Texas Regional Collaboratives

THE UNIVERSITY OF TEXAS AT AUSTIN

Building the Texas Computer Science Pipeline

Strategic Recommendations for Success

Carol L. Fletcher, Ph.D., The University of Texas at Austin

Building the Texas Computer Science Pipeline

Strategic Recommendations for Success

Policymakers, business leaders, and educators are all mindful of the importance of student preparation in STEM (Science, Technology, Engineering, and Mathematics) fields for individual college and career readiness as well as national economic competitiveness. As the primary beneficiary of well prepared STEM graduates, the business community is keenly aware of the fact that the majority of today's high-wage, high-demand jobs require a background in STEM. As such, there has been a concerted focus on policies that promote or require additional coursework in science and mathematics in high school and programs that focus attention on STEM in after-school and extracurricular activities. Given the ubiquitous attention STEM currently receives, one might logically predict that enrollment in all areas of STEM both at the high school and collegiate level would be increasing. Unfortunately, there is one area that is a notable exception: **Computer Science**. By 2020, there will be 1,000,000 more computing jobs than students/graduates to fill them, resulting in a $500 billion opportunity gap (Code.org, 2014).

> Computer science is the only STEM discipline that showed a **DECREASE** in high school enrollment nationally between 1990 and 2009.

While the importance of STEM is generally agreed upon, the reality is that only a small percentage of Texas high school graduates take a computer science course. Computer science is in fact the only STEM discipline that showed a **DECREASE** in high school enrollment nationally between 1990 and 2009. The percentage of graduates who earned credits in high school computer science classes fell to 19 percent in 2009 from 25 percent in 1990, making it the only subject among science, technology, engineering and mathematics courses to experience such a drop, according to the U.S. Department of Education (Nord et al., 2011). At the university level, there is a similar negative trend. According to estimates from the National Science Foundation, fewer than 40,000 students received bachelor's degrees in computer science in 2009, 33 percent fewer than at the peak in 2004 (National Science Board, 2014). All of this has resulted in a tremendous job-to-student gap in computing with 60% of STEM jobs requiring a computing background and only 2.4% of college graduates earning a degree in computer science (Code.org, 2014). It's been shown that students' positive exposure to computer science in high school correlates to success in computer science in college (Benford and Gess-Newsome, 2006). Unfortunately, only 1 out of 10 schools in the U.S. offer programming classes (Code.org, 2014). Texas is no exception, with less than 15% of Texas high schools offering the AP Computer Science course in 2013-14 according to the College Board (2014).

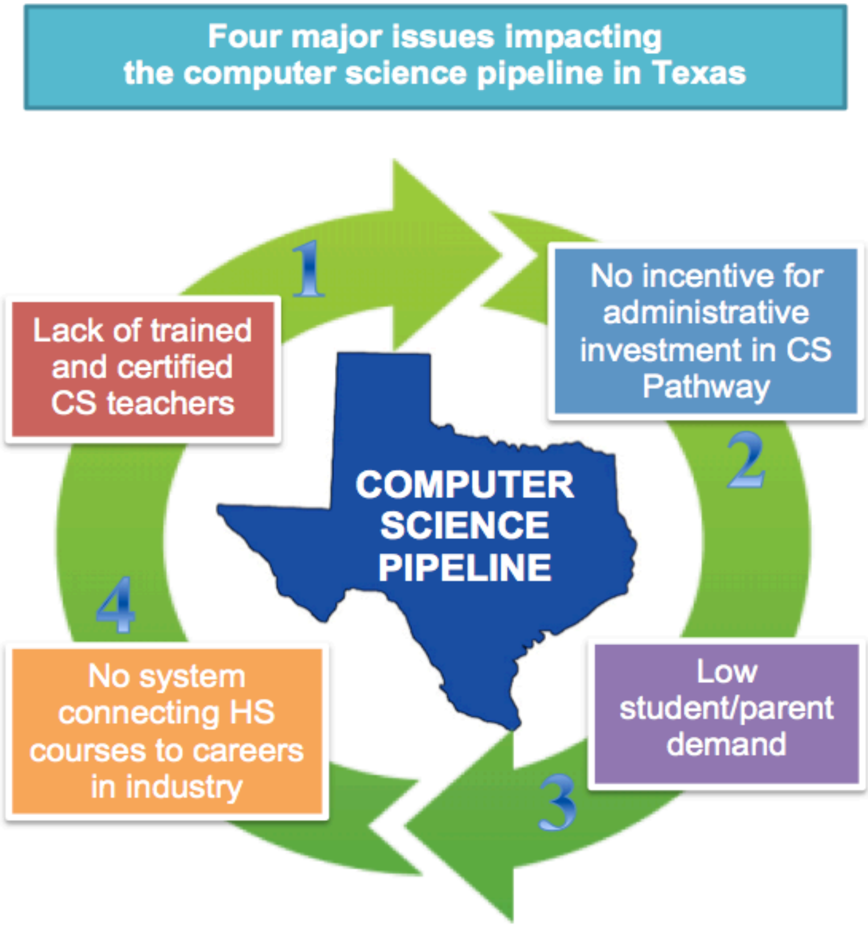
Given the Bureau of Labor Statistics projection that between 2012 and 2020 62% of the growth in STEM fields will be related to computer science (Austin, 2013), why are we seeing these disturbing trends?

