Computer Science as a Graduation Requirement:

Massachusetts Recommendations Report

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Purpose

In October 2022, the Massachusetts Legislature asked the MA Department of Elementary and Secondary Education (DESE) to provide "a recommendation on whether a foundational computer science course should be a requirement to graduate high school in the commonwealth" [Chapter 268 of the Acts of 2022, line item 7009-6601].

The DESE vision is that:

> All students in Massachusetts, particularly students from historically underserved groups and communities, will have equitable opportunities to excel in all content areas across all grades. Culturally and linguistically sustaining classroom and school practices will support students to thrive by creating affirming environments where students have a sense of belonging, engage in deeper learning, and are held to high expectations with targeted support.

This vision is operating against a workforce context in which Massachusetts has one of the most robust technology-based economies in the nation with significant pharmaceutical, life insurance and education sectors. Computer science (CS) education is not only relevant to the technology industry but can also prepare students to pursue a variety of careers.

In mid-2023, in order to understand the scope of a potential graduation requirement, DESE commissioned SageFox Consulting Group and CSforMA, Inc. via a competitive RFR procurement process to conduct (1) a National Landscape Analysis Report and (2) a Recommendation Report for a foundational CS course requirement for high school graduation for the state of Massachusetts. The Landscape Report was designed to learn what it takes to make CS a high school graduation requirement by examining states that are already implementing it.

Embodied below is the second part of the SageFox and CSforMA assignment: the recommendation report. This report draws from the engagement of nearly 200 community voices across the Commonwealth.

Executive Summary

CS education policy in Massachusetts has reached a critical moment, and policymakers must now promote its uptake in the K–12 setting while navigating the imperative to address existing inequities and avoid creating additional barriers for administrators, educators, and students. The pandemic has introduced new challenges for the education system, underscoring the importance of our digital infrastructure. However, it has also emphasized the essential role of CS skills in preparing students for future opportunities and navigating a world increasingly reliant on rapidly evolving technologies. Students equipped with these skills possess significant advantages in both the job market and broader societal contexts.

Our landscape study found that while a CS high school graduation requirement has been legislated in 9 states, questions persist regarding equity, student outcomes, required resources for quality CS program implementation, and downstream impacts. Thoughtfully designed policies should be tailored to Massachusetts' unique environment and demographics. Moreover, implementing a graduation requirement without consideration for the state-of-play at the district level could have unintended consequences. The current landscape of CS engagement in Massachusetts fails to mirror the diversity of the student body, and policy considerations should seek to avoid exacerbating those inequities.

Teacher capacity and funding challenges set the stage for a phased approach to creating a graduation requirement in Massachusetts. One of the greatest challenges to creating a CS graduation requirement is the availability and capacity of educators prepared to offer a high quality CS course. The teaching workforce needed to implement a graduation requirement at the state level will take years to build. Additionally, expiring ESSER funding has resulted in a fiscal cliff for districts — creating a greater demand for sustainable and equitable funding. Current estimates suggest MA will need to train 284 unique teachers to offer an additional 703 course sections of CS with an assumption that all high school students get only one CS course. Currently, approximately 2,681 sections of CS and related courses are offered at the high school level.

With these considerations in mind, findings from a landscape scan of other state policies and programs, along with webinars and focus groups with key stakeholders in Massachusetts, helped inform policy recommendations for creating a CS graduation requirement in the state. SageFox and CSforMA make the following recommendations:

1

Creating and Defining a Graduation Requirement

- The Massachusetts Legislature should provide funding for DESE to implement a CS graduation requirement using a phased approach.

2

Support for Middle School CS Programs

- The Massachusetts Legislature should require middle schools to offer a broad-based, high quality introductory CS course.

3

Sustainable and Equitable Funding

- Legislators in Massachusetts should appropriate funding to DESE to support regional CS specialists.
- Legislators in Massachusetts should create a recurring line-item of state appropriations to support CS programs in the state budget.
- DESE should encourage the use of existing funding for CS programs.

4

Building Educator Pathways

- The Massachusetts Legislature should enact funding to ensure CS teaching candidates receive incentives.
- DESE should allocate funding from the Legislature to expand CS teacher preparation options through partnerships with higher ed institutions and nonprofits.

