Computer Science Standards Input Meetings: Summary of Findings

Submitted by:

Education Commission of the States
December 9, 2016

Background

During the 2016 legislative session, the Colorado General Assembly passed House Bill 16-1198, which requires the Colorado Department of Education (CDE) to develop academic standards for computer science for secondary students during the next standards revision cycle. Pursuant to 22-7-1005(6), the state must review and revise the Colorado Academic Standards on or before July 1, 2018.

CDE conducted three listening sessions across the state to solicit input on the content of the computer science standards and the standards development process. In September 2016, CDE issued a request for proposals (RFP) to identify a vendor to assist in these listening sessions. In response to the RFP, CDE contracted with Education Commission of the States (ECS) in October 2016 to jointly conduct three in-person stakeholder input sessions, one each in Pueblo, Denver, and Grand Junction. Sessions were facilitated by ECS, and ECS and CDE staff collaborated in serving as facilitators and note takers. CDE conducted a fourth listening session via webinar.

ECS was contracted to deliver a final report summarizing key highlights from the stakeholder sessions.

The present report provides a summary of input from the three regional meetings and webinar. The report consolidates input across meeting sites, grouping responses by the following key discussion items put forward to stakeholders at each session:

- Suggested components of Colorado's computer science definition
- Indicators of success:
  - What would success look like for K-12 computer science education in Colorado as a result of these standards?
  - Five and 10 years from now, what would we see happening that demonstrates we are on track to accomplish our goals?
- Guiding principles: *CDE proposed as guiding principles: transparent, inclusive, research-informed, consistent with statutory requirements, and asked*:
  - What are your thoughts on these principles?
  - What other principles might inform the process?
- What are the most important issues for the committee [establishing voluntary computer science standards for secondary students] to address?
- What resources should the committee utilize?
- What should be the composition of the committee?

For K-12 and postsecondary stakeholders only:

- How should Colorado approach the development of courses that may count for mathematics or science high school credits?
- If districts were to move forward with offering graduation credit for computer science, what issues would we need to address?
- What other issues or questions do you foresee related to this?

Suggested components of Colorado's computer science definition

Common themes for Colorado's computer science definition emerged across sessions. These fell into the broad categories of:

- Computational Thinking
- Computing Systems
- Contexts and Uses
- Digital Citizenship

Participants quickly extended beyond these themes into key concepts underlying each. The section that follows identifies these underlying concepts that surfaced across sites.

Computational Thinking

- **Linearity and logical approaches, including algorithmic thinking**: Participants heavily stressed the importance of helping students understand the importance of computational thinking and develop thought processes to allow them to problem-solve in a linear, step-by-step manner. Specific (and interrelated) elements stakeholders cited as critical components: algorithmic thinking and algorithmic application [some participants used "computational thinking" and "algorithmic thinking" interchangeably, while others argued one was a subset of the other], mathematical computation and mathematical skill sets, systems thinking, and decomposition, i.e., breaking down a large problem into smaller, solvable elements, and arranging the logical order in which to solve them.

  There was some disparity among participants on the emphasis and approach to algorithms within computer science. One Pueblo participant argued that there should be a focus on algorithms more than the computer (computer science may be taught without the hardware), while a Denver participant asserted that less focus should be placed on algorithms because computer science is changing, and as such, the way algorithms are being used is changing.
- **Coding and programming**: Coding and programming were also both cited extensively by stakeholders as key components of computer science education. This includes key elements of programs (mathematical computation, creating and modifying algorithms), and student awareness of (not necessarily skill in) common coding and programming languages.
- **Problem-, project- or inquiry-based learning and critical thinking**, **including in "real-world" applications**: Participants emphasized that computer science should expose students to real-world experiences (for example, product design and implementation), and prepare students to solve real-life problems through computer science applications. Some participants extended this concept, suggesting that students be able to *define* or *find* problems, and then work through them. A Grand Junction participant called out the importance of teaching students to re-evaluate mistakes and identify the results of those mistakes.

  Stakeholders also repeatedly noted that success in computational thinking requires more than just an ability to code or program, and cited these dispositions as also essential:

- **Creativity**: Creativity was identified as a critical element in multiple contexts:
  - Design process, i.e., the process of exploration, development, testing, implementation/application, use (including coding and application design)
  - Identifying solutions in problem- or inquiry-based learning, including student ability to solve a single problem multiple ways.
  - Thinking outside the box.
- **Determination and "seeing the big picture"**: A few stakeholders cited certain dispositions/habits of mind critical to success in computer science. These were articulated as: trial and error, embracing the ability to make and learn from mistakes, grit, persistence/perseverance, self-motivation, and seeing the big picture and how components fit into it (the inverse of decomposition).

Computing Systems

- **Network components, including hardware and software**: Computer science should familiarize students with the operation of network/infrastructure components (i.e., hardware and software), including:
  - Differences between hardware and software
  - The design of these tools
  - How hardware and software interact, including systems integration
  - Limitations/constraints of hardware and software.

