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Computer Science as a High School Graduation Requirement: Planning for Policy Implementation.

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Computer Science as a High School Graduation Requirement: Planning for Policy Implementation (Fundamental)

Abstract

Over the last decade the Computer Science for All initiative has led states to consider how to embed computer science (CS) education more deeply into the core course of study for K–12 students. Many states are now at an inflection point; efforts to support the voluntary integration of computing education into the curriculum have reached saturation. To achieve greater and more equitable reach additional policy levers, such as a high school graduation requirement, are being considered. Eleven states have created graduation requirements that include computer science. This report draws on in-depth focus groups with nearly 200 educators, administrators, non-profit leaders, workforce development representatives, parents and students in Massachusetts and with state CS leaders and advocates across 30 states to better understand what considerations arise when designing and implementing a CS graduation requirement including potential costs and benefits. This paper explores how a graduation requirement could be defined and supported. Important considerations include financial support, building teacher capacity, building pathways into middle schools and utilizing data to monitor and measure outcomes to ensure equitable implementation.

Introduction

The Computer Science for All initiative, launched in 2016, led states to consider how to embed CS education more deeply into the core course of study for K–12 students. CS skills are now essential in preparing students for future opportunities and navigating a world increasingly reliant on rapidly evolving technologies [1], [2], [3]. Students equipped with these skills possess significant advantages in both the job market and broader societal contexts [2], [4]. As the need to equip students with computer science skills intensifies, many states find themselves at a critical juncture. Initiatives aimed at voluntarily incorporating computing education into school curricula have plateaued and often fall short of addressing persistent disparities in participation based on gender, race/ethnicity, and income. To broaden access and promote equity, advocates for CS education are now considering alternative policy approaches, such as implementing a high school graduation requirement. All states now allow CS to count toward the cumulative credits needed for graduation, often as a math or science class [5]. Other states are requiring CS to be offered at every school in an effort to build capacity, or requiring it as part of the admissions standards into state-run higher education institutions. Since 2021, eleven states have created graduation requirements for high school students that include computer science, which vary in content and length and when they can be fulfilled (middle or high school, or just in high school). States that require CS vary widely in the number of courses that count towards fulfilling the requirement, ranging from 12 in Rhode Island to 70 in North Carolina [6]. Some states have repurposed an existing technology credit as a computer science credit, while others have added computer science into the existing credit structure. Many states, however, are creating policy quickly, sometimes with rapid implementation timelines that may compromise quality, equity and capacity.

Without official policy change, computer science programs may only reach certain members of the public — potentially exacerbating inequities. Policy initiatives codify reforms to our laws, regulations and institutions. Often existing policies may run counter to new discoveries and developments; therefore, policy change is required to enact new programs and requirements that apply broadly and ensure they are funded. Working in conjunction with grassroots efforts, policy reforms can reflect public opinion by having a far-reaching, sustainable impact.

In the 2022 Massachusetts Economic Growth and Relief Act (Chapter 268) [7], the Legislature asked for a recommendation on a graduation requirement for a foundational CS course. This was unusual as Massachusetts only had three statewide graduation requirements at the time (namely, four years of a physical education credit, a civics credit and passing the statewide comprehensive exam; in the 2024 state election Massachusetts residents voted to drop the comprehensive exam as a graduation requirement). Graduation requirements in Massachusetts are otherwise at the discretion of the districts, of which there were 399 in the state for the 2023–2024 school year. The Massachusetts Department of Elementary and Secondary Education (DESE) and Massachusetts public higher education institutions allow CS to count as a swap for a mathematics or science credit as part of their recommended program of study (known as MassCore) in high school (see Table 1).

