Mid-Columbia STEM Education COLLABORATORY
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A Framework for Action in Computer Science Education

Lessons from the Computing the Future Project

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Background: The gap between computer science (CS) graduates and CS jobs continues to be large locally, regionally and nationally. To address this in Washington State the legislature passed bills related to computer science education during each of the last two sessions. In 2013 HB1472 provided the option for schools in Washington State to count advanced placement (AP) computer science as a required math or science credit rather than just as an elective. Then in 2015 Substitute HB 1813 prioritized investments to reach underrepresented students first. The bill establishes K-12 education standards for computer science, creates a K-12 computer science teaching endorsement and enables teacher to access state scholarships to pursue computer science professional development. Computer science education in K-12 is an equity issue, there must be access for all kids both to the 21st century skills and learning provided by computer science (starting with computational thinking), and to the higher paying jobs available to those with CS skills. More information about computer science education in other states can be found at https://code.org/promote .

United States cities and states that have recently made some element of computer science mandatory for all students include Los Angeles Unified Schools, San Francisco Public Schools, Chicago Public Schools, New York City Public Schools, Arkansas (high schools are required to offer CS). England, Finland and Australia have also recently made computer science education a mandatory component of education for students and some Estonia schools have students as young as six years old learning basic programming. In October 2015 President Obama signed the STEM Education Act of 2015 which explicitly includes computer science in the definition of STEM Education for federal purposes.

Purpose and Targets: In our local community, computer science is not taught routinely in grades K-8. While more schools are adding computer science courses at the 9-12 level, there is still considerably variability (Table 1), creating issues of access and opportunity to learn computer science knowledge, skills and habits of mind which are critical for all students in the 21st century (i.e., computer science literacy).

Table 1. High School Computer Science/Computer Science-Related Courses offered in three larger local districts (electives unless noted otherwise) in 2015-2016 school year.

High School	Computer Science Courses offered (including related courses)
Chiawana HS	Computer Engineering A+ 1-2, 3-4, 2D&3D Animation & Design; Web Design 1-2;
Delta High School	Required for all students – Robotics (9th); Computer Programming (11th), Multimedia Arts 1-2 (11th)
Hanford HS	Intro to Computer Animation; Web Page Design; AP Computer Science A; Computer Engineering/Microsoft Technology Associate; Advanced Computer Engineering/MTA; Cybersecurity (1 sem)
Kamiakin HS	Computer Science 1-2 (Python); AP Computer Science A (Java); Multimedia Design 1-2; Webpage Design 1-2, 3-4; Engineering 1-2; PC Trouble Shooting 1-2. PC Internship 1-2;
Kennewick HS	IB Computer Science (standard and higher), Principles of Computer Science; Computer Science 1-2 (Visual Basic),3-4 (Java)
New Horizons HS	Robotics
Pasco HS	Robotics 1-2; Industrial Robotics 3-4, Leadership-Robotics; Web Design 1, 2, Computer Science Java, SQL, Linux; Computer Engineering A+ 1-2, 3-4;

	Computer Science; 2D Animation & Design; Digital Design 1, 2 (which are actively taught?)
Richland HS	Intro to Computer Animation; Web Page Design; AP Computer Science A; Cybersecurity (1 sem)
Southridge HS	Multimedia Design 1-2, 3-4; Computer Science 1-2 (Visual BASIC.NET); Engineering 1-2, 3-4 (with Mechtronics)
Tri-Tech	Computer Science/CyberSecurity 1-2, 3-4; DigiPen Computer Science 1-2, 3-4; Graphic Communications/Web Design 1-2, 3-4; Health Informatics 1-2
River's Edge HS	Web Page Design

In 2013, the newly established Mid-Columbia STEM Education Collaboratory began the first phase of a project to help meet the growing gap in computer science education access in the Mid-Columbia region of Washington State. The first phase sought to determine existing needs and opportunities in order to recommend actions for Phase 2 and beyond.