Contexts and Uses

- **Postsecondary readiness and labor market alignment**: Some participants cited the importance of connecting computer science education with the skills students will need for postsecondary and workforce readiness. According to these participants, computer science should be business-focused, preparing students to earn certifications and fill tech sector job needs, and provide a pipeline to these careers.
- **Collaboration**: A few participants suggested teamwork skills in computer science education should be intentionally integrated. One Denver stakeholder noted such collaboration should be student-to-student as well as with business partners.
- **Inclusiveness in computer science learning environments**: A handful of Denver participants in particular stressed the importance of creating welcoming environments in computer science programs that are inclusive of females and students of color.
- **Global perspectives**: This extends the real-world applications mentioned above under "Computational Thinking" to questions on U.S. vs. international comparisons on specific aspects of computing, including global communication and the evolution of business and technology.

Digital Citizenship

Some stakeholders proposed that the following elements with broader societal implications be integrated into the Colorado definition of "computer science":

- **Ethics/ethical use:** Students need to understand the ethical issues around coding and program writing, i.e., the right vs. wrong way of using computer science, and develop positive computer ethics.
- **Safety/security**: Including cybersecurity.

- **Role within society/societal impacts**

While the elements stakeholders cited under these four categories may extend beyond the scope of a Colorado definition of computer science, they likely point to components for the standards development committee to consider for inclusion in the draft computer science standards.

Indicators of success

Stakeholders were asked two questions:

- What would success look like for K-12 computer science education in Colorado as a result of these standards?
- Five and 10 years from now, what would we see happening that demonstrates we are on track to accomplish our goals?

Stakeholders across sites identified a number of indicators of success. These may be grouped into the following categories:

- The standards themselves
- Enhanced student knowledge and dispositions
- Changes in students' college and career choices and success
- Changes in schools and staffing
- Improvements in Colorado's economic/workforce development

Many stakeholder responses did not distinguish between "success" and what the landscape would look like five and 10 years from now. As a result, in most instances responses to both questions are combined below.

The standards themselves

A few stakeholders commented that "success" would be measured by the very standards themselves. Responses here include:

- **Adaptability of standards**: Given rapid changes in technology, some stakeholders suggested that "success" would include that the standards developed through the current process are relevant in five years. The standards must be adequately flexible (not too general, not too specific) to adapt.

Enhanced student knowledge and dispositions

Specifically, stakeholders mentioned:

- **Student mastery and application of computer science skills, including in real-world contexts**: A key measure of success to many stakeholders is that students in general are comfortable with basic computer science principles and skills. These skills might include coding/programming, computational thinking, basic knowledge of computer languages, including programming and other activities in the elementary grades, in order to teach students linear thought processes. Students would be able to apply skills to solve real-world challenges in their communities. One Denver participant suggested that five and 10 years out, students will have had purposeful opportunities to solve problems creatively and to apply knowledge from other domains.

- **Adaptability of skills:** A few stakeholders mentioned the importance of not just student acquisition of computer science skills, but that students might be adaptable and flexible so as to apply these skills to a variety of areas and solve problems in diverse settings.
- **Development of soft skills:** These include:
  - **Communication skills**
  - **Problem-solving skills**: Students are able to locate information to find answers, and solve problems, including in multiple ways and in situations where they have to backtrack and revise thinking where a first attempt was not successful. Students can use a language to create an algorithm to solve problems. One Pueblo participant suggested "success" could include project-based learning in which students apply computer science skills to address community challenges.
  - **Collaboration skills**: Students are able to work as a team.

A number of participants underscored that "success" would include the introduction of students' computer science knowledge and skills in the early elementary grades, with a ramping-up of expectations in the middle grades, in order to prepare students to achieve mastery of essential computer science knowledge and skills in high school.

Changes in students' college and career choices and success

- **Student awareness (including early awareness) of computer science job opportunities**: Participants mentioned that to elevate computer science as a college and career option, students will need early exposure to computer science, to understand what it is and what they can do with it. "Success" would include students seeing computer science as a potential career path. Some stakeholders proposed identifying or increasing computer science career pathways, including from high school to postsecondary.
- **Increase in number of computer science majors, certifications/degrees completed:** This would include greater numbers of female and underrepresented minority students pursuing postsecondary credentials in computer science.
- **Increase in number of Colorado youth pursuing computer science careers**: Some stakeholders added that "success" would include increasing the number of Coloradans prepared to enter high-wage careers immediately after high school.