5

Expand the data infrastructure to monitor implementation and measure outcomes

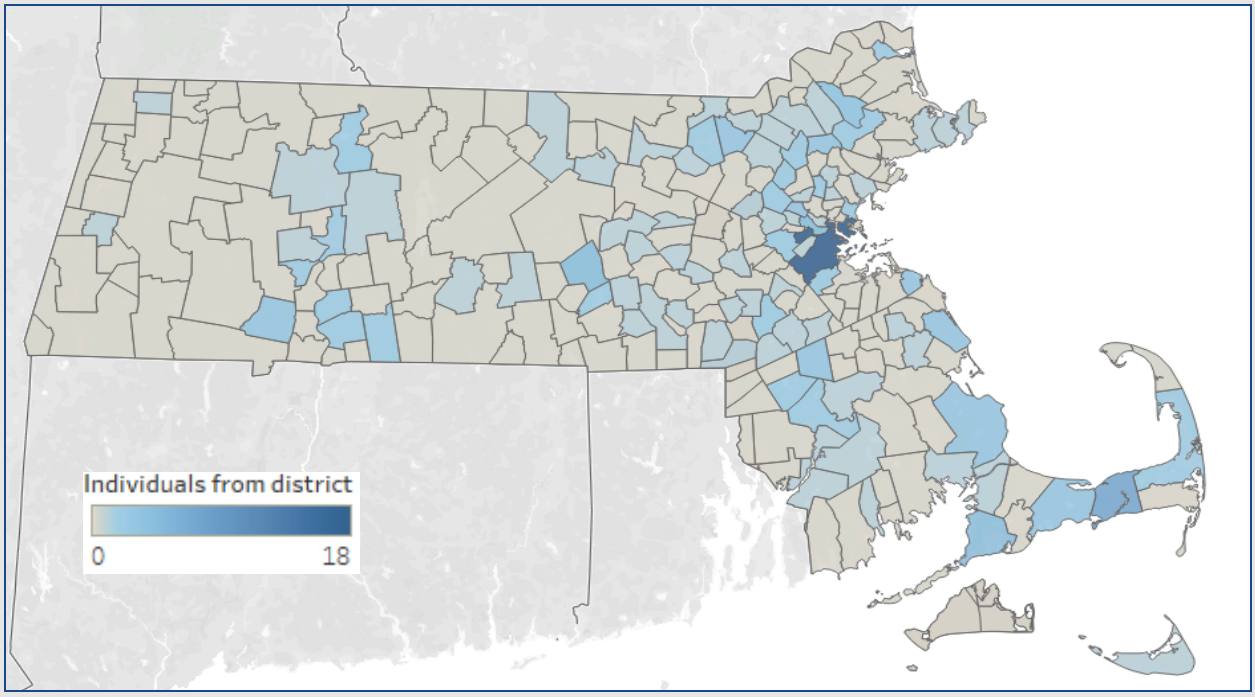
- With funding from the legislature, regional CS specialists should support schools and districts to measure and track implementation and ensure data integrity.
- The MA Legislature should initiate a multi-stakeholder coordinating body/steering committee to define meaningful measures to monitor all K–12 CS efforts in the state.

Introduction

Over the last decade the Computer Science for All initiative has led states to consider how to embed CS education more deeply into the core course of study for K–12 students. Many states including Massachusetts are now at an inflection point; efforts to support the voluntary integration of computing education into the curriculum have reached saturation. In partnership with the Massachusetts Department of Elementary and Secondary Education (DESE), SageFox conducted a landscape scan to capture themes and to better understand the variety of ways other states have designed and implemented CS graduation requirements. These findings from other states, along with webinars and focus groups co-led by SageFox and CSforMA with key stakeholders in Massachusetts helped the study team inform recommendations for policies to increase CS course taking and access to CS programs described in this report.

To study the issue and gain a better understanding of various perspectives, the High School Computer Science (HSCS) project engaged community members through five interactive webinars and eighteen focus groups. Interactive webinars provided an overview of the landscape report and learnings from other states. During these webinars there was significant discussion on the participant perspectives on policy options for MA. The focus groups explored the implementation context and student experience. Almost 200 individuals across the state reached out to participate in one or both of these types of sessions. More detail about the methods can be found in the appendix.