Table 1: MassCore Credit Structure

MassCore Framework for High School Students		
Subject	Units	Notes
English Language Arts	4 Units	
Mathematics	4 Units	Including completion of Algebra II or the Integrated Mathematics equivalent. A mathematics course during senior year is recommended for all students. Students may substitute one unit of Computer Science that includes rigorous mathematical concepts and aligns with the Digital Literacy and Computer Science standards for a mathematics course.
Science	3 Units of lab-based science	Coursework in technology/engineering courses may also count for MassCore science credit. Students may substitute one unit of Computer Science that includes rigorous scientific concepts and aligns with the Digital Literacy and Computer Science standards for a laboratory science course.
History and Social Science	3 Units	Including U.S. History and World History.

World Language	2 Units	Of the same language.
Physical Education	As required by law (4 units)	“Physical education shall be taught as a required subject in all grades for all students” (M.G.L. c.71 §3).
Arts	1 Unit	
Additional Core Courses	5 Units	Other additional coursework (including Career and Technical Education) or any of the above.

Massachusetts has invested in expanding CS opportunities by providing credit-bearing opportunities, teacher licensure pathways and grant opportunities to districts to develop CS strategic plans. Massachusetts has made progress in expanding access to CS education through previous policy and mostly ad-hoc financial investment. Massachusetts is also a highly technology enabled state, with 99.13% of residents having access to broadband internet [8]. In 2019, the state started allowing students to substitute CS for a MassCore mathematics or laboratory science course [9]. This swap allowance did not have a significant impact on the number of students taking CS courses [10]. Despite these efforts, equitable uptake is stagnating, underscoring the necessity for equity-centered policies. Currently, CS participation in Massachusetts does not reflect the student population (Fig. 1). During the 2021–2022 school year, while 83% of Massachusetts public high school students attended a school that offered at least one CS course, only 7.9% were enrolled in such a course [5]. This enrollment number was lower among students of color, female students, and high needs students[1] [11].

In mid-2023, in order to understand the scope of a potential graduation requirement, the Massachusetts Department of Elementary and Secondary Education (DESE) commissioned an independent research team via a competitive process to study the opportunity and implications for a CS graduation requirement, and make recommendations to DESE about the appropriateness of a graduation requirement and any design considerations. As part of the recommendation process, DESE expressed a desire for broad community engagement through interviews and focus groups and an emphasis on the implications for equity. The research team had two objectives: 1) Understand the national context [6] and 2) develop a recommendation report drawing from lessons learned in other states and local perspectives.

The significance of this work goes beyond providing DESE with recommendations for designing and implementing a graduation requirement. The excitement and concerns expressed from constituents across Massachusetts and a review of existing state policies nationally will provide others interested in pursuing a broadening participation strategy through policy with an

[1]DESE uses the term “high needs”when the student is designated as either low income (prior to 2015, and from 2022 to present), economically disadvantaged (from 2015 to 2021), English Learner (EL) / former EL, or a student with disabilities. A former EL student is a student not currently an EL, but who has been at some point in the four previous academic years.

understanding of the complexity of designing a broad reaching policy in science, technology, engineering and math (STEM) focused education.