Changes in schools and staffing

Stakeholders cited a diverse array of school and staffing measures that would indicate success for K-12 computer science education in Colorado as a result of the standards. These include:

- **Implementation of computer science standards:** Stakeholders repeatedly cited that one measure of success would be broad adoption and implementation of the voluntary computer science standards across the majority of (if not all) Colorado districts.
- **Offering of computer science in schools:** To many stakeholders, "success" would include an increase statewide in computer science courses offered – primarily in high schools, but to some extent in the middle grades. Although some argued against stand-alone computer science courses in the elementary grades, stakeholders suggested a measure of success might be increased exposure in the early grades to basic computer science principles, potentially via integration of computer science into core subjects in the elementary grades.
- **Increased enrollments (and greater equity in enrollments) in computer science courses:** Multiple stakeholders noted a measure of success would be not only increased student enrollments in high school computer science courses, but larger numbers of female and underrepresented minority students enrolees.

- **Advanced Placement (AP) and concurrent enrollment computer science:** A few stakeholders suggested "success" might include increases in:
  - The number of sections of AP computer science being offered
  - The number of high school students taking and passing AP computer science exams
  - Increased computer science course enrollments via concurrent enrollment. A few participants suggested a measure of success would be an increase in students finishing high school with a certification or associate's degree in computer science.

  A Denver participant suggested a measure of "success" would be that concurrent enrollment and AP computer science are universally possible, recognized, and valued.
- **High school graduation requirements**: A measure of success for some stakeholders would be seeing more high schools allowing students to apply computer science toward completion of graduation requirements in math, science, or foreign language (and more students taking advantage of this option). In this instance, "success" may include placing the choice to apply computer science toward fulfillment of math or science credits in the hands of students, rather than parents or administrators.
- **Integration of computer science into other disciplines – and requisite basic teacher knowledge of computer science across disciplines:** Stakeholders noted that, in order for teachers across grade levels and across the curriculum to be comfortable integrating computer science into their subject-area instruction, these teachers would need to be equipped with some basic understanding of (if not expertise in) computer science. Teacher preparation and professional development programs would need to be retooled to transmit these knowledge and skills. One Denver participant noted that infusing computer science into other disciplines would make computer science more authentic and meaningful to students.
- **Greater number of qualified computer science teachers**: According to many stakeholders, a key metric of success would be an increase in the number of qualified computer science teachers, particularly at the high school level.
- **Adequate staffing of computer science teachers in schools**: Adequate staffing of teachers goes beyond an increase in the number of qualified computer science teachers – this measure of success would mean that districts would not be impeded in the number of sections of computer science they could offer because of a lack of qualified teachers, even if the total number of qualified teachers had increased in the district.
- **Business partnerships, including through work-based learning opportunities:** A few participants indicated "success" would include more education-industry partnerships. Such partnerships could extend student opportunities for hands-on learning, apprenticeships, and internships, as well as business partnerships to assist with computer science instruction and internships/apprenticeships.
- **Rural involvement:** Under this measure of success, rural schools are also offering computer science.

Improvements in Colorado's economic/workforce development

- **Filling job needs:** Many stakeholders noted "success" must include a closing of the demand/supply gap in Colorado jobs requiring computer science. More specifically, success would address increasing job placements:
  - **In computer science occupations and jobs requiring substantial computer science skills:** Some participants suggested that "success" would mean an increase in the number of Colorado students filling good Colorado jobs either in computer science occupations or jobs that require the use of computer science (such as communications, health care, engineering). Students might be prepared to enter these jobs immediately after high school graduation, or after completing an associate's or bachelor's degree.

- **Across occupational sectors:** Some suggested that a measure of "success" would be that students understand how to apply computer science knowledge to industries generally, and have the computer science tools to use within any career, not just a computer science occupation.
- **Across Colorado demographics:** Regardless of whether Colorado jobs are in computer science or other fields, stakeholders maintained a measure of success would be that the demographics of Coloradans filling those jobs mirror the demographics of the state.

Guiding Principles

During each of the input-gathering meetings, CDE staff put forward the following guiding principles to participants:

- Transparent
- Inclusive
- Research-informed
- Consistent with statutory requirements

Participants were then asked:

- What are your thoughts on these principles?
- What other principles might inform the process?

The section that follows summarizes participant responses to these questions.

What are your thoughts on these principles?

Many stakeholders commented that they liked all principles listed. Additional thoughts from stakeholders on each of the guiding principles:

Transparent

- **Immediate and comprehensive communication**: Communication should be shared with stakeholders as things happen, and should be thorough.
- **Proactive communication**: Many stakeholders urged those in the standards development process to be proactive with communication – "transparency" shouldn't mean that information is available only if you search for or ask for it. Some also pointed to the importance of targeted outreach and ongoing support to rural educators in particular.
- **Public input/ongoing feedback loop**: Some stakeholders underscored the importance of a feedback loop throughout the standards development process. This feedback loop would provide ongoing information and an input mechanism for those who are not part of a committee or unable to travel to a public meeting. A few stakeholders specifically stressed the importance of posting drafts of standards for public comment throughout the process, from draft construction, to draft amendment, to adoption. SurveyMonkey was proposed as one means to facilitate public comment on drafts. Some stakeholders commented that the

process should explicitly solicit and incorporate feedback from rural district stakeholders to ensure their voices are invited and heard.