In 2014, The University of Texas at Austin's Center for STEM Education began collecting input from a diverse array of STEM stakeholders, particularly in computer science, to analyze this problem. Led by the Texas Regional Collaboratives (TRC) for Excellence in Science and Mathematics Teaching, a statewide STEM teacher professional development network, these initial conversations resulted in the formation of the Texas Computer Science Task Force, which was convened on October 8, 2014 in partnership with the Austin Chamber of Commerce.

The purpose of the Computer Science Task Force was to identify barriers to the development of a robust computer science pipeline in Texas high schools and make recommendations for overcoming or mitigating the barriers to improve student access. For the purposes of this paper, the Computer Science (CS) pipeline is defined as the range of experiences from K-12 to career that impact the development of computer science literacy and career potential in jobs related to computer science. A list of CS Task Force attendees and an agenda is included in the Appendix.

This whitepaper summarizes current data related to computer science enrollment and careers. Input was gathered from CS Task Force members and numerous other stakeholders in Texas with expertise in this area to develop a concise set of issues and recommendations related to repairing and building the computer science pipeline in Texas. Each primary barrier is further explained in detail along with an accompanying recommendation for overcoming the barrier. This, by no means, is an exhaustive list of every issue or solution but rather a reasonable start to address some of the fundamental issues around computer science through viable, scalable and achievable recommendations.

Four major issues currently impact the computer science pipeline in Texas.



There is evidence to indicate that each of these four areas poses a significant barrier to the development of a robust and sustainable pathway for preparing students in the computer sciences. This includes both developing computer literate young adults capable of functioning safely and effectively in a technology dependent world as well as building a pipeline of future graduates eager and prepared to fill the high-wage, high-demand computer science related jobs of the future.

BARRIER #1: LACK OF TRAINED AND CERTIFIED COMPUTER SCIENCE TEACHERS.

Ample evidence indicates that schools and districts simply cannot fill all the potential openings for computer science positions that exist in Texas high schools. In 2013-14, only 90 individuals in the state of Texas passed the Grades 8-12 Computer Science teacher certification exam (State Board for Educator Certification, 2014). Given that there are approximately 1,500 high schools in the state, this number is clearly not adequate to fill the need. This challenge is compounded by the extreme disparity between starting salaries for college graduates with computer science degrees, which

A typical teacher in the U.S. would need to work 25 or 30 years to earn a salary equivalent to a computer science degreed professional working in industry straight out of college.