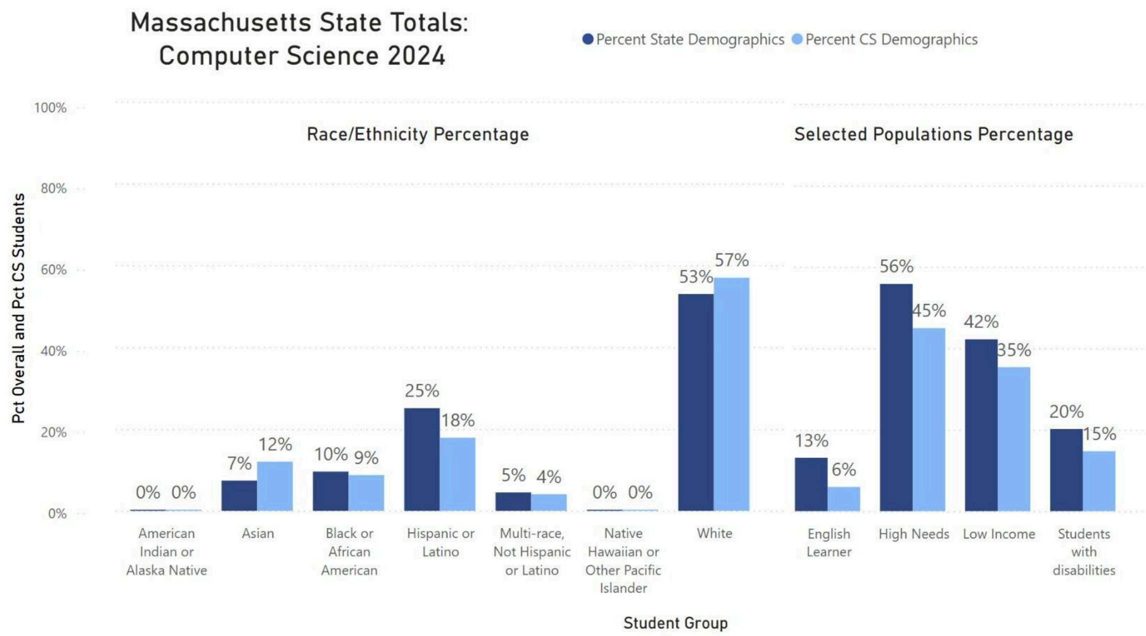

Figure 1: MA State Totals. Adapted from [11]

Methodology

To inform the first phase of this study, the research team produced a comprehensive landscape report that examined the rationale, language and design of CS graduation requirements across the country (9 states by the time the report was complete). The report was a result of a review of over 500 pieces of documentation including state plans, policy language, press releases and landscape reports. This report was used to engage stakeholders through a series of five interactive webinars covering the major themes of the report. These themes included: A summary of each state graduation requirement including how it was defined, timeline for implementation and financial support. The report also contextualized these findings against the states' vision for CS, how partners were organized for advocacy and implementation and how implementation is being monitored [6]. These webinars served as a collaborative forum for participants to examine key findings from the landscape report and gain insights into relevant policy models from other states. Each session encouraged active dialogue around the unique challenges and opportunities facing Massachusetts, with a particular focus on policy options, equity considerations, and potential state-level interventions to enhance computer science education. Policies presented include creating a legislative mandate (law), repurposing one of the elective credits under MassCore to CS, or creating a new option. Participants were also asked to reflect on the implementation timeline.

The webinars facilitated in-depth discussions covering how other states have implemented and funded a graduation requirement, the Massachusetts context for computer science education and policy, and a discussion of the pros and cons of policy action. The presentation also included equity considerations, initial ideas for how policies could be enacted, and the implementation context (for example, funding, professional development, etc.). This provided the background for participants to critically assess CS graduation policies from other states, consider their adaptability to Massachusetts, and brainstorm innovative policy solutions. Through a mix of verbal exchanges, written contributions, and collaborative virtual whiteboard activities, participants could express diverse viewpoints and respond dynamically to each other's ideas. This interactive approach enabled the collection of rich, real-time data, capturing a broad range of perspectives essential for shaping a responsive and inclusive set of policy recommendations.

Focus group protocols were developed drawing from the landscape report and the preliminary themes surfaced in the webinars. Different constituent groups were asked questions most relevant to their perspective. For example, teachers were asked about classroom contexts and professional development, superintendents were asked about administrative considerations and parents were asked about CS in the context of broader educational priorities.

The project team organized 18 focus groups to delve deeper into the implementation context and student experiences related to CS education. These sessions provided a more intimate setting for detailed discussions and exploration of specific issues faced by students and educators. During focus groups participants were presented with a definition of computer science, including the big ideas covered in the statewide Digital Literacy and Computer Science (DLCS) standards, and an overview of the current state of CS education in Massachusetts. This overview included a view of where CS is being offered and how many students are participating across the state and by gender, race/ethnicity, English learners, those with a disability and those with high needs; and also covered where CS fits in the current MassCore structure.