- **Documenting processes**: A few stakeholders expressed the importance of documenting processes, in order to track and sustain focus throughout the standards development process. These stakeholders noted the standards development process needs to include deliverable action items.

Inclusive

- **Confusion on the term itself, implications for equitable access for students**: The term "inclusive" in this context generated a certain degree of confusion among some stakeholders. While CDE intended for "inclusive" to signify that the standards-development process will be inclusive, some stakeholders interpreted the term to mean the standards themselves are intended to be inclusive/accessible to students, while others thought "inclusivity" meant all students should have the opportunity to learn computer science.
- **Role groups:** Stakeholders recommended the following role groups be included in the standards development process (listed in no particular order):
    - Students: A number of stakeholders elevated the importance of student voice in the standards development process.
    - K-12 – teachers and other representatives: Specific suggestions for representation:
        - All district types – rural, suburban, urban – should be represented.
        - Include schools that do not offer computer science classes
    - Parents
    - Legislators: Their inclusion may facilitate changes to the statute governing computer science standards.
    - Business/industry representatives: Their voice will ensure standards are aligned with industry needs, and that the standards reflect the skills and knowledge students need for workplace success.
    - Higher education representatives: Their voices are needed to ensure seamless student transitions from secondary to postsecondary computer science.
    - Professional organizations
    - Other community members
        - AP and College Board representatives
        - Some stakeholders suggested the importance of including individuals skilled in ethics in the standards development process, given the role of security and ethics in computer science, and presumed inclusion of these issues in the computer science standards.

Some stakeholders pointed out that "diverse thinkers" should be actively and proactively involved, that the standards development committee cannot only include those with the time to attend a meeting. Stakeholders highlighted the value of greater use of technology to remove the barriers of time and distance to an inclusive process.

- **Inclusive communication, including with legislators**: Some stakeholders raised the importance of communicating with a view to equity and inclusiveness. Regardless of whether legislators are included in the standards development committee, communication with legislators is essential.

- **Collaboration**: Some Denver stakeholders specifically proposed that "inclusive" be expanded to "collaborative," to message that the group is constructing something together and not simply engaging in a discussion. Other Denver stakeholders emphasized the importance of "consistent collaboration."
    - **Rural**: Inclusivity to some stakeholders meant including representatives from across the state, including rural areas.

Research-informed

This guiding principle in particular was embraced by a number of stakeholders. Additional thoughts:

- **Look to other states and organizations, including existing standards**: Stakeholders believed that to avoid re-inventing the wheel and to ensure the best possible standards are crafted, the standards development committee should look to ideas and expertise beyond Colorado. Specifically, the committee should consider existing high-quality standards, including state, national, international, and association- and industry-based standards. A few stakeholders even suggested that Colorado collaborate with one or more states that are also in the process of developing computer science standards.

Consistent with statutory requirements

The statutory requirements that the computer science standards be "voluntary" and "secondary" were not well-received by a number of stakeholders. Specifically:

- **Voluntary**: Some stakeholders wondered why the computer science standards are voluntary, when state standards for the other ten subject areas are mandatory. These stakeholders encouraged lawmakers to make local adoption of computer science standards mandatory.
- **Secondary**: Numerous stakeholders cited the importance of extending the scope of the standards to K-8 or even preK-8. Key reasons for extending the scope of the standards are:
    - **Developing knowledge and skills students will need in grades 9-12**: Numerous stakeholders raised the concern that students will need exposure to computer science concepts in elementary and middle grades in order to be prepared for high school computer science.
    - **Increasing student diversity:** Students make critical decisions about what they're "good at" and "not good at" well before high school. Many stakeholders articulated the hope that extending computer science standards into the earlier grades will help female and underrepresented minority students in the elementary and middle grades see themselves as capable of pursuing computer science in high school and beyond, and thus increase diversity in computer science course enrollments at the high school level.

  One stakeholder suggested the skills might shift from the high school to lower grades over time, to allow more cutting-edge learning to take place in high schools.

What other principles might inform the process?