was $64,000 in 2013 (Adams,2013), and the average starting salary for Texas teachers, which was $36,352 that same year (Texas Association of School Boards, 2013). In fact, given that the average maximum U.S. teacher salary is $67,000 (Auguste, Kihn, & Miller, 2010), a typical teacher in the U.S. would need to work 25 or 30 years to earn a salary equivalent to a computer science degreed professional working in industry straight out of college. The likelihood that more than a tiny fraction of college graduates with computer science degrees will choose a career in teaching out of college rather than a career in industry is small. As such, attempting to encourage more computer science graduates to go into teaching is laudable but is not a realistic, strategic, or scalable approach to resolving the teacher shortage problem. Other approaches are more likely to result in short-term and long-term increases in the number of certified and qualified computer science teachers. Such approaches include the following recommendations:

RECOMMENDATION #1:

PUBLIC/PRIVATE PARTNERSHIPS TO INCENTIVIZE AND PREPARE CURRENTLY CERTIFIED EDUCATORS TO TEACH HIGH SCHOOL COMPUTER SCIENCE COURSES.

Identifying currently certified classroom teachers, particularly high school mathematics teachers with an interest in expanding their skill set to include computer science, can quickly increase the number of teachers able to offer CS course to students in Texas high schools. With adequate support, currently certified teachers, particularly those with a mathematics background, can gain the skills necessary to offer courses such as Fundamentals of Computer Science, Computer Science I, and Computer Science II. In addition, teachers who are already certified can obtain additional certification by simply taking and passing an additional Grades 8-12 Computer Science certification exam, making certification for knowledgeable individuals a fairly direct process.

Recent initiatives offered to provide this support indicate that there is a substantial pool of teachers who are interested in participating in such a training program. For example, in August 2014, the TRC at The University of Texas at Austin announced a partnership with Oracle Academy called “Keep Calm and Java On”. This project included free online coursework in Java to Texas teachers followed by face-to-face training in Austin. Within two weeks of the initial online invitation for applicants, over 120 teachers across Texas had applied to participate for only 40 available enrollment spots. Over half of the applicants came from rural school districts. Such interest indicates that with the right structure and support, Texas could increase the number of qualified and certified computer science teachers, even in rural districts.

Criteria for successful scale-up of such a project include:

- ***No cost to teachers*** - Teachers who take the initiative to gain new skills and certification should not also be expected to pay for this professional development personally. Unlike other professionals, they do not generally receive a raise or promotion when taking on additional responsibilities. If teachers add to their skill set or innovate to bring cutting edge experiences to their students, there is little financial incentive, especially if they choose to remain in the classroom. As such, the normal incentive structure that exists in the business world to support personal investment in professional growth does not exist in education. If developing a larger pool of qualified computer science teachers is a statewide priority, teachers must be supported to gain these additional skills.
- ***Low-to-no cost for school districts*** – School districts are currently struggling to fill the STEM positions they already have with qualified employees with little incentive for diverting limited professional development dollars to courses they may find valuable but are not part of the core curriculum. Ensuring that districts from across the state are able to develop the talent necessary to teach Computer Science will require strategic, state-level support. A comprehensive statewide plan to increase the number of computer science teachers will benefit all Texas schools, not just a select few higher wealth districts.
- ***Cohort model of sustained support*** – In most high schools, there is only one computer science teacher, if any. A successful program should apply a cohort model for supporting teachers from multiple schools and districts working together to grow professionally. This cohort model can create a supportive network that can be sustained after the initial intensive professional development experience, thus building leadership capacity for scaling computer science instruction to additional teachers and schools.
- ***Blended learning*** – A combination of online and face-to-face professional development will deliver the greatest return on investment while allowing professional development to occur at an economy of scale across the state. Initially, developing a critical mass of teachers interested in intensive and sustained professional development will require casting a wide net in urban, suburban, and rural districts. The blended approach can facilitate technical learning through online coursework while still attending to the very real need to nurture a supportive network of professionals to combat the isolation of most Computer Science teachers. The blended approach is the most cost-effective method for achieving these dual goals.
- ***Leveraging of existing high quality professional development*** – University-based programs such as the TRC, UTeach, and Project Engage at UT Austin, have successful track records of providing high quality professional development and

can be used as incubators for piloting effective professional development models. Non-profits such as Code.org and the College Board also have resources that can be scaled to support teacher growth.