Between the webinars and focus groups, 200 individuals from across the state interacted with the project team or attended at least one type of session. Participants from over 41% of Massachusetts' K–12 districts were represented in the study. Participants included CS teachers, teachers of other subjects, school and district administrators, state education officials, education researchers, nonprofit leaders, parents, recent high school graduates (class of 2018 and later), and current students.

Efforts were made to ensure a diverse range of voices, particularly focusing on equity and inclusion. The study team generated a list of communities that would potentially be impacted by or concerned with a CS requirement such as special education advocates and families, English Language Learners and immigrant support centers, educators in other content areas, community organizers, service providers, out of school CS providers and religious organizations across the state. The study team reached out to 29 of these organizations or advocacy groups directly to invite them to participate though not all groups responded . It is important to note that participants did not receive external incentives to join the study.

Results were also shared through two facilitated webinars with the national Expanding Computing Education Pathways (ECEP) community, an alliance of 30 states including the territory of Puerto Rico who utilize a collective impact model to expand equity-explicit computing policies, pathways and programs. These webinars were designed to spark a broader discussion beyond Massachusetts about the implications of graduation requirements. These webinars allowed for multiple breakout groups, and each room was recorded and notes were kept by the facilitator.

Each webinar and focus group session was recorded and transcribed to facilitate thorough analysis to inform this recommendation report. Transcripts were coded to surface themes that could be used to inform policy development using an inductive approach, in which the researchers did not identify themes a priori. This thematic analysis helped in identifying key issues, challenges, and recommendations from the community discussions. Using an iterative process, the project team continued to develop and hone policy options with feedback from focus group and webinar participants. By intentionally reaching out to a wide range of stakeholders we aimed to capture a broad spectrum of viewpoints. While the sample overrepresented those particularly invested in CS education, the analysis took care to include the voices and concerns of all participant groups. The research team maintained a reflexive approach, acknowledging potential biases and actively seeking to minimize their impact. This included being aware of the overrepresentation of certain groups and striving to balance their input with that of less represented voices.

Results

Broad-Based Support for a Graduation Requirement

Webinar and focus group participants ("participants") overwhelmingly support a CS graduation requirement; however there was concern for what the requirement would entail and how it would be supported. One participant said that "students of all backgrounds should be prepared for personal and civic efficacy in the twenty-first century and should have the opportunity to consider innovative and creative technology-based careers of the future," capturing a common theme expressed by attendees. Reasons for widespread support often centered around equity. Specifically, a CS graduation requirement policy would reach all students, but more than that, computing offers growing economic, social and political power in society. As one participant commented, "Rather than a growing digital divide we have the opportunity to shrink it." Other participants noted that currently, a lot of computer science opportunities happen outside of the classroom in the form of clubs (like robotics) that may require a fee or happen after school, which may limit who can participate. Finally, school elective courses are often the most unstable during times of budget cuts, scheduling challenges, or competing educational priorities.

In addition to promoting equity, participants spoke in favor of a graduation requirement because of the role in career preparation. Many educators who participated noted that computer science is highly creative, which inherently offers students the choice of how they engage with technology in their learning, working and civic life. Computer science is a tool that can be used across disciplines. Participants felt that for many students, exposure to CS in school provides an entree into spaces they may never have considered. They may develop a deeper interest, while all students will develop job-ready and future-ready skills. Providing students with a foundation in computer science prepares them for a future we cannot yet conceptualize. A foundational course may not be enough to provide all students with day-one ready skills, but it can provide students with a greater understanding of the possibilities and applications of computing in all industries. By providing CS to all students, the future workforce may also diversify, including creators of new technology. Many of the study participants noted that students need to be prepared to create technology in this rapidly changing technology landscape. The flip side of being technology creators is not simply being technology users but themselves being the product creators. Some participants were concerned about students who did not receive instruction in computing not fully appreciating how their engagement with technology could be dangerous or how young people could be manipulated. Finally, as one person noted, "exploration in college is expensive," and exposing students to CS concepts in high school gives them information as they make future learning, work, and life choices.

