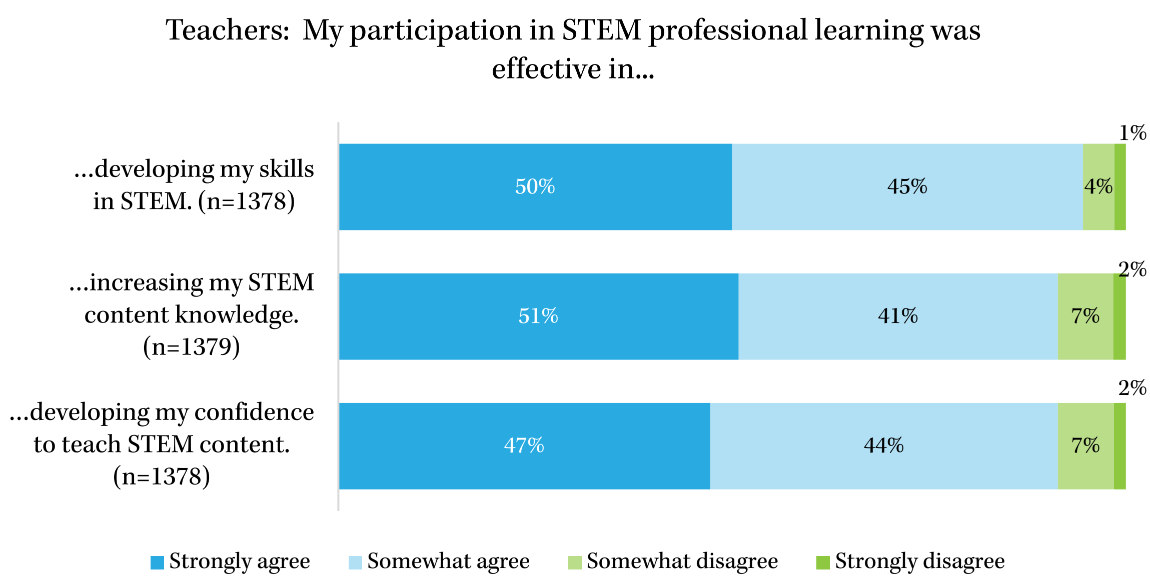
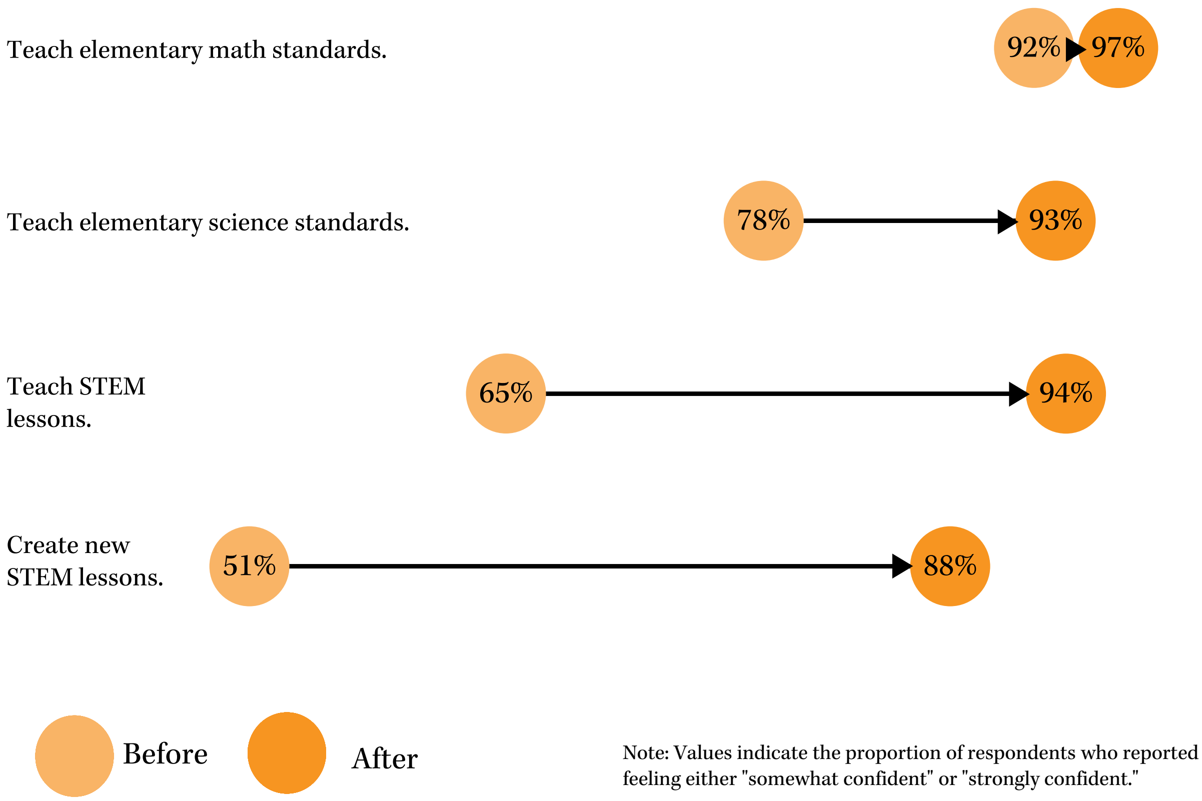


Figure 21. Teachers' Responses to Additional Questions About Their Skills Before and After Participating in STEM Professional Learning