BARRIER #2: NO INCENTIVE FOR ADMINISTRATIVE INVESTMENT IN THE COMPUTER SCIENCE (CS) PATHWAY THROUGH THE STEM ENDORSEMENT.

In Texas, the Texas Essential Knowledge and Skills (TEKS) define course standards. The TEKS are categorized by content areas such as science, mathematics, fine arts, etc. The TEKS for most computer science courses are categorized under Technology Applications, or Chapter 126 of the Texas Administrative Code. Another category of courses (Chapter 130) is called Career and Technical Education (CTE). These courses include many areas of applied science such as Agriculture, Biotechnology, Audio/Video Technology, Business, Health Science, Culinary Arts, Engineering and Information Technology. Some CTE courses can count as math or science credits. School districts receive weighted per pupil funding for each student that enrolls in one of these CTE courses (1.35x). Given the incentive structure that exists for CTE courses, school districts that support students to follow endorsement pathways that do not include CTE (as is currently the case with most CS courses in the STEM endorsement) put themselves at a financial disadvantage when it comes to funding the equipment, training, mentorship programs or stipends for hard to staff areas that CTE course enrollment could cover.

RECOMMENDATION #2:

MOVE COMPUTER SCIENCE COURSES OUT OF TECHNOLOGY APPLICATIONS AND INTO CAREER AND TECHNICAL EDUCATION (CTE).

> With additional CTE funding tied to student enrollment in Computer Science, campuses and districts will be incentivized to encourage students to complete a Computer Science pathway.

Classifying computer science courses as CTE will encourage enrollment. With additional CTE funding tied to student enrollment in Computer Science, campuses and districts will be incentivized to encourage students to complete a Computer Science pathway in the STEM Endorsement. Additional costs that would be incurred in developing a robust and engaging series of Computer Science courses could include up-to-date equipment and software to ensure students are working with industry standard tools and resources; stipends for teachers with a strong computer science background; professional development to support existing teachers to obtain an additional computer science certification; reimbursements for the costs of the 8-12 Computer Science certification exam if teachers pass the exam; dual credit fees for students completing Computer Science courses for dual credit (i.e. UT Austin's Project Engage course); and support for students to compete in motivating and engaging competitions and programs using computer science such as Cyberpatriot, SkillsUSA, FIRST Robotics, Code Jams, Hack-a-thons, etc.

BARRIER #3: LOW STUDENT/PARENT DEMAND FOR CS COURSES

One concern that school administrators have when they consider investing in computer science is their perception of limited student and parent awareness, interest, and demand. It is unclear as yet the degree to which this perceived low demand is a result of explicit student disinterest or a lack of awareness of the extensive career opportunities available in computer science related fields. In contrast to computer science, programs and courses that appeal more directly to a wide range of students, such as band and athletics, but may have less direct connection to future careers for most participants, are in high demand both by students and the parents whose local tax dollars make up the bulk of school district budgets. Lack of parental awareness related to the outsized career potential of a computer science background compared to some other STEM areas is evidenced by a recent Microsoft survey conducted by Harris Interactive. Even though 50% of parents surveyed in 2011 said they would like their child to pursue a STEM career (Microsoft Corporation, 2011), this interest isn't translating into specific demand for computer science coursework in high schools. This parent survey also found that only 15% of parents identify IT professional or computer scientist as the STEM career of choice for their students. Only 4% of parents think their children want to pursue a career as an IT professional and only 8% of parents responded that their students want to pursue a career in computer science. Given that 60% of STEM jobs of the future will require a computer background, this represents a significant mismatch. This disconnect plays out in Texas in the form of student enrollment. For example, in the 2013-14 academic year, a total of only 15,583 students across the state of Texas were enrolled in either Computer Science I, Computer Science II, or AP Computer Science A, and only 133.15 Full-Time Teacher Equivalents (FTEs) were dedicated to teaching these three courses across the state (Texas Education Agency, 2014). Given that there were approximately 1.4 million high school students in Texas in 2013-14, this represents less than 2% of high school students.