In addition to providing policy recommendations, this report highlights the key themes that emerged from the community discussions. In an intentional effort to include as many diverse voices as possible, we reached out to a range of organizations across the state that serve various demographics and are focused on equity and inclusion. We sought input not just from those familiar with CS education but also from non-profit leaders, parents, recent and current MA high school students, education researchers, and state and district administrators. The visual below is a geographic representation of where participants are employed and/or located. Participants from over 41% of Massachusetts' K–12 districts are represented. The map reflects the voices of community members across the state with an interest or concern in CS education in Massachusetts. Community members include: CS teachers, teachers of other subjects, administrators at the school, district and state levels, CS education researchers, nonprofit leaders, parents, recent high school graduates (class of 2018 and later), and current students. We received the most participation from Massachusetts' largest district, Boston Public Schools. This is shown by the darker shading on the map.



Map: Participation in the HSCS study in Massachusetts

Providing students with a foundation in CS prepares them for a future we cannot yet predict. A strong body of evidence demonstrates that CS education is linked to improved computational thinking and higher rates of college enrollment, in addition to enhancing career opportunities. CS education is not only relevant to the technology industry but is a tool that can be used across disciplines. For many students, the exposure to CS in school provides an entry into spaces they may never have considered. By providing CS education to all students, we may also be diversifying future workforce leadership including creators of new technology.

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, makes new policies that support CS education imperative. The project team developed the following policy goals based on our understanding of the national and MA context as a barometer for our proposed recommendations. SageFox and CSforMA posit 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;
- 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.

Recommendations and Rationale

Creating and Defining a Graduation Requirement

The Massachusetts Legislature Should Provide Funding for DESE to Implement a CS Graduation Requirement Using a Phased Approach

Though expanding CS education is vital, the pandemic's ripple effect on education demands policymakers address urgent needs before considering new state-level graduation requirements. Additionally, CS teacher shortages make it difficult for districts to implement a graduation requirement in the near future. Since the onset of the pandemic, rates for Advanced Placement exam passage, high school graduates attending college, and high school graduation have all decreased in Massachusetts. Moreover, reading and math proficiency levels have fallen significantly in recent years, according to Northwest Evaluation Association and the National Assessment of Educational Progress. Due to other more basic and pressing educational priorities, legislators may be hesitant to enact a state-wide CS graduation requirement. However, Massachusetts has already fallen behind on CS education and currently ranks 12th in the nation for student CS participation. With these considerations in mind, Massachusetts can make progress on creating a graduation requirement, while building state educator capacity and remaining mindful of equity, by implementing a phased approach that starts at the district level.

There has been interest in creating policies that enhance uptake of CS in Massachusetts for years. In 2022, the legislature asked DESE to provide a recommendation on a foundational CS course graduation requirement. Most recently, in 2023, Massachusetts legislators introduced Senate Bill 277/House Bill 445 to expand access to CS coursework. If passed, the legislation would require every public high school in the commonwealth to offer at least one foundational CS course. Though this legislation does not go as far as creating a graduation requirement, it demonstrates that there is appetite and support for expanding access to CS in the legislature.

Massachusetts has made progress in expanding access to CS education through previous policy and mostly ad-hoc financial investment, but equitable uptake is stagnating, underscoring the necessity for equity-centered policies. In 2018, the state started allowing students to substitute CS for a MassCore mathematics or laboratory science course. This swap allowance did not have a significant impact on the number of students taking CS courses. Currently, CS participation in Massachusetts does not reflect the student population. In 2021, while 83% of Massachusetts high school students attended a school that offered at least one CS course, only 6.6% were enrolled in such a course. This enrollment number was lower among students of color, female students, and disadvantaged students (Figure 1). There are also regional disparities in Massachusetts in terms of access to, participation in, and quality of computing courses. Depending on how a requirement is created and supported, regional disparities could be exacerbated creating greater inequities between students in the state. Measuring equity outcomes in the Phase 1 districts can help policymakers and administrators design a scaled-up requirement that mitigates unintended consequences.