Key Findings on Teachers' STEM Instructional Practices

A Vast Majority of Administrators and Teachers Agree That Participating in STEM Professional Learning Improved Teachers' STEM Instructional Practices

Questions were included in the survey to understand the impact of STEM professional learning on teachers' STEM instructional practices. The first of these questions, posed to administrators, sought to understand the extent to which they agree or disagree that STEM professional learning was effective at "advancing teachers' STEM instructional practice" (Figure 22). Teachers, in turn, were also asked to specify the extent to which they agree or disagree that STEM professional was effective at increasing their ability to integrate the different STEM areas (science, technology, engineering, and mathematics) in their instruction (Figure 23). Additionally, they were asked to indicate the extent to which they agree or disagree that they made important changes to their STEM curricula, lesson plans, and instructional practices following participation in STEM professional learning (Figure 24). As Figure 22 illustrates, 100% of administrators strongly agreed or somewhat agreed that STEM professional learning was effective at advancing teachers' STEM instructional practice. As shown in Figure 23, most teachers strongly agreed or somewhat agreed that STEM professional learning increased their ability to integrate different STEM areas in their instruction, although they held the most positive sentiments concerning their ability to integrate technology in their instruction (86%, up from 85% in 2019), followed by mathematics (84%, up from 82% in 2019), science (83%, up from 75% in 2019), and lastly, engineering (74%, up from 60% in 2019). Finally, between 87% and 94% of teachers (compared to 87% to 93% in 2019), depending on the indicator, strongly agreed or somewhat agreed that they made important changes to their STEM curricula, lesson plans, and instructional practices following their participation in STEM professional learning (Figure 24).

Figure 22. Percent of Administrators That Agree That STEM Professional Learning Was Effective in Advancing Teachers' STEM Instructional Practice

100% **of administrators agreed that the STEM professional learning was effective in advancing teachers' STEM instructional practice.**

Figure 23. Teachers' Responses About the Impact of STEM Professional Learning on Their Ability to Integrate the Various STEM Areas in Their Instruction

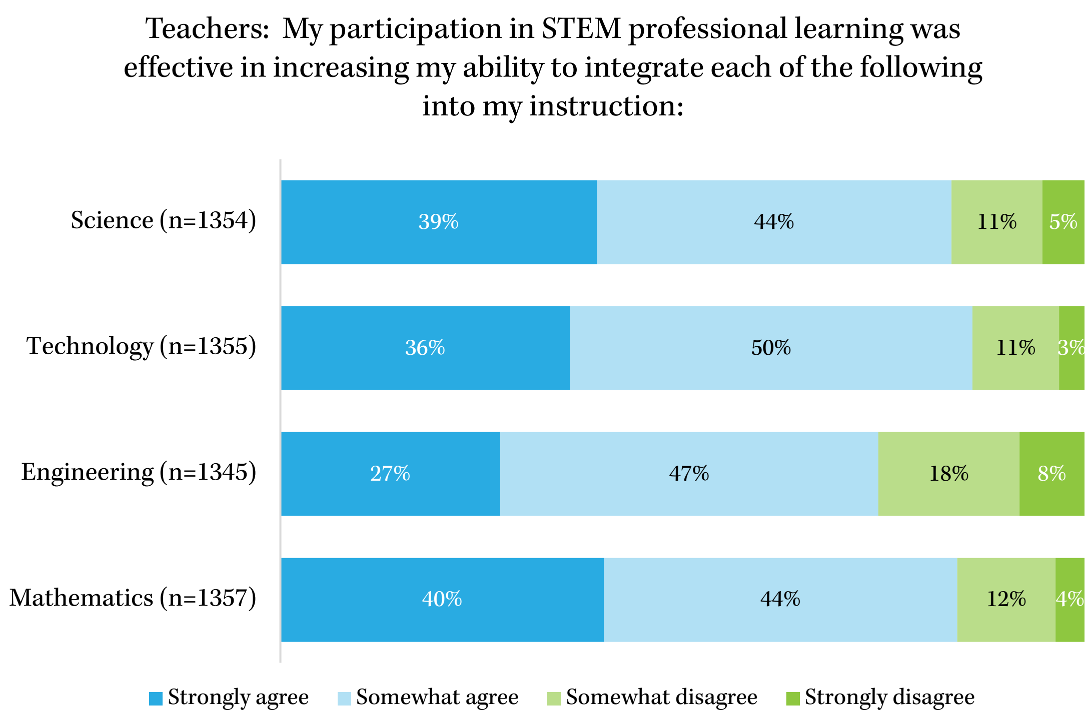
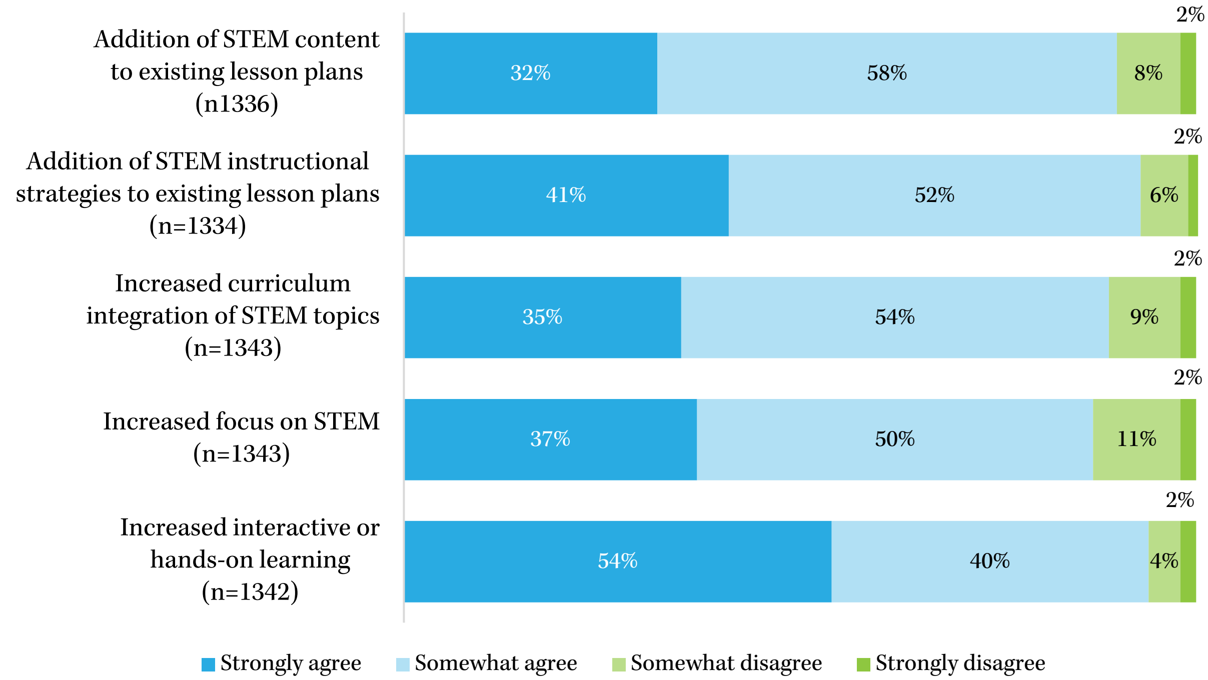