Phase 1 Goals and Objectives:

- Raise Awareness and support in our community for computer science education efforts
- Through collaboration and leveraging of resources develop a framework for action that coordinates current efforts and includes:
    - Model projects that "teach" core ideas/skills (proof of concept)
    - Proven methods to develop/identify tools to share widely (and tools recommended)
    - Options that enable equity
    - Identification of potential funding sources for future efforts

Information gained about CS Education in our community during Phase 1 activities is summarized in Table 2. This information, which include reviewing recent research in computer science education, was used to create a Framework for Action (Table 3) for use in addressing four specific challenges in CS Education that were identified during Phase 1. The challenges identified in Phase 1 were:

- Curricula and Professional Development in computer science are less available than in other STEM disciplines.
- Teacher Certification is not standardized or universal and often absent. The computer science teacher certification that Washington State is developing must provide a realistic pathway to certification to insure equity in access to computer science education for all Washington students. In addition, Washington State is in the process of reviewing computer science education standards developed by nationally recognized organizations for possible adoption as state computer science education standards.
- Many computer science teachers teach in isolation from other computer science colleagues.
- Out of school opportunities for computer science learning are growing but are less available in the Mid-Columbia than in more urban areas of the state. Student participation in computer science learning at the secondary level lacks diversity and out of school opportunities can help to address this issue.

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Table 2. Summary of Phase 1 Activities and Outcomes

Activity	Target Audience	Desired Impact	Implementation Outcome/ Lessons Learned
Raspberry Pi Demos	Community, general	Advocacy	Several demonstrations at STEM nights and other events were successful in building interest but did not necessarily translate to increased involvement by the partners or participants. Other groups are interested in providing these demonstrations and have more capacity to do so on a regular basis.
RECOMMENDATION: Recommend transfer of this activity to other interested groups in order to have the capacity to support other activities with more potential for immediate impact. These include CBC Tech Club, Delta High student clubs, and local Raspberry Pi enthusiasts.			
After school clubs or classes	K-12 students, teachers	Demonstrate student interest, provide support for early efforts	Limited participation due to competing activities and a lack of available teacher hosts. Collaborated with 21st Century Community Learning Center on one club and maintained support of existing high school programs; supported one existing club in efforts to include Raspberry Pi learning. Promotion and support of robotics participation supported one club and generated two others with interest for more. Richland Public Library started monthly Raspberry Pi Users Group.
RECOMMENDATION: Continue to promote local robotics clubs as the infrastructure exists to support new clubs. Support existing and additional clubs as able. Support others efforts to begin or develop clubs (school or community) that meet the needs of underrepresented groups for CS learning and experiences. Phase 2 should include after school experiences if they can be made available beyond a single school and encourage the involvement of underrepresented populations.			
High School level competitions	High School students and teachers	Support existing interest, build enthusiasm	Three events were held under name ByteFest – two coding challenges and one design challenge. All three events had limited participation. This was due to lack of time and support (by teachers) to attend and a small population of students currently participating in CS classes.
RECOMMENDATION: Transfer to other interested parties as these events do not meet project goals for phase 2. Potential to transfer to Tri-Tech, Delta or another school, LiveTiles or another organization/business with interest. Continue to support as interested party rather than lead.			
Teacher, Researcher, Raspberry Pi	Teachers with limited to no background in computer science	Support existing interest and build capacity of teachers to teach CS	Summer two day workshop was successful with positive surveys and engaged participants; however, there was only limited transfer of this new learning to the classrooms.
RECOMMENDATION: Provide K-12 teacher PD for CS programs in Phase 2. This includes code.org Computer Science Fundamentals, App Inventor, My			