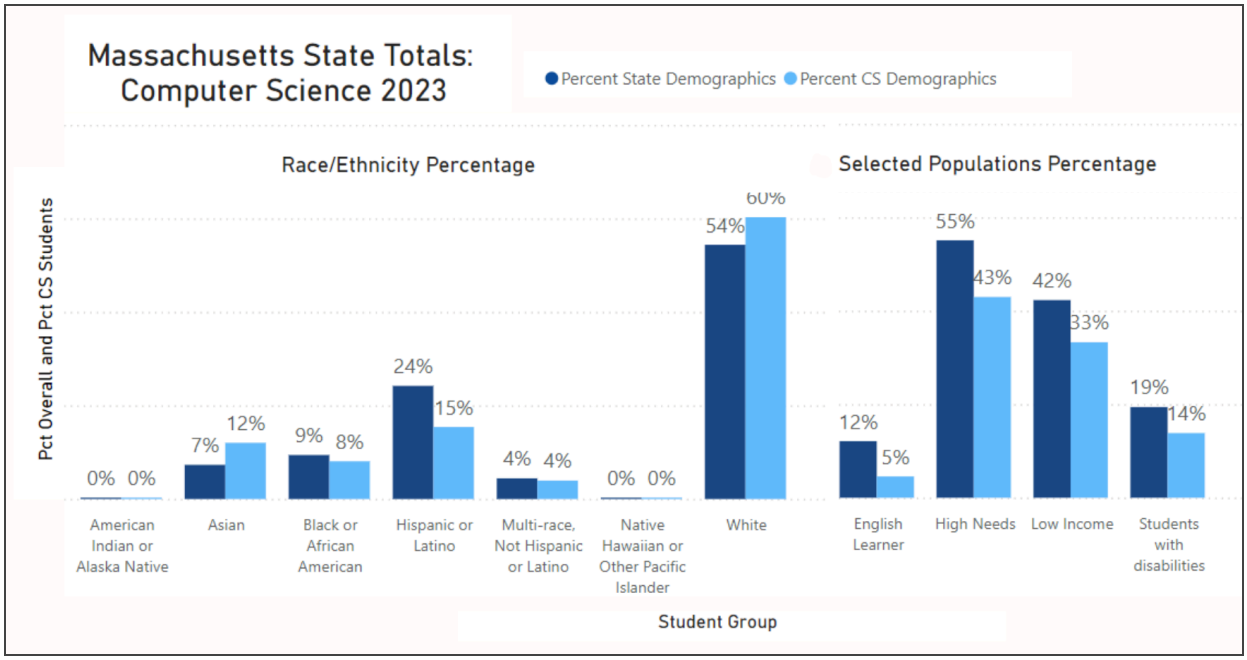


Figure 1: MA State Totals. Source: [Massachusetts Digital Literacy or Computer Science (DLCS) Data Dashboard]

Implementing the graduation requirement with a representative sample of districts in a phased approach, which involves breaking down the process into distinct stages each with their own set of objectives, activities, and timelines, would allow Massachusetts to test out the feasibility of programs and regulations on a smaller scale and smooth out potential issues before enacting a larger-scale solution. While a CS graduation requirement has been legislated in 9 states, questions persist regarding equity, student outcomes, required resources for CS program implementation, and downstream impacts. Massachusetts can evaluate the implementation and mitigate any issues that may arise by enacting a phased approach. With the proper data collection infrastructure in place, testing out a CS graduation requirement at the district level would enable DESE to evaluate curriculum efficacy, identify resource needs, address equity issues, and measure student outcomes. This evidence can inform state-wide policy decisions on how to expand the requirement, how to best support districts, schools, and teachers, and what resources are needed for scaling-up and implementing a graduation requirement. The initial phase findings can aid in developing an implementation toolkit for districts when statewide requirements are adopted.

A phased approach in Massachusetts would allow for three years of capacity building and learning before the statewide requirement is implemented. The approach will involve introducing a graduation requirement with a representative sample of districts with support from regional CS specialists, while building state-wide teacher capacity, for the first 3 years (Phase 1). A learning community can engage in cycles of learning and iteration across the phases to refine the approach and provide useful information about the rollout (see pg 11 for more). Findings from Phase 1 should be used to implement a scaled-up, state graduation requirement and expand associated programs to ensure consistency and equity across schools (Phase 2). Finally, in Phase 3, policymakers and administrators will continue to sustain CS programs and evaluate associated outcomes. This includes tracking student enrollment and performance in CS courses, assessing the impact on student achievement and college readiness, and evaluating the effectiveness of teacher training programs. Data collection and analysis will inform ongoing adjustments,

teacher preparation, and support initiatives to optimize student outcomes. Moreover, continuous evaluation would ensure that the CS graduation requirement remains relevant and effective in preparing students for success in a technology-driven world.