Figure 24. Teachers' Responses to Questions About the Impact of STEM Professional Learning on their STEM Instructional Practices



Key Findings on Teachers' General Instructional Practices

An Overwhelming Majority of Administrators and Teachers Agree That Participating in STEM Professional Learning Improved Teachers' General Instructional Practices

In addition to examining the impact of STEM professional learning on teachers' *STEM* instructional practices, the survey administered to administrators and teachers also sought to understand the impact of STEM professional learning on teachers' *general* instructional practices. For one, administrators were asked in the survey to indicate the extent to which they agree or disagree that they "observed a transfer of STEM professional learning to classroom practice" (Figure 25). Teachers, on the other hand, were asked to indicate the extent to which they agree or disagree that they made a variety of changes to teaching and learning in their classrooms following participation in STEM professional learning (Figure 26). Additionally, they were asked about the impact that STEM professional learning had on their ability to facilitate students' acquisition of important skills (Figure 27) and their ability to use effective and equitable pedagogical approaches in their instruction (Figure 28). As Figure 25 illustrates, 100% of administrators strongly agreed or somewhat agreed that they "observed a transfer of STEM professional learning to classroom practice." As shown in Figure 26, between 79% to 94% of teachers (compared to 81% to 94% in 2019), in response to the first six statements, strongly agreed or somewhat agreed that they made important changes to teaching and learning in their classrooms following participation in STEM professional learning. The seventh and last statement in Figure 26, "I've been too busy with professional learning to implement much in my classroom," was intentionally worded *negatively*; findings concerning this indicator can be interpreted to mean that most teachers (69%, down from 71% in 2019) have implemented new practices in their classrooms since participating in STEM professional learning. Ninety-two percent, 95%, 94%, 94%, and 89% of teachers respectively (compared to 91%, 95%, 93%, 93%, and 87% in 2019) strongly agreed or somewhat agreed that STEM professional learning improved their ability to teach students to "communicate effectively," "think critically," "think creatively," "collaborate," and "be self-directed learners" (Figure 27). Finally, between 89% and 95% of teachers (compared to 90% to 95% in 2019), contingent on the indicator, strongly agreed or somewhat agreed that STEM professional learning improved their ability to utilize effective and equitable pedagogical practices in their instruction (Figure 28).

Figure 25. Percent of Administrators That Agree That STEM Professional Learning Influenced Teachers' Classroom Practice

100% **of administrators agreed that they were able to observe transfer of STEM professional learning to classroom practice.**

Figure 26. Teachers' Responses to Questions About the Impact of STEM Professional Learning on their General Instructional Practices