CS from Harvey Mudd, Advanced Placement Computer Science Principles (CS4HS), Exploring Computer Science (ECS), Lego robotics. Continue to provide Raspberry Pi sets for teacher to try with students. Continue awareness of free learning options such as EdX, Coursera, Udacity.			
Online community	Everyone	Connect, advocate, educate	Started a Google+ Group but had almost no participation. Surveyed educators and others on social media they use – no consistency among group and many do not use social media or only use it for personal business. Other groups are developing which we could join. Also may be able to use a blog (with comments and RSS feed) that is connected and shared to other sites.
RECOMMENDATION: Encourage participation in existing forums and build additional means of connecting electronically – email, blog, website. In addition, create opportunities to network in person with possibility of a local CSTA chapter. Refer teachers to growing online communities hosted by coed.org and others. This will be an active part of Phase 2 work.			
Summit	All interested	Connect, advocate, educate, create vision	Unable to gain enough support and find a date and time that was likely to have significant participation. Teachers did not have subs easily available and many could not meet during out of school times. The information needed from the summit was gained through other network opportunities (other events, meetings, personal communications).
RECOMMENDATION: Consider implementation for later date if teacher sub shortage improves or if a summit can be combined with an event for students that enables teacher participation in the summit at that time. During Phase 2 explore possibility of a virtual summit.			
Hour of Code	K-12 students and teachers	Build awareness and interest	Actively promoted this event in 2013 and 2014. Increased participation in 2nd year and one local district set a goal for all students to participate in 2015.
RECOMMENDATION: Continue involvement during phase 2 and promote the event to get increased participation. Add family events and/or include business events if support from other organizations in the Collaboratory. Provide teacher Hour of Code PD workshops with follow-up optional code.org CS Fundamentals workshop for interested teachers. Enable clock hours for both Hour of Code and follow-up workshops.			
Raspberry Jam	All interested	Build awareness and interest	First event was successful. Difficulty finding space and lead organization beyond Richland (Richland now has a Users' Group) prevented a second event.
RECOMMENDATION: Support efforts of others to host these events, but do not instigate/lead at this time due to limited capacity.			

Summer Camps	MS Girls 2014; 7-10 grade girls (and boys) 2015	Develop skills, interest and confidence among underrepresented group participants	Both camps filled quickly and resulted in additional interest. Student surveys results were positive. App Design Camp led to additional similar camps at CBC. Second camp allowed boys but reserved seats for girls which led to more girls participating than boys. Neither camp was successful at recruiting large number of underserved students.
RECOMMENDATION: Continue and expand if additional support can be identified. Locate more hands-on resources to include in camps. Collaborate with MESA and others to improve diversity of students. This is an active part of phase 2.			
Career Pathways	MS and HS counselors, students, parents	Build interest (long-term)	Identified existing pathway documents available through ACM and other organizations. Shared those from ACM with local schools.
RECOMMENDATION: Continue to share and reference existing pathways, including on website and social media. Revisit and review as new information emerges. Not recommended as an active element for phase 2.			
Collaborations with others	CBC, Tech Alliance, PSD, STEM Foundation, Google, code.org, various schools, Boys and Girls Club, Delta High	Increase awareness and advocacy	Collaborations centered on summer camps, demonstrations, workshops and other trainings. In addition, funding was provided as a result of collaborations with Washington Technology Alliance, Delta High and The Washington State STEM Education Foundation, specifically for summer camps.
RECOMMENDATION: Continue to collaborate with others and grow as available. Continue to focus on trainings and workshops while shifting leadership of demonstration type activities to others as a means of building capacity beyond the project and focusing limited project resources on areas with most potential for impact.			
Support developing CS classes and programs	HHS cybersecurity and AP classes, Tri-Tech cyber, Rosalind Franklin CS	Build capacity	Developing programs are continuing to grow and are producing some interest from others. HHS cybersecurity course has led to AP Computer Science classes at HHS and RHS.
RECOMMENDATION: Continue to support new classes as possible and link these to one another to build a network of support by and for teachers. Pilot use of blog in combination with website and social media as a means of building this network.			