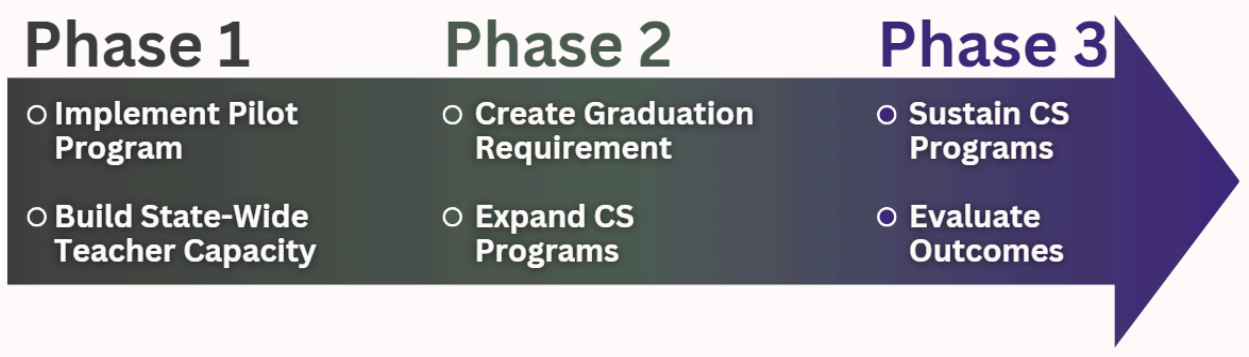


Figure 2: Three-Phased Approach

Webinar and focus group participants felt that implementing a graduation requirement would put appropriate pressure on administrators to take CS education seriously. Without a requirement, CS will always be at the whims of individual administrators, budget conditions, and other contextual factors.

A well-designed and well-supported policy needs to be clear about the expectation but flexible enough for districts to meet the requirement in a variety of ways (i.e. stand-alone classes, integrated classes, etc). Using a state coordinated and regional model will help coalesce resources around the state for districts, teachers, administrators and families.

Identifying and defining foundational courses can be informed by existing state standards and guides, as well as national efforts to define foundational CS courses. Though Massachusetts has identified foundational CS courses in DLCS standards and the curriculum guide, the dynamic nature of course development means there may already be new courses that could meet standards. Additionally, existing courses could fall out of favor in the future. In addition to looking at existing state standards and guides, Massachusetts could look to national efforts focused on defining foundational CS courses to guide what counts as an acceptable foundational course. Defining foundational courses and maintaining currency in the DLCS standards and curriculum should be overseen by a broad based working group (see "Organizing the State") to ensure CS guidance is high quality and relevant.

Additionally, ensuring sufficient capacity for CS educators needed to implement a graduation requirement at the state level will take years to build. Current estimates suggest MA will need to train 284 unique teachers to offer an additional 703 course sections of CS with an assumption that all high school students get only one CS course. During Phase 1, Massachusetts can focus on building robust teacher pathways so there are enough educators to implement the scaled-up graduation requirement during Phase 2. This includes recruiting, training, and retaining qualified CS teachers with a focus on teacher diversity. Having teachers of color in a school has been shown to have a positive impact on the outcomes for all students, including students of color.

Designing Phase 1

Focus group and webinar participants surfaced some potential negative consequences of creating a graduation requirement:

- 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 CS would fit into the schedule.
- Creating an additional barrier to graduation: For students that are struggling the most to graduate, creating an additional barrier could prevent a student who would otherwise graduate from successfully doing so. However, focus group participants repeatedly reported that well-designed CS courses, such as those identified in the MA DLCS curriculum guide, often engage struggling learners in a way that traditional courses do not. Introductory CS teachers report these well-designed and high quality CS courses work well for English Language Learners and many students with disabilities.
- Exacerbating existing regional disparities: There are already regional disparities in our state in terms of access to, participation in and quality of CS 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 our students in the state.

These challenges indicate that CS programs and policies should be designed with flexibility and equity in mind.

For Phase 1 of implementing a graduation requirement, funding from the legislature should allow at least 20 districts in Massachusetts to be included in a three-year program to test out a graduation requirement. Initial funding should allow DESE to appoint regional CS specialists to oversee district implementation and help districts develop plans. These regional CS specialists would be responsible for coordinating all CS programs in the state, in addition to supporting districts in Phase 1. Guaranteed funding should be distributed equitably (described in the sustainable and equitable funding section below).