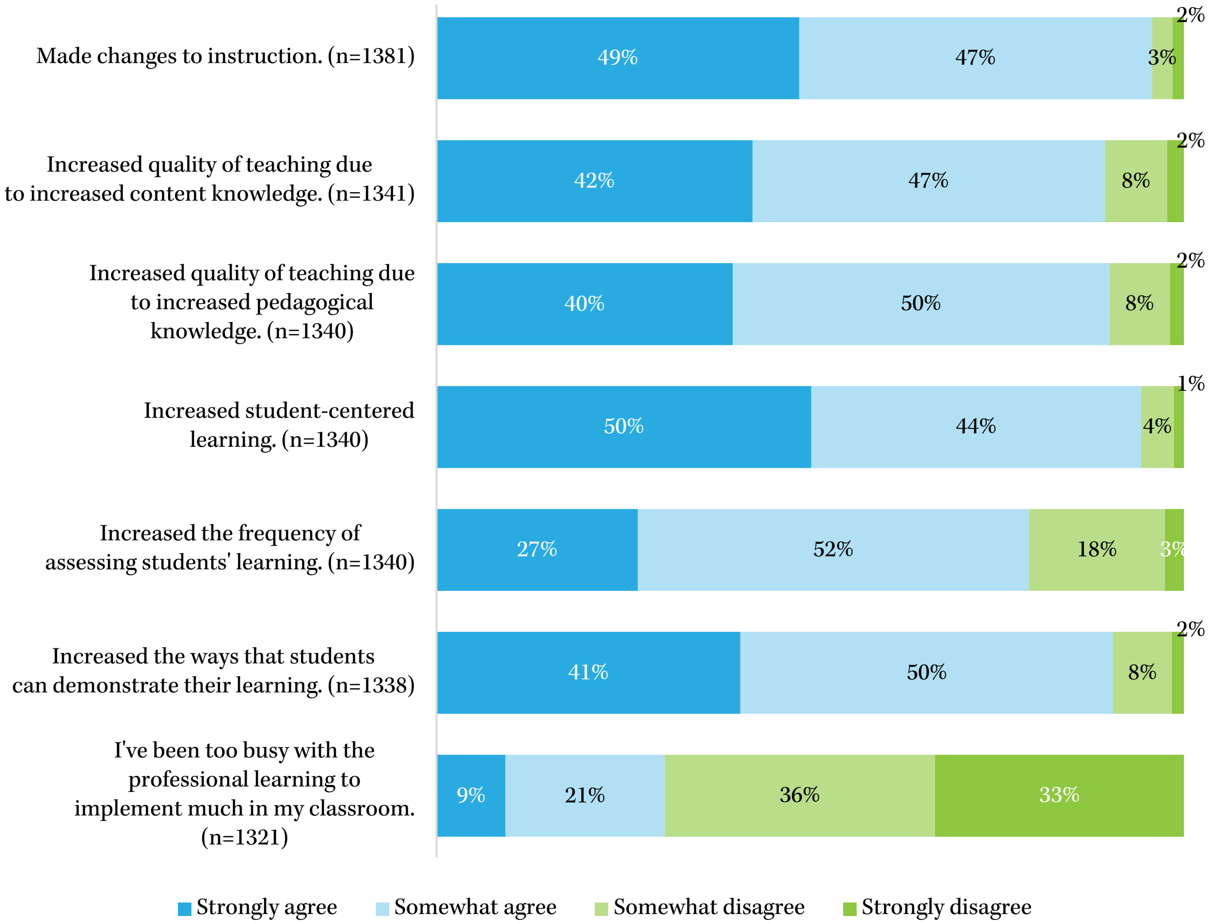


Figure 27. Teachers' Responses About the Impact of STEM Professional Learning on their Ability to Facilitate Students' Acquisition of Important Skills