Stakeholders had numerous additional recommendations:

- **Clear definition of computer science before standards are developed**: A group of Grand Junction stakeholders underscored that a definition of computer science should be established before computer science standards are developed.
- **Keep what's best for students at the center**: This would include student pathways through and out of high school.
- **Concept-based rather than skills-based:** Stakeholders argued that a concept-based rather than skills-based approach will increase the likelihood that the computer science standards will remain relevant as technological changes emerge. Stakeholders held up as models for concept-based standards the International Society for Technology in Education (ISTE) standards and Advanced Placement (AP) Computer Science Principles course, both of which focus on concepts and strategies, rather than skills that will change over time.
- **Asset-focused:** Colorado should highlight and build off what it already has.
- **Revisions to the standards:**
    - **Standards revision cycle**: A few stakeholders argued that, given the rapid pace of technological changes, including changes to hardware and methods of teaching technology, a six-year revision cycle for computer science standards is unrealistic. Some stakeholders proposed a two-year revision cycle for computer science standards.
    - **Continuous revision process**: Other stakeholders, while not calling for a shorter revision cycle, pointed to the importance of keeping in mind how computer science will evolve, and suggested a continuous revision process.
    - **Fluidity**: To help address the challenges posed by constantly-changing technology, some stakeholders encouraged the standards to be fluid and able to evolve as technology evolves.
- **Consider impact to classroom practitioners:** This may include needs related to recruiting highly-qualified staff, curriculum development, and assessment development (particularly in rural areas).
- **Guidelines to support standards implementation:** A few stakeholders suggested standards implementation might be facilitated by the issuance of flexible, forward-thinking standards implementation guidelines that identify solutions to potential district-level implementation challenges. Implementation guidelines might:
    - Create a network for sharing resources and best practices
    - Provide sample content units as resources
    - Offer suggestions on how computer science can be integrated into other disciplines for more robust implementation.

Stakeholders suggested that absent these implementation guidelines, districts might see the voluntary standards as an "unfunded mandate."

- **Connections to math, science, real-world and workforce**: A few stakeholders suggested that the standards draw connections between computer science and math and science (or even integrate these to a certain degree). Making standards explicitly cross-curricular may facilitate adoption and implementation in rural schools in particular. Stakeholders also proposed that the computer science standards draw connections to real world applications and the workforce, in order to meet pipeline demands in the community.

What are the most important issues for the committee to address?

K-12

K-12 educators raised a broad array of topics. These include, in no particular order:

- **Establishing a definition of "computer science"**: Before launching into the creation of computer science standards, stakeholders need to be in agreement on what "computer science" is.
- **Voluntary nature of standards**: Some raised the concern that the "voluntary" nature of the computer science standards would broaden an existing divide between the "haves" and "have-nots." Students in the "haves" districts will have exposure to rich computer science experiences aligned to the standards, while students in districts with lower funding bases and a lack of technology will miss out on these experiences and be unprepared for the high-tech careers their more affluent peers receive training for.
- **Placing students at the center**: One participant specifically suggested the standards be student-driven, not grade-level-driven.
- **P-20 alignment**: Recommendations in this area fell into two categories:
    - **Creation of computer science standards for earlier grades**: This may be extending the standards into middle grades, or further broadening the scope to P-8 or K-8. The main concern for stakeholders was ensuring students are prepared for high school-level computer science.
    - **Alignment of secondary standards with postsecondary expectations**: One stakeholder cautioned, however, against too great a focus on postsecondary.
- **Not reinventing the wheel**: The committee should consider standards that have already been adopted by other states and national organizations, as well as available data and research on computer science.
- **Relevance/fluidity/adaptability:** Stakeholders concerns on this issue can generally be grouped into the following three categories:
    - How in the face of changing hardware, programs, apps, etc. will the standards stay current?
    - The need for the standards to stay current and be regularly updated
    - (Most commonly mentioned of the three): Rather than aiming to update the computer science standards on a continuous basis, the standards should be "foundational" and "broad," written to be descriptive rather than prescriptive, which will make them flexible/fluid/nimble. This will ensure the standards are adaptable yet still relevant as technological changes occur.
- **Teacher capacity and supports:** Specific issues raised include:
    - Finding/preparing an adequate supply of teachers to teach computer science courses
    - Skill-based competency considerations for teachers
    - Coherent pedagogy for teaching computer science courses
    - Potential of blended or online courses to facilitate course delivery, particularly in rural areas.
- **Technological capacity:** Inequities in technology across the state was sometimes, but not exclusively, raised in relation to rural districts. Questions include:

    - How will we address discrepancies in access to technology to provide equity in access to these courses?
    - How will funding keep pace to keep up with new technology as it becomes available?
- **Integration of other disciplines:** Some stakeholders wondered if or suggested that the computer science standards be interdisciplinary, and embedded in other disciplines
- **Role of business/industry:** Stakeholders want to ensure the standards are aligned with business/industry needs, to prepare students for future careers.

Postsecondary

- **Not reinventing the wheel**
- **Alignment of standards with postsecondary expectations**. One stakeholder specifically advised the committee to be cautious about assumptions of AP computer science alignment, and that two- and four-year institutions do not yet share a common GT pathway.
- **Focus on broad student participation**
- **Balance of breadth/depth in standards**
- **Scalable/implementable in diverse school contexts**
- **Determining what defines "success"**: Denver postsecondary stakeholders suggested the standards committee make the standards measurable so as to be able to define success. Is it computer science for all, or a pathway for future computer science majors? Stakeholders also urged the development of "off-ramps" for students who exit the pathway along the way.