Grants and other funding	Tech Alliance, STEM Foundation, Google	Enable additional efforts (beyond those initially proposed)	Two summer camps (original phase 1 plan was for just one) and funding to support teacher PD in the new AP Computer Science Principles course (from Google's CS4HS) were result of phase 1 efforts. These both have led to other collaborative efforts.
RECOMMENDATION: Continue to identify possible grant opportunities and collaborate with others to apply for the funding in phase 2 as a means of expanding the work in future phases.			
Identify tools/ curriculum for use	Code.org curricula, Raspberry Pi, Robotics, App Inventor, MyCS CSP piloted curric, Scratch, Tynker, EdX Courses, Cyber curric, after school curricula	Build teacher capacity and support interest in providing CS Education	Have a set of resources to share with others as interest increases. These resources have been vetted by others and some are in the process of being reviewed by the CtF team.
RECOMMENDATION: Continue to grow "library" of resources and make these resources available on Collaboratory website, through the Facebook page and other venues. Suggested curriculum pathway for K-12 of currently available materials is provided in Table 4 with a recommendation that this be updated in 3-5 years.			
Gather information on current context, other research findings	NA	Inform phase two efforts	Our findings in the literature and work locally matched much of what was found in research by the Outlier group at the University of Chicago (http://outlier.uchicago.edu/outlier/research/ and http://outlier.uchicago.edu/outlier/projects/).
RECOMMENDATION: Share information we have collected with others (like this framework), use collected information for blog entries and other social media efforts. Continue to gather and share as the CS education context evolves to inform work in future phases.			

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Recommended set of policy and program options:

In order to significantly increase the availability of quality computer science education for all Mid-Columbia K-12 students and increase advocacy for continued growth the following actions are recommended (Table 3) and have been proposed for Phase 2 of the Mid-Columbia Collaboratory project. Currently available curriculum pathways are recommended in Table 4 and indicators of success specific to the Collaboratory Project are included in Table 5:

- K-12 Teacher Professional Development and implementation support for Computational Thinking and Computer Science curriculum in Mid-Columbia classrooms
- A community network of and for teachers implementing computer science in their classrooms
- Out of school opportunities for underrepresented populations at the secondary level
- Increased local participation in the Hour of Code that results in more awareness of and participation in computer science education.
- Thought leadership (as possible) for the new computer science teacher certification and for the adoption of computer science standards in Washington State.
- Collaboration on potential grant opportunities for additional work in computer science education
- Proposed sub-projects in the area of computer science education led by others, particularly in the area of cybersecurity

Mid-Columbia STEM Education Collaboratory Computing the Future Project Phase 2:

Vision: All Mid-Columbia students have the computational thinking and fundamental computer science skills necessary for success in the technologically rich future

Outcome: Computer science, especially computational thinking, is part of the core curriculum in grades K-8. All students have access to additional computer science courses in grades 9-12

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Table 3. CS Framework for Phase 2 Action Based on Phase 1 Learning and External Research

High Impact Strategies for CS in K-12	K-5 Recommendations for Action	MS Recommendations for Action	HS Recommendations for Action
Professional Development	Provide code.org trainings through schools, districts and other organizations such as LASER and MESA. Also offer code.org trainings open to any teachers.	Provide trainings in robotics, App Inventor, and Scratch in 2015-16. Look for additional options for 2016 and beyond.	Provide Google CS4HS PD in Computer Science Principles AP course in collaboration with CBC.
Underrepresented Students in CS	Actively assist in developing robotics and other options (Scratch) after school when possible.	Offer summer camps in app design, cyber security and, when possible, after school programs in coding and cyber security	Seek opportunity to offer 15-20 out of school sessions or 1-2 week summer camp for target populations.
Other high impact strategies that deal with the purpose, policy, program, practice and partnership aspects of bringing CS into K-12?	-Promote the Hour of Code Support community events led by others -Develop and grow an online community of teachers in CS. -Collaborate with others to submit one or more grant applications. -Support demonstration opportunities for others -Consider potential for virtual summit	-Promote the Hour of Code Support community events led by others -Develop and grow an online community of teachers in CS. -Collaborate with others to submit one or more grant applications. -Support demonstration opportunities for others -Consider potential for virtual summit	-Promote the Hour of Code Support community events led by others -Develop and grow an online community of teachers in CS. -Collaborate with others to submit one or more grant applications. -Support demonstration opportunities for others -Consider potential for virtual summit

Table 4. Curriculum recommendations *(recommend revision in 3-5 years due to speed of new curriculum being produced in this content area)*