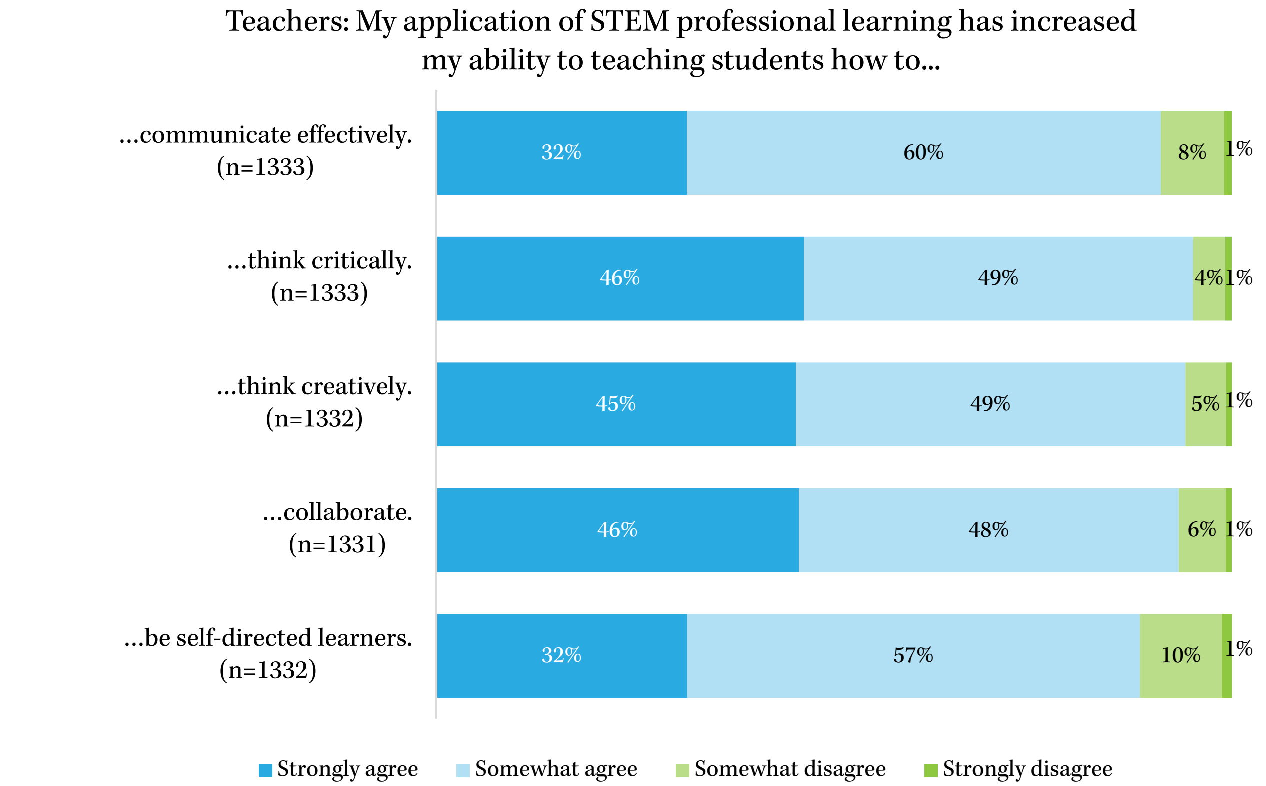
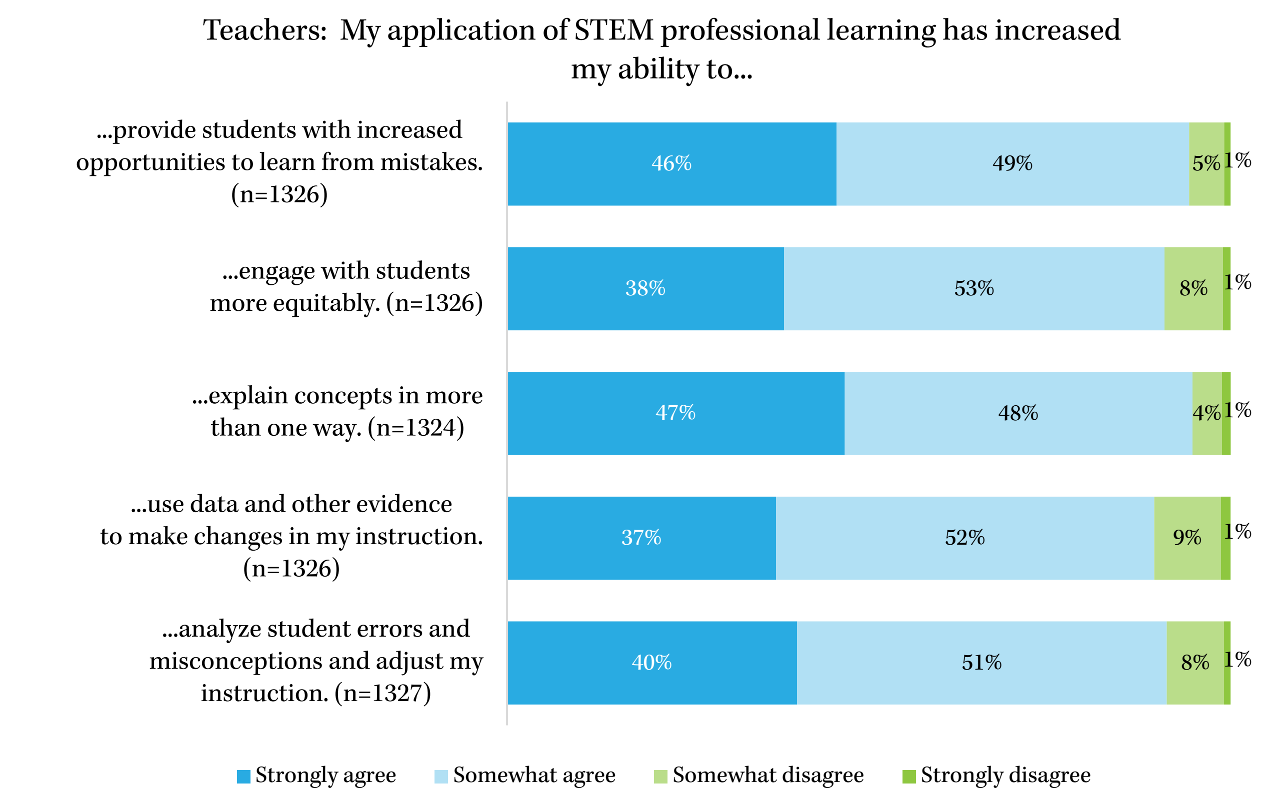


Figure 28. Teachers' Responses to Questions About the Impact of STEM Professional Learning on their Ability to Utilize Effective and Equitable Pedagogical Practices



Key Findings on Teachers' Job Attitudes

Most Administrators and Teachers Agree That Participating in STEM Professional Learning Improved Teachers' Job Attitudes

To gauge the impact of STEM professional learning on teachers' job attitudes, administrators were asked to indicate the extent to which they agree or disagree that STEM professional learning was effective at "increasing teacher job satisfaction" and "increasing teacher retention" (Figure 29). Relatedly, teachers were asked to specify the extent to which their "job satisfaction" and "commitment to teaching" increased or decreased following participation in STEM professional learning (Figure 30). As Figure 29 depicts, 87% and 90% of administrators, respectively, strongly agreed or somewhat agreed that STEM professional learning was effective at "increasing teacher job satisfaction" and "increasing teacher retention." As shown in Figure 30, 61% and 61% of teachers respectively (down from 62% and 63% in 2019), indicated that STEM professional learning "greatly increased" or "somewhat increased" their "job satisfaction" and "commitment to being a teacher."