Participants brought up the 'myth of the digital native' which recognizes that many young people are growing up with ready access to smart devices. They know how to play with text, video and applications. One current student, making the case for more in-depth computing instruction observed that "I think for people our age, we kind of all grew up using technology and using computers and like a pretty large capacity. So it's just pretty intertwined with our life." However, much of this knowledge is superficial. These young people do not understand how technology works nor the fundamental concepts of digital literacy, digital safety, data structures, organization and how their data is collected and used by third parties. Although students may seem proficient with these technological tools, educators report that they lack fundamental digital literacy skills such as how to appropriately send an email or organize their files. Participants also noted that the experience of students varies greatly, often based on what their parents teach them at home and to what extent they have access to devices. Meaningful participation in modern society requires fluency in the uses of, impact of, and ability to manipulate technology for living, learning, and working.

Finally, many participants felt that instituting a graduation requirement would put appropriate pressure on administrators to take computing seriously. Without a requirement, CS education will always be at the discretion of individual administrators as they manage budget conditions and other contextual factors. One person shared that their high school is the only school in the district with a librarian, and they only have it because it is required by the state. Policies like these offer clarity around what is essential to a student's education.

Potential Negative Student Impacts

Most of the concerns with a CS policy relate to the logistics of the policy (to be discussed), and not student experience or learning. The topics that did relate to the student experience include:

1. **Limiting student choice:** In many districts students have limited time in their schedules, especially in the first two years of high school. For students that take other electives such as band, or students that need academic support services, it is unclear how computer science would fit into the schedule. Students in vocational programs already balance both their academic and vocational training.
2. **Creating an additional barrier to graduation**: For the students that are struggling the most to graduate, creating an additional barrier could bar a student from graduating who otherwise would. However, focus group participants repeatedly reported that well-designed CS courses often engage struggling learners in a way that traditional courses do not. CS teachers report that these courses work well for English Language Learners and many students with disabilities.
3. **Exacerbating existing regional disparities:** Already there are regional disparities in the state in terms of access to, participation in and quality of computing courses; as well as other educational indicators such as graduation rates, absenteeism, and other academic opportunities. Depending on how a requirement is created and supported, regional disparities could be exacerbated creating greater inequities between students in the state.

Policy Considerations

Participants overwhelmingly agree that a well-designed policy needs to be clear about its expectations, but flexible enough for districts to meet the requirement in a variety of ways (e.g. stand-alone classes, integrated classes, etc.). A state policy could help coalesce resources around the state for teachers, administrators and families. Participants were clear that any policy would need to be well-supported including clear implementation guidance, financial resources and an implementation timeline.

Building Educator Pathways and Teacher Capacity

The greatest barrier to a graduation requirement will be ensuring enough qualified CS teachers. One participant aptly noted that "students can only get foundational computing skills if their teachers also have them." Meeting the staffing needs for CS teachers would require addressing the training needs of in-service teachers, preparing preservice teachers, and creating opportunities for career transitioners. There are many options for CS teacher professional development (PD), but many of these programs run under capacity. Webinar and focus group participants emphasized two critical aspects for successful teaching: content knowledge and teaching pedagogy. Without both, the student class experiences tend to be unsuccessful. Teachers need to be prepared with both the content and classroom skills to run a successful learning experience.

While Massachusetts has systems in place for teacher candidates to learn pedagogical skills and earn general licensure, the options for obtaining CS-specific content knowledge are more sparse. Teacher burnout is also a significant issue. Participating educators and administrators reported that many teachers are already at mental and physical capacity meeting the demands placed on them, particularly coming out of the pandemic. Asking teachers to take on a new subject area needs to be appropriately supported and incentivized. When asked what might incentivize greater participation, the following ideas emerged from webinar and focus group participants:

- Paying for professional development commensurate with the value of teachers' time
- Offering debt forgiveness for pre-service teachers who pursue CS or add CS to another disciplinary area (for example English + CS or Special Education + CS)
- Providing a one-time or recurring bonus or stipend for obtaining a CS license
- Supporting graduate credit for CS professional development, which may allow for salary increases on some district union pay scales.