Recommended Curriculum Pathways for CS in K-12	During Transition Phase	Long-term
Elementary School (K-5)	Code.org Computer Science Fundamentals (courses 1-4) Follow up with Scratch, Tynker, Alice if interest indicates	Code.org Computer Science Fundamentals (courses 1-4) Follow up with Scratch, Tynker, Alice if interest indicates
Middle School (6-8)	Accelerated version of code.org courses 2-4, Project Guts, CS in Algebra, Robotics, App Inventor	Exploring Computer Science and/or new code.org MS option, with additional options such as robotics, online safety, etc
High School (9-12)	Exploring Computer Science, AP Computer Science Principles (CSP), AP CS course A (Java)	AP CSP and AP CS A (Java) with additional options available such as robotics, web design, cyber security
NOTE: Transition Phase refers to the period during which a school or district is adding computer science courses for all students. During this time older students will need to have the opportunity to develop the fundamental skills of computer science. After the transition phase, most students will have fundamental skills but schools and districts should consider offering a means for new students who come from a district or school with no common access to computer science to “catch-up”.		

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Table 5. Indicators of Success (Evidence of impact) for each strategy proposed for Phase 2 of the Mid-Columbia STEM Education Collaboratory project.

High Impact Strategies for CS in K-12	K-5 Indicators of Success	MS Indicators of Success	HS Indicators of Success
Professional Development	By Sept 30 , 2016 - 8 code.org workshops offered result in 150 or more teachers trained. 75% or more of trained teachers implement curriculum in their classroom (as measured by Code Studio). Workshops are offered with a variety of collaborators.	10 teachers trained in 2015-16 (robotics) and 8 or more express interest in additional MS trainings.	8 or more teachers participate in the CS4HS opportunity by summer 2016. 50% or more of attendees plan to implement AP CSP and gain support in their school or district.
Underrepresented Students in CS	Robotics and other options (Scratch) are offered after school at an additional 4 or more schools	Summer camps are held during 2016 in app design or cyber security OR After School programs in coding and cyber security are available to students from multiple schools	15-20 out of school sessions or one summer camp is held for 20 or more students by September 2015. More than 50% of participants report interest in pursuing additional CS opportunities
Other high impact strategies that deal with the purpose, policy, program, practice and partnership aspects of bringing CS into K-12	-Record participation in Hour of Code event locally. -Others request support for community events only as needed -Online community and in person network exist and are growing -At least one funding proposal submitted and receives positive feedback	-Record participation in Hour of Code event locally. -Others request support for community events only as needed -Online community and in person network exist and are growing -At least one funding proposal submitted and receives positive feedback	-Record participation in Hour of Code event locally. -Others request support for community events only as needed -Online community and in person network exist and are growing -At least one funding proposal submitted and receives positive feedback

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Final Notes

For Phase 2 of the Collaboratory project the following challenges and opportunities have been identified.

Expected Challenges:

- Lack of qualified substitute for teachers may limit teacher participation in day long professional development experiences. To address this issue it is suggested that workshops occur in off-school hours whenever feasible.
- Computer Science certification requirements will be addressed in the next 12-18 months. This could impact growth of computer science education as very few teachers have formal education in computer science. To address this issue it is recommended that the Collaboratory work with those we know engaged with the work to monitor possible impacts and contribute to the planning when possible.

Potential Opportunities:

- Several recent grant opportunities have focused on the integration of computer science ideas and practices with other content areas. This type of integration can also be helpful to teachers who want to include computer science but need to prioritize other content areas. It is recommended that opportunities to integrate CS ideas and practices into other subject areas be utilized whenever possible and that those integrations be shared broadly.
- The National Science Foundation is funding work in Broward County, FL on the integration of computer science and other content areas. The Collaboratory has an established relationship with the research group assisting with the work. It is recommended that this work be monitored as a potential area to collaborate more broadly and to bring new tools to teachers in our region.
- Phase 1 of the project identified a broad set of resources that teachers could employ in their classrooms. It is suggested that either phase 2 or a future phase of the work create a repository of resources – vetted or not (but with potential), and request reviews by others in the Collaboratory as means of moving from not vetted to vetted. These resources would be identified in the categories of K-2, 3-5, 6-8, 9-12, adult learners, informal, and other. The Collaboratory vetting focus should be on the K-12 materials, but also acknowledge other resources that may currently have a purpose for K-12 education, including professional development for educators at all levels. Once vetted these resources could be shared on the Collaboratory website.