Figure 29. Administrators' Responses to Questions About the Impact of STEM Professional Learning on Teachers' Job Attitudes

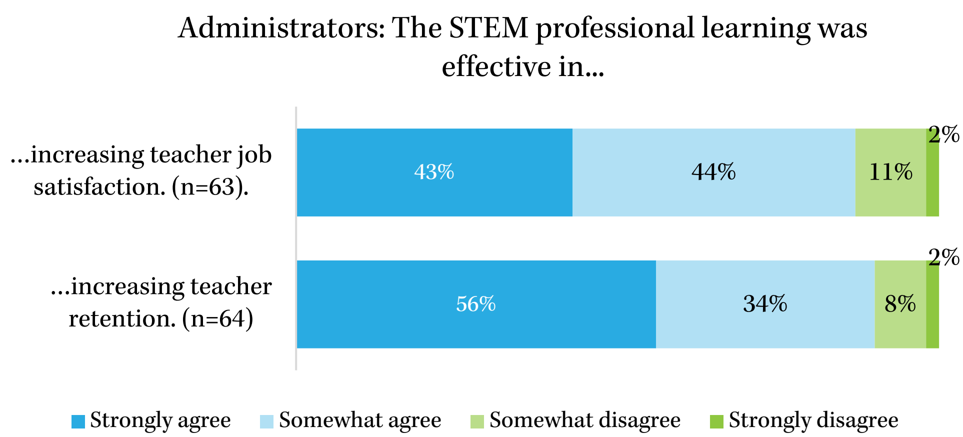


Figure 30. Teachers' Responses to Questions About the Impact of STEM Professional Learning on Their Job Attitudes

As a result of participating in the STEM professional learning, respondents reported that their job satisfaction...

20% greatly increased

41% somewhat increased

and that their commitment to teaching...

23% greatly increased

38% somewhat increased

PART FIVE:

STUDENT OUTCOMES

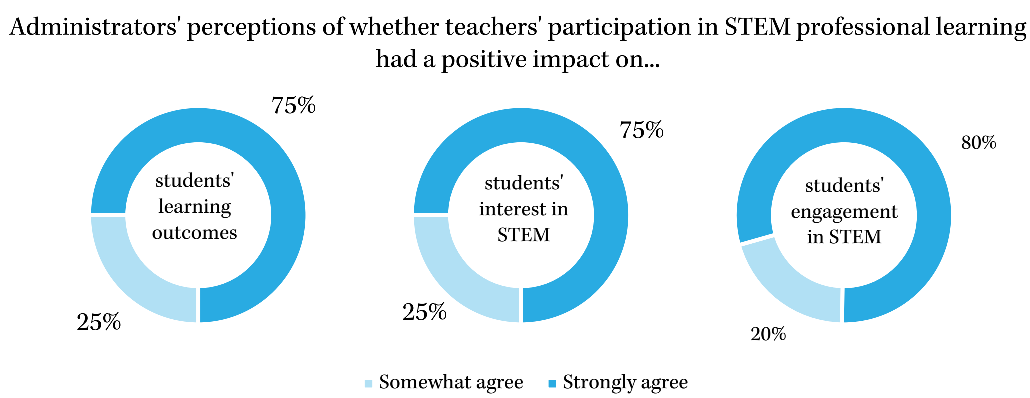
This section examines the impact that teachers' participation in STEM professional learning had on students' outcomes. The three student outcomes assessed include students' learning outcomes in STEM, interest in STEM, and engagement in STEM.

Key Findings on Student Outcomes

All Administrators Strongly Agreed or Somewhat Agreed That Teachers' Participation in STEM Professional Learning Positively Impacted Students' Outcomes

Administrators were asked to specify the extent to which they agree that teachers' participation in STEM professional learning had a positive impact on students' "learning outcomes in STEM," "interest in STEM," and "engagement in STEM." To provide their assessment, they were presented with a 4-item Likert scale that included the categories "strongly agree," "somewhat agree," "disagree," and "strongly disagree." As Figure 31 suggests, 100% of administrators strongly agreed or somewhat agreed that teachers' participation in STEM professional learning had a positive impact on the three aforementioned student outcomes. Equally importantly, Figure 31 also suggests that administrators' held very firm/conclusive stances, with the vast majority indicating that they "strongly agree" as opposed to "somewhat agree." In 2019, however, lower percents of administrators, 99%, 91% and 92% respectively, strongly or somewhat agreed that teachers' participation in STEM professional learning had a positive impact on students' "learning outcomes in STEM," "interest in STEM," and "engagement in STEM."