> Less than 2% of Texas high school students took CS I, CS II or AP CS in 2013-14.

Computer science clearly has an identity problem. The challenge is greatest for women and minorities who have traditionally been underrepresented in computer science. In 2013, the percentage of African-Americans who sat for the AP Computer Science A exam was 3.7%. In 11 states not a single African-American student took the test, and in three states not a single female took the test (Ericson, 2014). Overall, only 19% of AP Computer Science A test takers were female in 2011 (NCWIT, 2012). One can conclude from such data that even in schools where AP Computer Science is offered, women and minorities are either not choosing to enroll in the class or, if they are enrolling, not choosing to take the AP exam.

RECOMMENDATION #3:

EXPAND OPTIONS FOR CORE COMPUTER SCIENCE IN TEXAS TO INCLUDE ADDITIONAL ENGAGING, PROJECT-BASED COURSES SUCH AS AP COMPUTER SCIENCE PRINCIPLES.

While there are clearly talented computer science teachers in Texas who have developed strong CS programs with large enrollment in their own schools, this appears to be the exception rather than the norm in Texas. The current standard options of Computer Science I, Computer Science II or AP Computer Science focus heavily on programming. While programming is an important component of computer science, such an exclusive focus may be ineffective at engaging a more diverse range of students in introductory CS courses. Several innovative courses have been researched and developed over the past decade that provide students with a broader overview of computer science or address computer science instruction in a more engaging, project-based manner. Two of these courses are Computer Science Principles and Exploring Computer Science. Both of these courses teach the big ideas of computing along with coding and also focus on projects that help students understand how the creative potential of computer science can transform society. Even though existing CS I and CS II courses can also be taught this way, expanding the portfolio of courses that can be taught and that can fulfill the requirements for the high school curriculum could increase enrollment. For example, the AP CS Principles course, developed in conjunction with the College Board and the National Science Foundation, will be launched in the 2016-17 academic year with a student AP test available in May of 2017. Unfortunately, this course does not closely match our current Texas Essential Knowledge and Skills (TEKS) for CS I or CS II and only approximates the TEKS for Fundamentals of Computer Science. Recently, the State Board of Education included Computer Science I and Computer Science II or AP Computer Science as part of the required curriculum for Texas High schools. This is an admirable start. However, simply requiring courses that are not currently effective at attracting large or diverse numbers of students isn't likely to increase actual enrollment. Rather than simply "doubling down" on existing courses with limited evidence of effectiveness, the state should consider allowing courses like the AP Computer Science Principles to satisfy this requirement as well. What can accomplish this goal is either creating a new stand-alone AP CS Principles course and associated TEKS, or modifying current courses to reflect the AP CS Principles framework. Based on the AP Computer Science Principles framework, several organizations have already begun to develop and implement courses for Texas including The University of Texas Project Engage and Project Lead the Way.

Changing the standard for what constitutes the computer science pathway may result in the greatest return on investment for females who have demonstrated limited enrollment in traditional computer science classes.

In addition, other courses such as Exploring Computer Science have been researched and developed with NSF support and have demonstrated notable effectiveness at attracting a more diverse array of students to computer science (Bernier and Margolis, 2014). Additional courses such as Video Game Design have shown to be another attractive gateway course to computer science. Organizations like Globalaria and Code.org support computer science classes and creative, collaborative student experiences that are engaging and project-based. State policies regarding the computer science pathway should encourage and promote adoption of these kinds of innovative courses rather than limit student options or campus course offerings. Modifying the Texas Administrative Code that deals with the required high school curriculum in §74.3(b)(2)(I) to include these innovative courses as an option will support their large-scale implementation. Changing the standard for what constitutes the computer science pathway may result in the greatest return on investment for females who have demonstrated limited enrollment in traditional computer science classes. When college STEM majors were asked what made them interested in STEM prior to college, 68% of females cited a teacher or class - the number one motivator for females. For males, only 51% cited a teacher or class, but 61% cited games or toys (the number one motivator for males) as compared to 29% of females. Interestingly, only 4% and 6% of males and females respectively cited science fairs and contests as that which interested them in STEM (Microsoft Corporation, 2011). Such research may prompt business and industry, which supports many of these types of competitions, to consider greater investment in improving core computer science coursework. That may impact more students than extracurricular contests that are engaging but often available to only a limited number of well-resourced students and schools.