Participants also report that job stability can influence the decision to pursue a CS teaching credential. With CS often scheduled as an elective course, there is concern that teachers will not retain their jobs during periods of budget constraint. Because subjects like math are required, there is a sense that there is greater job security for math teachers. That said, there seems to be a shifting mindset because CS teachers are getting hired before jobs are even posted, often being recruited directly out of the PD programs.

Staffing is the biggest challenge reported, and this seems to be a particular issue in rural areas and at vocational schools. Many of the schools in the state are also struggling with ensuring there are enough teachers at all, particularly for required subjects such as math. Participants reported that some schools start to build a successful CS program only to lose momentum or support when a teacher leaves the district (either by choice or administrative decisions).

Investing in K-8 Computer Science Opportunities

In focus groups and webinars, participants emphasized the need for students to be exposed to CS prior to high school in order to build curiosity and set the foundation for more complex concepts. Many questioned if a high school requirement without meaningful exposure in middle school could be too late. Participants noted that every other subject area has early exposure, with one participant noting that "Having the on-ramp from middle school is something that we need to help specify so there is equity for all students coming to HS." By the time students reach high school and are required to take art, for example, they have been exposed to a variety of arts (visual, music, theater) and even foreign language is introduced in middle school. People felt that it would be unfair to expect students to meet a requirement without preparing them early. One student noticed how important and useful early exposure with a direct link to the more sophisticated concepts would be, saying “You could introduce computer science intertwined with digital literacy or like the bigger concepts of technology in general. It would be kind of a good way to go from introducing — to go from teaching like the basics to introducing something bigger so that it can set them up for something in high school.”

Participants discussed approaches to meeting a high school requirement, and reported that in an ideal situation, students would have choices in how they meet a CS requirement (for example multiple types of courses, or by integrating CS into other subject areas). Early exposure to computing would allow students to knowledgeably self-select a course that would have personal relevance. Participants also reported that student interests, biases, and perceptions are often solidified early in the academic pathway. Focus groups and webinar participants note that early exposure to CS may help equity concerns. If some students are exposed to CS for the first time in high school it may put them at a disadvantage compared to those exposed earlier. This may be especially true for girls and underrepresented racial groups, for which early exposure can help disrupt these negative perceptions.

Finally, a strong recommendation for including a required foundational middle school course which could provide more flexibility in the high school requirement emerged during the focus groups. Middle schools may have more room in the schedule to place a required course. One participant commented that “The K–8 area is a sweet spot for mandating in our district because the high school schedule is already so packed.” One student reflected on their experience saying “I don't know if this is standard in every school, but we have a class in middle school called STEM and you take it like an elective for a third of the year because that's how we do electives in middle school. And I think it could be a good place to integrate, like, some, like, very simple computer science, like, principles and stuff because it's already, you know, science, technology, engineering, math, stuff like that. So I just think that could be a way to integrate it at an earlier age, but still when kids are old enough to understand it.”

A CS Policy Could Promote Stability of CS Programs

Computer science programs have been voluntarily developed by school districts across the state. Because they are voluntary, their stability is subject to external pressures. Common disruptions to CS programs noted by participants include:

1. **Teacher departures.** In some cases teachers move to other districts; in others budget cuts remove the CS teaching position, especially if it is an elective course.