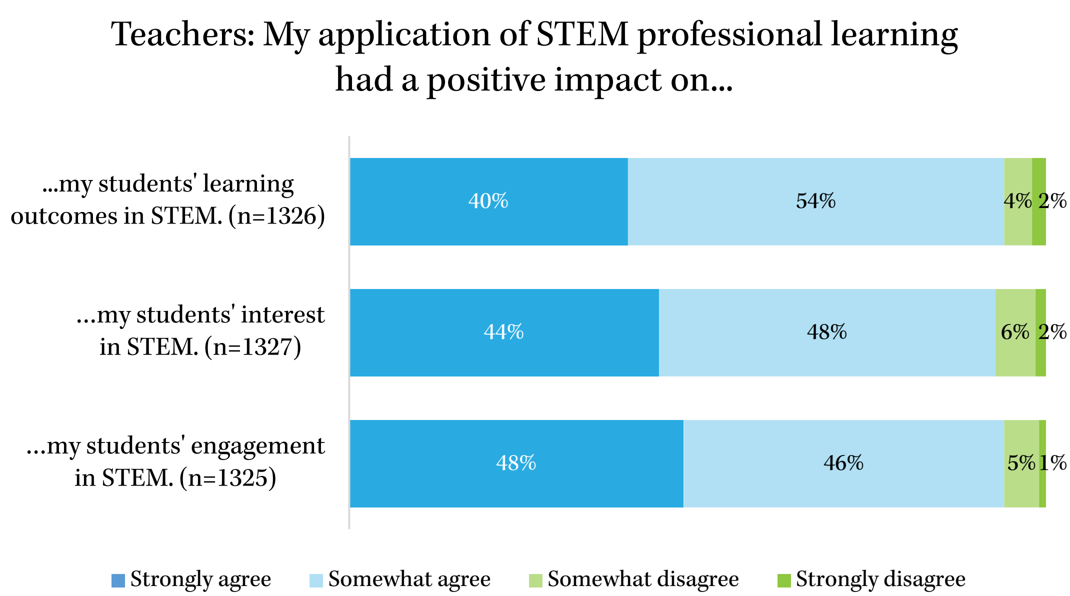
Figure 31. Administrators' Responses to Questions About the Impact of STEM Professional Learning on Student Outcomes in STEM



Most Teachers Affirmed That Their Participation in STEM Professional Learning Positively Impacted Students' Outcomes. However, Their Responses Were Less Conclusive Than Those of Administrators

Teachers were asked to self-evaluate the impact that their participation in STEM professional learning had on students' "learning outcomes in STEM," "interest in STEM," and "engagement in STEM." While the vast majority of teachers—94%, 92%, and 94% respectively—strongly agreed or somewhat agreed that their participation in STEM professional learning positively impacted students' "learning outcomes in STEM," "interest in STEM," and "engagement in STEM" (Figure 32), their responses were less positive than those of administrators, 100% of whom agreed that teachers' participation in STEM professional learning positively impacted students' outcomes (Figure 31). Additionally, teachers' affirmative responses about the impact of STEM professional learning on students' outcomes were less firm/conclusive than those of administrators, with teachers being more likely than administrators to indicate that they "somewhat agree" than "strongly agree" (see Figures 31 and 32). In 2019, similar percents of teachers, 94%, 91% and 93% respectively, strongly or somewhat agreed that teachers' participation in STEM professional learning had a positive impact on students' "learning outcomes in STEM," "interest in STEM," and "engagement in STEM."

Figure 32. Teachers' Responses to Questions About the Impact of STEM Professional Learning on Student Outcomes in STEM



PART SIX:

CONCLUSION AND CONSIDERATIONS

This report evaluated the effectiveness of the Professional Learning Grant Program in meeting its stated objectives to impact STEM professional learning implementation as well as teacher and student outcomes in STEM. Drawing on survey data, the report addressed the demographics of teachers and administrators in schools that received funding from the grant program. Next, it examined a myriad of issues related to the implementation of STEM professional learning in participating schools, including the degree of enforcement of STEM professional learning, level of teacher participation, nature and quality of activities provided, level of administrator and teacher satisfaction with provisions, and actionable feedback for the grant program. Third, it explored the impact that participating in STEM professional learning had on teacher outcomes. Outcomes of concern for teachers included their interest in STEM professional learning, STEM skills, knowledge, and confidence, STEM instructional practices, general instructional practices, and job attitudes. Finally, the report examined the influence that teacher participation in STEM professional learning had on student outcomes in STEM. The student outcomes of interest included their learning outcomes, interest, and engagement in STEM. This section provides an overview of the report's main findings in relation to the aforementioned topics. It also provides considerations for the Professional Learning Grant Program that are informed by the evaluation's findings, relevant research, and program objectives.

Summary of Findings

Demographics

Findings reveal that a variety of local education agencies, including 25 public school districts, received funding from the grant program. As it concerns the demographics of survey respondents, the vast majority were teachers and a small percent were administrators. Teachers who participated in STEM professional learning primarily taught elementary grades, particularly grades 3, 4, and 5. Additionally, they tended to teach or integrate mathematics into their curricula more frequently than they did the other three STEM areas—science, technology, and engineering. With regards to their possession of STEM-related endorsements, a majority of teachers indicated that they did *not* have a STEM-related endorsement. However, most expressed interest in pursuing an elementary science endorsement if one were offered.

Professional Learning Implementation

The current evaluation also investigated the implementation of STEM professional learning in participating schools, particularly with respect to the degree to which it was enforced, the level of teacher participation, the nature and quality of activities provided, the experiences of teachers, and feedback from teachers and administrators about whether they would recommend participation to other schools. Findings from administrators and teachers suggest that STEM professional learning was highly enforced at participating schools and most teachers participated in STEM professional learning. Concerning the nature and quality of STEM professional learning activities provided, a variety of activities were provided, however, administrators rated peer-to-peer sharing as more effective than the others provided. Concerning teachers' experiences with recoding videos of themselves for self- or peer-reflection, teachers found the practice to be beneficial for improving their instructional practices, promoting group learning and support among teachers, and encouraging self-reflection and improvement. At the same time, an important number of teachers discussed negative experiences with the practice suggesting, for instance, that it was time-intensive, overly involved, discomforting, distracting to students, and unbeneficial for improving their teaching practice. With regard to whether or not teachers and administrators who recommend STEM professional learning to other schools, teachers and administrators tended to hold similar sentiments. Among teachers and administrators who would recommend STEM professional learning to other schools, they indicated that they would do so because of the benefit it provided for increasing student knowledge, increasing student engagement/interest in STEM, increasing teacher knowledge, improving teachers' instructional practice, providing hands-on training and other resources to teachers, and promoting group learning and support. However, others indicated that they would not recommend the practice because it was unbeneficial/ineffective, overwhelming, time consuming, disorganized, and did not give adequate attention to particular grade levels.