Business, other

- **Designed with business/industry preparation in mind, business buy-in**: The computer science standards should be back-mapped from what students will need to know and be able to do upon workplace entry, to help students achieve their career goals. Businesses need to feel comfortable with the standards, and that they have something to be gained by approval and implementation of meaningful computer science standards.
- **Foundational/fluid standards**:
    - **Foundational**: The standards should start with and map backward from the primary goals.
    - **Fluid**: The standards should embrace an evolving market. The standards should recognize that the foundational skills of computer science do not change, but how it is taught will evolve.
- **Placing students at the center:** The standards should prepare students to be well-rounded, and be driven by student needs.
- **Equity:** It is critical that the committee emphasize bridging gaps, creating equity and access, in order for the computer science standards to be meaningfully scaled statewide. The standards should be developed with a view to creating an equitable space for students to develop computer science skills.

What resources should the committee utilize?

K-12

- **Existing standards**

- **District:** Computer science standards in some Colorado districts (BVSD, Jefferson County, Douglas County were explicitly mentioned)
- **Colorado:**
  - Colorado math and science standards
  - Colorado Department of Education 21st Century Skills Standards
  - Colorado Technology Association (CTA)
- **State:** Existing best-practice standards in other states should be adopted or modified. Arkansas' and Texas' standards specifically were called out. The committee might also look at already established practices in other states.
- **National standards:**
  - K-12 Computer Science Framework
  - Next Generation Science Standards (NGSS)
  - International Society for Technology in Education **(**ISTE)
  - Computer Science Teachers Association (CSTA)
  - IT certification program standards
  - Various career/technical education (CTE) association standards
  - Association for Computer Machinery (ACM)
  - Institute of Electrical and Electronics Engineers (IEEE)
  - International Technology Education Association (ITEA)
  - American Association of School Librarians (AASE) (their standards include a section on ethics in information literacy/digital citizenship)
  - AP Computer Science Principles
- **International standards**

One stakeholder suggested cross-referencing the standards to recognize interdisciplinary learning opportunities.

- **Colorado postsecondary institutions**: Including syllabi from postsecondary computer science courses
- **District, teacher, and student surveys**
- **Other Colorado and national organizations**:
  - Compute Colorado Task Force
  - Colorado Workforce Development Council
  - Code.org
  - College Board: AP computer science principles and AP computer science A (to design standards to prepare students for those courses)
- **Education research**
- **Business/industry resources**: Industry standards (i.e., Google) may be useful, along with job outlook forecasts, and analyses of future workforce needs.
- **Cybersecurity experts**

Postsecondary

- **Existing standards**: CSTA, ISTE
- **Postsecondary textbooks**: Share knowledge about the textbooks and materials postsecondary institutions use
- **Postsecondary faculty/institutions**: Use community college instructors as a resource. Ask four-year institutions what they're using to structure their programs. Survey higher education on the deficiencies they're seeing in incoming students. This might include reaching out to for-profit providers such as Galvanize and SecureSet.
- **Other organizations:**
  - Colorado Technical Association (CTA)
  - National Center for Women in Technology (NCWIT)
  - Colorado Regional Business Alliance
  - Colorado IT initiative: One stakeholder mentioned a statewide IT initiative, a partnership between the Colorado Workforce Development Council and the Colorado Department of Labor, as a driver in computer science workforce/careers in the state.

Business, other

- **Existing standards**: Including state standards
- **Industry certification lists**
- **Code.org**
- **Postsecondary institutions:** Higher education groups should be very clear on what a student should be able to do upon postsecondary entry.
- **Business hiring processes**
- **Annual talent report updates**
- **Colorado Workforce Development Council**: Can provide resources and context in terms of what has worked and what hasn't.

What should be the composition of the committee?

K-12

- Students (current or former)
- Parents (some participants suggested these could be business experts who are also parents, teachers who are also parents)
- School counselors
- K-12 educators from
  - Across the state (with emphasis on rural)
  - Across grade levels (including elementary and middle grades)
  - Across subject areas (not just computer science teachers but also math, science, CTE, STEM, language arts, potentially other subjects)

- K-12 building and district administrators (some commented their voices are valuable in weighing in on implementation issues)
- District IT specialists
- District instructional coordinators or content standard specialists (professionals who will understand and be responsible for implementing the standards)
- Business/industry (medical, automotive, engineering specifically called out), including:
  - Local employers
  - Entrepreneurs (start-ups)
  - Diverse perspectives, such as rural vs. urban business, or big company vs. small company)
  - Women in technology (female engineers)
- Postsecondary representatives, including:
  - Computer science and engineering faculty
  - College student who has gone through a computer science program, and knows what would have been of benefit to him/her
- Education school representative(s)
- Representatives of non-traditional secondary education options (tech schools)
- CTE representatives
- Diverse voices, including
  - Rural representatives
  - Geographic representation from across the state, including Western slope
  - Resource-rich vs. resource-poor
- Legislators, other government representatives
- Congressional members (non-voting)