2. **Grant funding ending.** Some programs are built on grant support. These efforts are time-bound. When funding ends or if the grant is no longer available for renewal, these programs are no longer sustained.
3. **Changes to the curricular priorities** Several districts report their electives being modified. In one example the district removed all electives from its graduation requirements. At this point the CS program was absorbed into the Science department but a CS teacher was let go.
    a. **Pandemic disruptions:** A sub-component to the curricular priorities challenge is related to the pandemic. Many districts lost momentum during and just after the pandemic as they were asked to focus on "core" content. In the post-pandemic world it has been challenging to rebuild these programs.

Grant programs have been useful for many districts but they require the capacity for someone in a district (often a teacher) to identify the grant opportunity, and the administrative capacity to apply for and manage the grant. This process may have led to inequity between districts due to staff capacity further exacerbating the CS divide in the state.

With a CS requirement, the state can even more efficiently organize resources including professional development, implementation plans, curriculum and professional learning networks. This may increase efficiencies and make it easier for districts to develop a "recommended" program rather than each having to individually develop a program from scratch.

Some participants noted that the CS courses themselves are cost-effective. Most districts have the technological infrastructure to support CS courses, particularly as many of the curricular materials and software are freely accessible through organizations such as Code.org. As one person said, "We found that CS courses were very cost effective to put in place. Infrastructure was largely already in place. What's going to hold us back is finding the right staff people." The exception to this is when a district purchases a proprietary educational program and cannot independently maintain the cost of the curriculum.

Integrating CS into Existing Courses

There was overwhelming conceptual support for integrating CS into existing courses. Many people noted that CS isn't inherently a stand-alone subject. In the real world it is almost always used for problem solving, creating, or exploring in another discipline. Over the course of focus groups, we heard people discuss integrating CS into:

- Social studies
- English
- History
- Physics
- Algebra II
- TV Broadcasting
- Video production
- Animation
- Game design
- Electronic music
- Digital Art

Arguments for threading CS into existing subjects include:

- CS is relevant to every industry and job. Contextualizing it into different subject areas reflects the real world applications of CS.
- By integrating CS into existing courses the CS skills of many teachers would increase.
- It would reduce the number of licensed CS teachers a graduation requirement would carry, as teachers would be credentialed in their primary subject area.
- It would create more systemic and sustainable support for CS, rather than having it dependent on one teacher.
- It would give districts flexibility in how they meet the CS requirement.
- It would give students choice in how they meet the CS requirement.
- Counselors are often CS gatekeepers. Their own biases may influence who they recommend into CS courses. If CS is embedded into existing subjects counselors may see more relevance of the content.

Other participants were concerned that integrating CS into existing courses would make it difficult to ensure a consistent set of foundational skills, and that non-CS teachers would not be adequately equipped to integrate CS into their existing courses.

CS in math

Math has often been recognized as a natural course for CS alignment. In our conversations we heard arguments both for embedding CS in math and against it.

Embed it in math: Math has historically been an area where we have taught a unique approach to problem solving, thinking, and perseverance. Computer science also leverages many of these same systems of thinking.

One particular course we heard mentioned repeatedly is Algebra II. Many of the educators and administrators mentioned that there are units in that course that are out of date and could easily be replaced with CS content. Infusing CS into existing core courses like Algebra II would essentially ensure that all students who take math up to that level are exposed to CS. This would reduce student choice in how to meet the requirement but would ensure that CS content is accessible to most students, and relieve scheduling burdens.

Decouple it from math: The historical alignment of CS in math has emphasized programming and coding. By removing computer science from math there is more room to lean into the creative opportunities CS offers, perhaps appealing to a wider range of students.

Additionally, any stand-alone CS requirement would need to be cognizant of any math prerequisites that may create even more burden for students seeking to graduate.

Discussion

The opportunity to expand computing in Massachusetts through policy efforts has a high level of support but will require careful consideration of several factors including the design of the requirement itself, building teacher capacity, and allocation of resources. This research solicited a high level of engagement from people across the state and included voices from multiple perspectives. One opportunity is to establish a broad-based team that can help organize and steer the policy design and implementation.