Barrier #4: No system for connecting HS students, teachers, or courses to careers and professionals in the computer science fields.

Only 36% of classroom teachers have non-teaching industry work experience that they can use to connect their subject matter to the real world (Microsoft Corporation, 2011). Given the enormous pay disparities between classroom teachers and computer science professionals, that number is likely even lower for those who teach Computer Science.

As a state, there is no system-wide structure for helping students and teachers connect high school coursework to the real world. A key component of Project Based Learning

(PBL) is that students collaborate to tackle meaningful problems that are grounded in issues that are important both inside and outside the classroom. Research comparing learning outcomes of students involved in PBL versus traditional instruction indicate that such a model connected to realistic problems results in high achievement on standardized tests, improved student attitudes toward learning, and improved collaboration and problem solving skills (Strobel and van Berneveld, 2009; Walker and Leary, 2009). Numerous programs, such as Skillpoint's Velocity Prep, SureScore, Nepris, Spark101, VirtualJobShadow and the Technology Education and Literacy in Schools (TEALS) program are attempting to make such connections more systematic, sustainable, and robust for high school students. Sites like InternMatch connect college students to internships but no similar resource exists for high school students. None of these resources has yet to fulfill the enormous need that exists in the state to connect high school students, courses or projects in a meaningful way to businesses or professionals involved in computing outside of the school system.

RECOMMENDATION #4:

DEVELOP A ROBUST AND SCALABLE ONLINE SYSTEM THAT CONNECTS HIGH SCHOOLS TO CAREERS AND PROFESSIONALS IN COMPUTER SCIENCE FIELDS.