Postsecondary

- K-12 teachers and administrators from all grade levels
- Higher education instructors/experts (one site suggested 60% postsecondary representation), including
  - Community college instructors
  - Computer science department heads
  - Deans
- Industry representatives
- NCWIT
- State cybersecurity representative(s)

Input from Texas, Washington State, Charleston (South Carolina)

Business, other

Business and other representatives suggested that the committee consist of a **core group of primarily educators**, but that additional key stakeholders delve into the process as needed to provide input:

- **CTE representatives:** It was observed CTE is a underused resource at this point – computer science is CTE, in a new frame of reference.
- **Postsecondary representatives**
- **Business/industry leaders**: These should be involved in elements they will be prepared to provide input on. Business needs to better understand how they fit into the standards development process, and be invited to participate when appropriate.
- **Non-traditional education providers**: Galvanize or similar programs

A structure in which not all members attend all meetings will require:

- A set of notes all participants can access
- An individual who can reach out to all stakeholders, all stakeholder groups to bring/keep those coming in to, out of the process up to speed.

K-12 and Postsecondary Only:

How should Colorado approach the development of courses that may count for mathematics or science high school credits?

K-12

Course content/approach:

- Courses should include mathematical computation
- A coding/basic computer science course needs to be included early
- A computer science course would need to cover enough math and science content to justify the equivalency to math and science requirements.
- Consider fundamental high school-level skills than can be integrated.
- Consider existing programs/courses (i.e., Bootstrap)
- Consider AP computer science principles
- Consider personalized learning, interdisciplinary approaches (math and computer science, science and computer science, rather than an either/or siloed mentality).
- Develop as a STEM course
- Look to approaches in other content areas (i.e., traditional and integrated mathematics)
- Ensure a course covers a portion of math and/or science standards.

How courses count:

- Look to what other states are already doing.
- Allow computer science or coding courses to fulfill a foreign language credit.
- Student should be able to choose how a computer science course counts.
- Computer science could count toward two or three types of credit chosen from high school, postsecondary, CTE.
- If the standards development committee identifies the primary computer science domains, districts might be able to parse out how the domain embeds in current courses, thereby allowing computer science standards to apply to multiple courses. Then a district could consider what the other subject/computer science content threshold would be for a course to fulfill the other subject's credit requirement.
- Could awarding of course in a non-computer science subject be a two-part process? For example, a student who takes a coding class could then apply those skills in a subsequent class in which coding is applied in a problem-based or project-based context. The student would earn math or science credit in the subsequent class while applying coding knowledge and skills.
- Need to consider admissions requirements to Colorado public four-year institutions.

Other observations:

- Important to involve math and science teachers in these decisions.
- How can we show value in computer science applications that translate to math and science skills and real-world applications, to help math and science teachers embrace this shift?
- There should be flexibility and local decision-making in how computer science courses may count toward high school graduation requirements.
- Various teacher issues were raised, including appropriate credentials and who may teach courses that are applied toward math or science credit.
- Computer science certifications could potentially be an option for students to meet College and Career Ready Demonstrations for Graduation Guidelines. Doing so might offer more detail on specific course requirements. (Additional observation that computer science certifications would continually be changing.)

New questions raised

For some participants, the question of developing courses that count toward math or science high school credit raised further questions, such as:

- Why does it have to be math or science credit? Why can't a course count as computer science credit?
- Is the course a separate computer science course that counts for math or science, or a course integrating computer science into a traditional discipline such as math or science?
- Would districts want to see sample course options for local decision-making? Alternatively, a crosswalk or integration document illustrating pairings (similar to the Common Core State Standards document that shows English and math standards connections to science/social studies)

Postsecondary

- Postsecondary already has course-level competencies for computer science.
- A Venn diagram showing existing overlap between computer science and math/science course expectations would be useful.
- Look to what other states are already doing re: awarding math or science credit for completion of computer science coursework.

If districts were to move forward with offering graduation credit for computer science, what issues would we need to address?