Because evaluating potential impact on equity is a key goal of Phase 1, DESE should emphasize the inclusion of districts with different CS assets and different demographics. Considerations for Phase 1 districts could include: rurality, high vs low socio-economic status (SES), racial demographics, and different levels of existing CS assets including course offerings (number of courses and curricular variation), prior participation in strategic planning through Digital Literacy Now, CS Engage, SCRIPT or other facilitated process. Though an apples-to-apples comparison across districts is not possible, individual districts *can* test out innovative models and track changes in comparison to a baseline. These varying models could include:

- Selecting a variety of high quality instructional materials and curricula for CS courses. The Massachusetts Digital Literacy and Computer Science Curriculum Guide provides curriculum options for districts. Districts may choose to use instructional materials or curricula highlighted in the curriculum guide differently depending on their unique populations and needs.
- Creating a requirement for middle schoolers to take a broad-based, introductory CS course. In addition to creating a high school graduation requirement, districts in Phase 1 could also create a

requirement for middle schoolers to take a broad-based, introductory CS course that is appropriate for middle school.

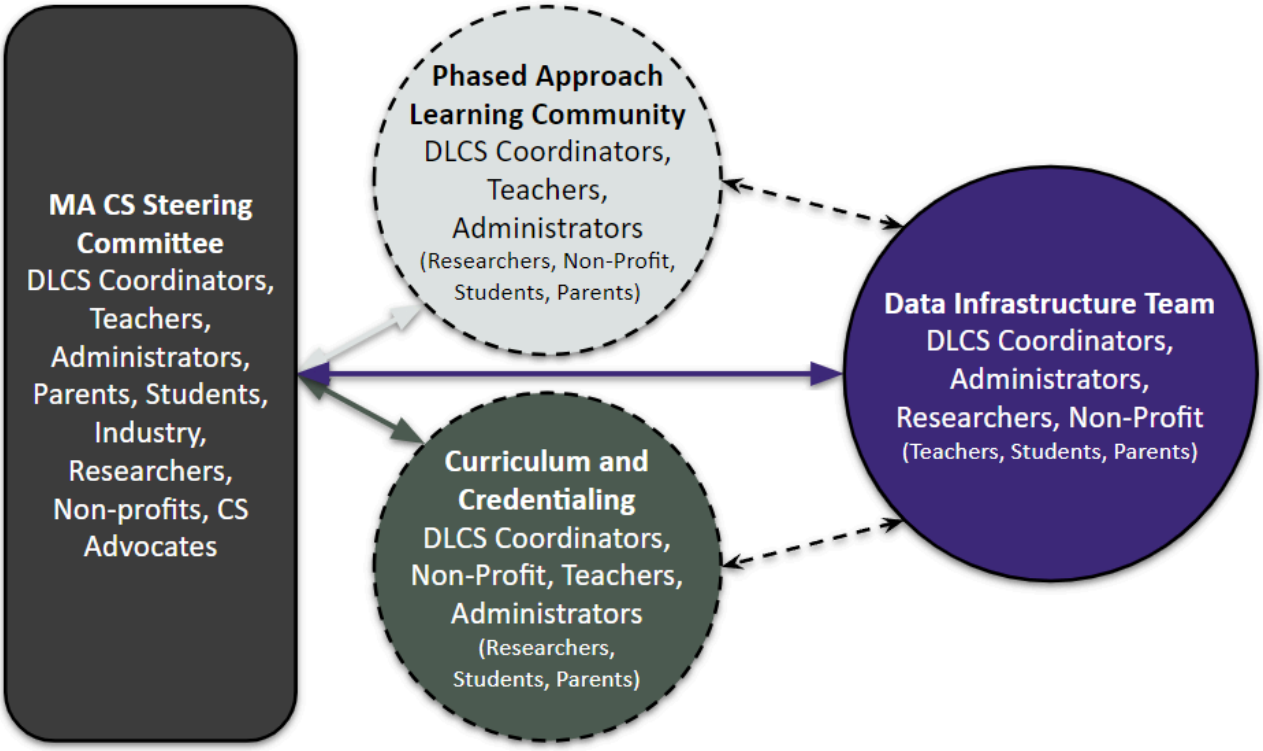
- Providing access to virtual options in places where teacher capacity is low, while preparing educators within a district. Given challenges with the availability of CS teachers, districts could provide students with access to virtual CS courses. Currently DESE has been testing virtual options for AP CS courses.
- While most districts should create a strictly course-based CS graduation requirement, others could test out more flexible models. For example, there may be ways to robustly integrate CS into other courses. In the real world CS is often used for problem solving, creating, or exploring in another discipline. Webinar and focus group participants consistently opined that CS can be used to reinforce and support other content areas. This is a promising strategy but one that would need additional research before wide scale implementation. Other states have adopted a flexible approach, such as Utah where although not an explicit requirement for CS credits for graduation, it does require students to complete a one-semester half-credit digital studies course. The requirement was designed to "advance students from being computer users to being computationally literate creators." Districts could test out implementing a similar requirement. Some webinar and focus group participants felt it was important for a requirement to include additional CS-related course options for students who want to pursue arts and humanities.