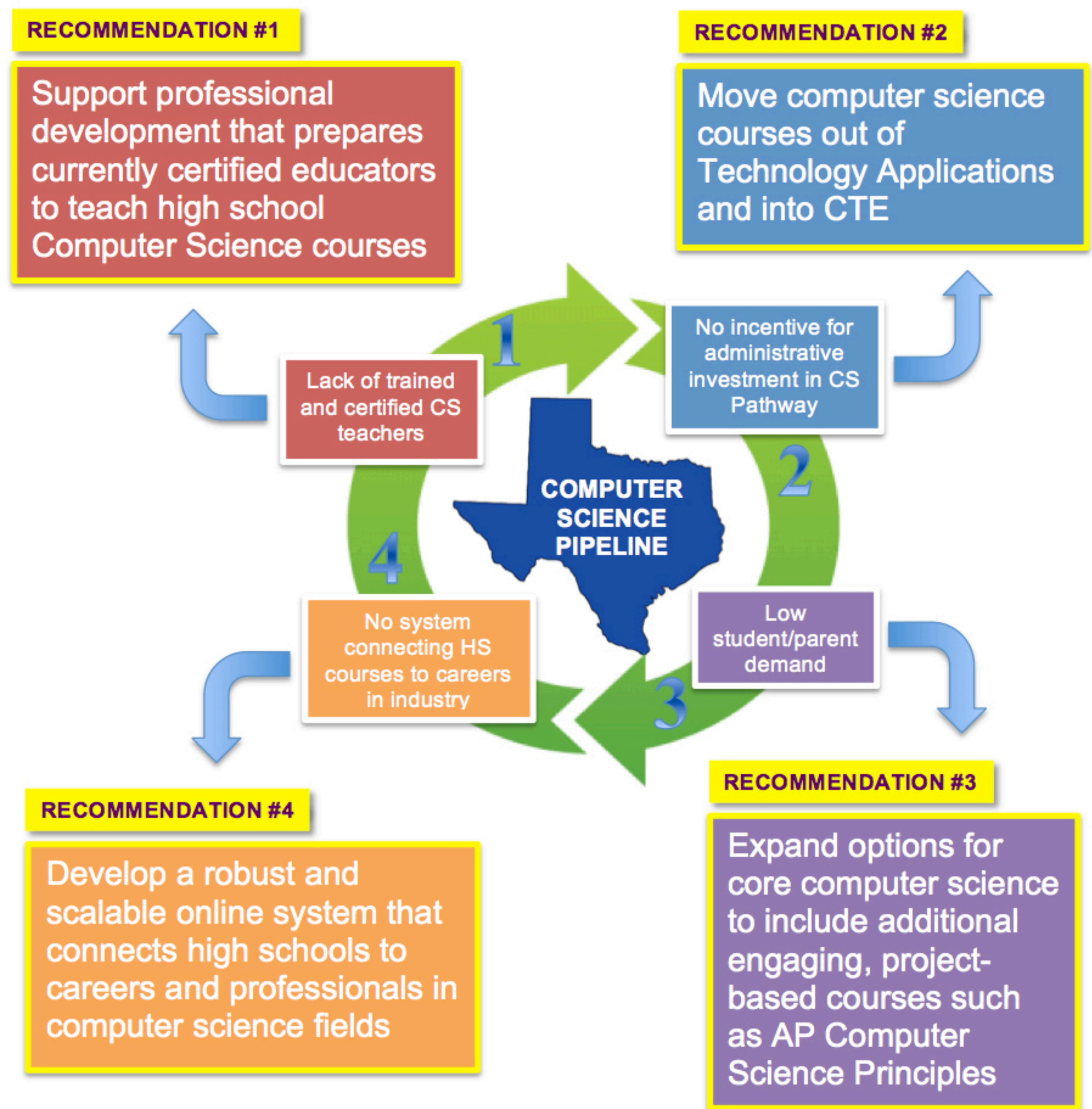
Texas businesses and education leaders must collaborate to develop and support a robust and scalable system for connecting high school students, teachers, courses, and schools to careers and professionals in the computer science fields. Many CTE courses already have a tradition of internships, mentorships and real world experiences that make these courses credible for students. By moving computer science under the CTE umbrella, the state can encourage school districts to integrate similar experiences in computer science into their existing programs and management structures for mentorships and industry connections. This is a first step toward solving the problem. Unfortunately such school level programs are often difficult to sustain when personnel leave a school or district, or when these programs are uniquely built on personal relationships. Additionally, school-level programs often lack scalability or transferability to other communities or contexts. Such ad hoc solutions will not be adequate to address the breadth of the mismatch we are currently facing between computer science opportunities in high school and the demands of a 21st Century economy and employment landscape. Therefore, a more scalable, strategic and systemic effort must also be made to facilitate these connections between business and their future customers and potential employees. Such an online system will support not only computer science but other fields where students would benefit from more clear connections between what they study in school and future careers.

The Technology Education and Literacy in Schools (TEALS) program mentioned above may be a model that Texas business leaders would find worth replicating. This grassroots program was begun in the San Francisco area in 2009-10 with one industry professional volunteering to teach one class of 12 students in one school. It has expanded to include 18 states plus the District of Columbia, 131 schools, 490 industry volunteers, and over 6,000 students in the 2014-15 school year (Technology Education and Literacy in Schools, 2014). The program is designed to recruit, train, mentor, and place high tech professionals into high school Computer Science classes in a team teaching model. A notable benefit of the TEALS program is the capacity to directly impact the quality of computer science instruction in Texas schools over the short-term and also build public school capacity over the long-term through the team teaching model.