Many states have adopted partnerships with organizations that help coordinate the efforts in the state, either under the banner of a CSfor[STATE] nonprofit or other academic or nonprofit organizations. These partnerships allow states to implement more sustainable and equitable CS programs because their design and execution includes expertise from stakeholders with varied perspectives. Including other organizations in the policy work can also allow people to work collaboratively towards a shared goal while respecting the boundaries of their professional roles. For example, state departments of education representatives are prohibited from lobbying; however, they could support advocacy efforts undertaken by other groups by providing deep contextual knowledge.

Supporting the organization of statewide stakeholders could be part of a state strategic plan for computer science. Setting a state vision for CS can help guide policy and implementation decisions as CS becomes embedded into the K–12 milieu, providing a sense of direction and purpose. The CS strategic plans that have been created in other states are important documents for guiding and organizing a variety of stakeholders as decisions concerning implementation and resource allocation are made. Goals and timelines for CS expansion within the states are laid out within the plans. Values that drive the states' commitment to CS are articulated in the plans either implicitly or explicitly.

Secure and sustainable funding is also important when trying to increase access to high quality computing opportunities. In addition to securing funding, the management and distribution of funds should be part of how a state organizes itself. Some states allocate funding directly to the Department of Education while others may distribute funding to districts and local agencies. There are also models of an independent entity receiving the state funding through a combination of a competitive grant process and service provision (such as centralizing professional development).

Implementation of any requirement requires educator support. One successful strategy is to create a state supervisor of CS with additional regional or grade-span specialists. The supervisors and specialists are important for understanding local implementation and providing support as needed to ensure equitable outcomes across the state.

Finally, any implementation effort requires ongoing assessment to guarantee that policies are enacted as planned. Assessing the implementation is crucial to ensure that students are receiving equitable access to quality instruction, participating in all courses proportional to their demographics in the state (for example, no disparities in who takes more or less rigorous courses), and that longer term outcomes such as subsequent coursetaking in CS are equitable. Assessing the implementation is also critical as states often have significant regional variation. By monitoring student outcomes and implementation, modifications can be made to ensure that implementation adheres to the intent of the state policy.

Conclusion

Our landscape analysis and community conversations through focus groups and webinars underscored the importance of advancing CS education in Massachusetts. A rapidly evolving and technologically-driven society, as well as existing inequities, make new policies that support CS education imperative. Based on our understanding of the national and MA context as a barometer for our proposed recommendation, the research team proposes that CS education policies in Massachusetts should:

- Enhance students' understanding of CS to prepare them for an evolving, technology-driven world;
- Align educational outcomes with workforce needs to prepare students for careers in technology and related fields;
- Address inequities in educational outcomes and ensure new programs and regulations do not exacerbate existing disparities (including home access to technology);
- Collect data to enact effective, evidence-based policy solutions; and
- Support, build, and retain the educator workforce to enable them to effectively teach CS.

These policy goals align with the new educational DESE vision, which emphasizes equitable opportunities for all students and that educational opportunities are culturally and linguistically sustaining. All students, regardless of race, gender, socioeconomic status, location, and disability status, should be supported and valued.

The official recommendation report, which will not be publicly shared, explored additional considerations for developing and implementing a graduation requirement. The report covers topics such as creating and defining the specific requirement (content, format, duration and situation within the K–12 curricular pathway), evaluating implementation strategies in Massachusetts, building educator pathways, sustainable and equitable funding approaches, educating the community about the requirement, and the data infrastructure for monitoring implementation and measuring outcomes.

Each state has to make context-specific decisions about graduation requirements. The Massachusetts approach provides a valuable example for engaging a wide array of community members and fostering a learning community as they think through policy design and implications. In addition to the approach, the themes identified may be of use to other states as they consider equitable and sustainable CS policies. Over the next few years states will start being able to report some of the longer-term outcomes of a graduation requirement such as college enrollment in computer science or computing intensive majors and workforce impact. These data will contribute to lessons learned about designing and implementing CS requirements.

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