Teacher Outcomes

Both administrators and teachers were asked to evaluate the impact that participating in STEM professional learning had on teachers' interest in STEM professional learning, teachers' STEM skills, knowledge, and confidence, teachers' STEM instructional practices, teachers' general instructional practices, and teachers' job attitudes. As findings reveal, an overwhelming majority of administrators and teachers agreed that participating in STEM professional learning improved teachers' outcomes in the aforementioned areas. Administrators, however, tended to hold slightly more positive sentiments than teachers.

Student Outcomes

In a similar vein to teacher outcomes, administrators and teachers were asked to assess the impact that teacher participation in STEM professional learning had on student outcomes, particularly their learning outcomes, interest, and engagement in STEM. *All* administrators agreed that teacher participation in STEM professional learning positively impacted students' learning outcomes, interest, and engagement in STEM. And while not all, the vast majority of teachers similarly affirmed that their participation in STEM professional learning positively impacted students' learning outcomes, interest, and engagement in STEM.

Considerations for the Professional Learning Grant Program

Encourage Participating Schools to Provide Teachers with Engineering-Specific Professional Learning Sessions

Findings from the current evaluation suggest that teachers who participated in STEM professional learning were least likely to integrate engineering in their teaching in comparison to the other STEM areas—science, technology, and mathematics. In line with the current evaluation, a number of research studies have also found that STEM teachers feel less competent and confident to teach science and mathematics concepts using engineering activities (Webb, 2015). As early introduction to engineering facilitates students' acquisition of 21st century skills such as the ability to analyze, evaluate, design, and create evidence-based solutions to problems, it may be useful to encourage the provision of engineering-specific professional learning sessions that provide teachers with hands-on participation in engineering research, information about various engineering-related careers available to students, and training with developing engineering-related lesson plans (Autenrieth, Lewis, & Butler-Purry, 2018; Estapa & Tank, 2017; Webb, 2015). When teachers participate in engineering-specific professional development, they often report an increase in their knowledge of engineering concepts and confidence to integrate engineering and inquiry-based activities in their lessons (Billiar et al., 2016; Holbert, Grable, Overbay, & Nzekwe, 2014; Nathan et al., 2011).

Provide Opportunities and Incentives for Teachers to Earn STEM-Related Endorsements

As research suggests, most STEM K-12 educators in the United States do not hold a degree in the subject areas they teach and for this reason, often lack the content knowledge and pedagogical knowledge needed to teach STEM courses effectively and increase students' interest in STEM careers (Hossain & Robinson, 2012; Jensen et al., 2016a; Leyzberg & Moretti, 2017). Findings from this evaluation, in line with current research, shows that the majority of teachers who participated in STEM professional learning do not have a STEM-related endorsement. At the same time, most expressed interest in pursuing an elementary science endorsement if one were offered. It is useful, then, for the STEM Professional Learning Grant Program to provide opportunities and/or incentives for teachers to develop their knowledge and pedagogy in STEM though acquiring STEM-related endorsements.

Encourage Trust-Building in STEM Professional Learning Communities

As findings from the evaluation suggests, teachers who participated in STEM professional learning were less likely to use videos of their teaching for peer-reflection as compared to self-reflection. Additionally, in their responses to open-ended questions, teachers expressed discomfort with having other teachers watch videos of them teaching. Indeed, as research suggests, while STEM professional learning communities are important, they are mostly effective when anchored by particular principles, one of which is trust (Fulton & Britton, 2011). When professional learning communities place importance emphasis on cultivating trust among participants, teachers feel more empowered to learn collectively, to invite others to observe their teaching, and to receive feedback about areas for improvement (Roy & Hord, 2006; Thornton & Cherrington, 2014). In light of the aforementioned research findings, it is useful for the STEM Professional Learning Grant Program to encourage trust-building among teachers involved in STEM professional learning.

Provide Teachers with Access to the Technologies Necessary for Participation in STEM Professional Learning

Among the barriers teachers identified that precluded their participation in video-based STEM professional learning was access to technology. More specifically, teachers often expressed that the technology needed to participate in video-based professional learning were not available at their schools. To encourage or facilitate participation in video-based self- and peer-reflection activities, it may be useful for the grant program to either provide video equipment and related technologies to participating schools or encourage administrators at participating schools to acquire these technologies for their teachers.

Create and Make Available a Repository of STEM Lessons That Teachers Could Integrate in their Curricula

While the vast majority of teachers who participated in STEM professional learning noted that they feel confident with creating STEM lessons because of STEM professional learning, they felt least confident in their ability to perform this practice in comparison to other activities including teaching elementary science standards, teaching elementary math standards, and teaching STEM lessons. Given this finding, it may be useful for STEM professional learning communities to place greater emphasis on developing teachers' skills to create STEM lessons. Additionally, it may also be important for the STEM Professional Learning Grant Program to create and make available a repository of STEM lessons that teachers can utilize in their teaching.

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