The TEALS program could directly impact the quality of computer science instruction in Texas schools over the short-term and also build public school capacity over the long-term through the team teaching model.

In summary, while the challenges to creating a robust statewide computer science pipeline in Texas schools are substantial, there are viable solutions to each of these barriers. A state-level strategic plan must address the recommendations outlined in a comprehensive and integrated manner to ensure that policy, teacher preparation, funding, and curriculum are all aligned. Tackling this issue through a coordinated campaign that addresses each of these components will ensure that efforts throughout the system are aligned to achieve the objective of engaging more students in meaningful, motivating, and rigorous courses that promote computer literacy as well as developing a pipeline that leads to more computer science professionals and a stronger economic future for Texas.

Recommendations for Building a Robust Texas Computer Science Pipeline



Inquiries or feedback regarding this whitepaper can be addressed to Dr. Carol L. Fletcher, Associate Director, TRC, Center for STEM Education at The University of Texas at Austin. Carol.fletcher@austin.utexas.edu.

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Appendix

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The University of Texas at Austin

Austin Chamber

Texas Computer Science Task Force: Strategic Leadership for Building a CS Pipeline

Attendee List *(for October 8, 2014 Meeting)*

NAME		ORGANIZATION	EMAIL ADDRESS
Brooke	Bennet	Representative Donna Howard's Office *Policy Analyst, Director of Constituent Services at Texas House of Representatives*	donna.howard@house.state.tx.us
Bradley	Beth	UT Austin - CS OnRamps course Project Engage *Senior Program Coordinator*	bbeth@cs.utexas.edu
Phillip	Eaglin	Changing Expectations - Code.org volunteer *Founder and CEO*	phillip.eaglin@changeexpectations.org
Carol	Fletcher	The University of Texas at Austin – TRC *Associate Director*	Carol.fletcher@austin.utexas.edu
Kim	Garcia	Georgetown ISD *EdTech Coordinator*	garciak@georgetownisd.org
Lori	Gracey	TCEA *Executive Director*	lgracey@tcea.org
Annette	Gregory	Austin ISD Career and Technical Education *Executive Director*	annette.gregory@austinisd.org
Susan	Harris	TCU College Board AP Summer Institutes *Director*	ap@tcu.edu
Holli	Horton	ESC Region 2 Instructional Technology *& TCEA Director Area 2*	holli.horton@esc2.us
Deborah	Kariuki	Round Rock ISD *Computer Science Teacher (Former IBMer)*	deborah_kariuki@roundrockisd.org
Scott	Lipton	Globaloria, *Director, Central/South*	scott@globaloria.com
John	Owen	Aransas County ISD *Academic UIL Coordinator*	captainjbo@gmail.com
Robin	Painovich	CTAT *Executive Director*	robin@ctat.org
Drew	Scheberle	Austin Chamber of Commerce Sr. VP, Federal/State Advocacy and Education/Talent Development	dscheberle@austinchamber.com
Hal	Speed	Code.org *UX Strategist at Dell*	hal@halspeed.com
Amy	Werst	The University of Texas at Austin – TRC *Compliance and Accountability Coordinator*	Amy.werst@austin.utexas.edu

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The University of Texas at Austin

Austin Chamber

Texas Computer Science Task Force: Strategic Leadership for Building a CS Pipeline

Wednesday, October 8, 2014
11:30 am to 1:00 pm

Austin Chamber of Commerce
535 E. 5th Street
Austin, TX 78701

AGENDA

Welcome and Introductions

State of CS Education in Texas

Factors Impacting the CS Pipeline

- Teacher supply
- Student demand
- Administrative support
- Funding
- Certification
- Curriculum/Courses
  - CS Principles course
  - Tech Apps, CTE, Math, AP course?
- CS Pathway in the STEM Endorsement
- Policy levers
  - District
  - SBOE
  - Texas Legislature
  - Federal Government

Brainstorming Recommendations

Next Steps

- White paper - outline factors impacting pipeline and recommendations
- Next meeting
- Who else should be involved?