K-12

- **Substitution for math or science**: Some stakeholders opined that computer science should be taken concurrently with, not as a replacement for, math or science. A few stakeholders suggested a student be required to fail a math or science course before the student is allowed to apply a computer science course for math or science credit.
- **Course rigor/implications for college- and career readiness**: A few stakeholders expressed concern that computer science courses would need to prepare students to be college- and career-ready, and that students completing computer science in lieu of a math credit might not complete adequate levels of advanced math to be college- or career-ready. Algebra II should be considered a prerequisite for computer science courses. Some stakeholders also wondered what level of computer science would be offered at the high school level (not just coding or the basics).
- **Infrastructure capacity**:
  - **For students**: Some students are already struggling with the credit they have to complete. How could computer science be fit in – is reconfiguring requirements in all content areas an option or requirement?
  - **At district level**: A few stakeholders noted a need to identify the resources districts would need to offer computer science, identify ways to fit computer science into the curriculum (schedules of course offerings are already full), and create assessments.
  - **At school level**: Some stakeholders wondered about infrastructure capacity for increased computer science course-taking, including security and firewalls, and the risk of too much security.
- **Buy-in**: Stakeholders noted that districts will experience pushback from math and science departments, as well as potential reluctance from parents to adopt computer science as a substitute for traditional graduation credits, which in turn could impede district buy-in.
- **Communications and advocacy**: Alternatively, stakeholders noted the importance of providing information/communications about the benefits of completing computer science coursework. Some stakeholders suggested district-level committees to advocate for acceptance of computer science credits as a substitute for math or science credits in high school graduation requirements.
- **Staffing and compensation issues**: How will postsecondary institutions prepare and how will districts attract teachers to teach computer science courses? How will they provide adequate professional development? What compensation issues would need to be addressed?

    - **Alternatives**: Could online courses, courses taught in partnership with community colleges be alternatives, particularly in rural areas?
- **Postsecondary admissions**: If computer science is taken to fulfill math, science, or foreign language graduation requirements, four-year postsecondary institutions would need to amend admissions requirements so that computer science could fulfill those credit requirements.
- **Career pathways and certifications**: Some stakeholders suggested pathways through computer science would help all types of students, while others proposed pathways from high school to career especially for students not interested in college. Stakeholders also advocated for making industry certifications available to high school students, noting it would empower students to leave high school with a credential and not just CTE credit in computer science. Stakeholders also commented that students need to be aware of the types of jobs available to them if they complete computer science coursework.
- **Perkins funding and CTE**: If computer science is integrated into high school graduation requirements, there is a risk of losing Perkins funding for CTE.

Postsecondary

The math underlying the computer science courses should focus on problem-solving and logic. Postsecondary stakeholders voiced a preference for students taking math classes in high school than computer science courses (computer science can be taught to students who already know math, but teaching computer science to students who do not know math is problematic).

What other issues or questions do you foresee related to this?

K-12

- **Ensuring equity and access**: Some stakeholders commented these need to be at the forefront of conversations about computer science standards adoption and implementation. One Denver participant commented, "How do you scaffold students, structure courses to meet the needs of those [students who] have the skills and those [who] do not?"
- **Considering the earlier grades, and sequencing of expectations**: A few stakeholders commented on the need for a roadmap to prepare students for secondary-level computer science. Unlike math, computer science, say these stakeholders, does not have a sequence of topics that build. A sequence is needed to scaffold levels of competency. Further, all grade levels should integrate computer science terms into comparable tasks (i.e., process writing = writing an algorithm).
- **Importance of interdisciplinary models and flexibility**: Some stakeholders noted the importance of an interdisciplinary approach to integrating computer science standards into curriculum and instruction. They added that the standards should be written in a manner that they fit into the subject area that best fits, be it computer science, math, science, language arts, etc. Showing district leaders concrete examples of how interdisciplinary approaches can work may prove valuable.
- **"Values" question of replacing rather than adding:** A few stakeholders commented that math, science, and computer science coursework may to some extent be devalued if it is not concurrently taken but rather substitutes for credits in other subject areas.

- **Concurrent enrollment and certification partnerships**: Stakeholders remarked on the potential implications of integrating additional computer science courses into existing concurrent enrollment and industry certification partnerships with community colleges. For example, if some existing computer science courses were to be offered for concurrent enrollment, course rigor would need to be increased.
- **Staffing and licensure issues**: This may include an enhanced need for alternative certification approaches.
- **Out-of-school and informal learning opportunities**: A few stakeholders wondered how out-of-school and informal learning opportunities might be able to integrate the computer science standards.
- **Postsecondary admissions and course credit transfer**: One stakeholder suggested including computer science in guaranteed transfer (GT) pathways curriculum could alleviate student challenges.
- **Communications and buy-in**: Stakeholders commented on the importance of gaining buy-in from parents, content area teachers (particularly in math and science), district boards, and administrators for adoption of the voluntary computer science standards. Comments on these points were numerous, including:
    - If the standards are not mandatory, they may not be valued. How do you build support for something that is optional?
    - The significant importance of a communications strategy that is both horizontal and vertical.
    - A solid framework for standards implementation may alleviate district pushback, and make it less burdensome for districts.
    - What is the role of the Colorado Education Association (CEA)?
- **Implications for CTE funding**

Postsecondary

- **Perkins and secondary-level Career and Technical Act (CTA) funds**: These can be used to support elective courses. How courses are defined will determine whether courses qualify for funding.
- **K-8**: A plan or support for K-8 computer science is needed. Richard Charles in Cherry Creek's STEM Center can serve as a resource.