Districts enrolled in Phase 1 and key stakeholders should form a "learning community" (see "Organizing the State") to prevent information silos, which can stifle coordination and innovation. This learning community can be managed by CS specialists to ensure districts enrolled in Phase 1 receive peer-to-peer education and guidance. The findings from the learning community can inform the implementation toolkit. This learning community could meet on a regular basis (quarterly or twice per year) and include local CS educators, administrators, DESE representatives and the CS Specialists. Findings and updates should be shared with a larger group of CS stakeholders which would include parents, students, researchers and industry representatives to ensure coordination and alignment of CS priorities across CS initiatives in Massachusetts.

The Institute of Education Sciences has developed a guide for implementing pilot studies that can serve as a resource for designing Phase 1. Of particular importance is the design of strong outcome measures that will ensure policymakers and practitioners are equipped with enough data to make evidence-based policy decisions. Outcome measures the learning community could leverage the newly released DLCS Dashboard to explore include: graduation rates, course participation rates, course completion rates, transfer rates, etc. (stratified by race, gender, SWD, rurality, and students with IEPs).

Organizing the State

The recommendations presented in this document should be supported by a **MA CS Steering Committee**. The steering committee should be made up of a broad set of stakeholders to ensure coordination of CS advocacy, investment, and implementation across the state with an overarching goal of equity.



The **Phased Approach Learning Community** can be made up of a subset of the MA CS Steering Committee and additional district representatives participating in the three year Phase I component. A primary goal of phased approach is to learn from a variety of districts as they build capacity and define the local requirement for their students and context. This community should come together regularly (quarterly) to discuss the implementation design choices, challenges, benefits and impacts.

Curriculum and Credentialing this group may be a subset of the MA CS Steering Committee and will focus on ensuring high quality curriculum and materials are being recommended and used by practitioners in the state. This group will also be responsible for addressing the teacher credentialing pathways.

Data Infrastructure Team: This group may be a subset of the MA CS Steering Committee and could include additional researchers and equity advocates who will be responsible for reviewing data about the capacity being built, access to, and participation in CS courses. Theis team would report data back to the community to help inform the CS Steering Committee.

Support for Middle School CS Programs

The Massachusetts Legislature Should Require Middle Schools to Offer a Broad-Based, High Quality Introductory CS Course

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. Multiple studies have shown that middle schoolers (ages 11–13) are at a critical age for engagement in CS, especially ones from historically marginalized groups. Moreover, early exposure enhanced girls' perceived computer skills and support for computing. Researchers stated that, "Exposure to computational activities in school can increase students' interest and ability in computational thinking and CS, which in turn can shape their motivation to engage in computing activities in the future and perhaps even to consider careers in CS." Requiring middle schools to offer a comprehensive or core foundational CS course would allow students to develop a foundational understanding of CS and problem-solving skills, in addition to fostering computational literacy. Investing in middle school supports a pathway into high school level CS.

Self-efficacy and identity — beliefs that are often built in early adolescence — are primary drivers for students' intention to further study CS, and contribute to gender disparities in CS education. Researchers stated that, "Many introductory courses focus on teaching basic programming constructs and could even support common misconceptions about the CS field." Earlier exposure to a quality CS course may encourage students to feel they are capable of using and understanding CS concepts and to apply CS constructs to their future personal and professional lives.

Early exposure to CS is an important part of building a CS pathway. Middle school courses should be developmentally appropriate and focus on the DLCS standards for the 6–8 grade band as a foundation for high school level CS. Focusing on existing standards will reduce potential content redundancy for students fulfilling a high school graduation requirement who participated in a foundational course during middle school.

Massachusetts can choose to either use an existing well-defined course that would be appropriate for middle schools, or create one that aligns with existing state standards. The Massachusetts Digital Literacy and Computer Science Curriculum Guide includes a list of comprehensive curriculums for middle school courses that align with MA DLCS Framework strands — for example "Computational Thinking" and "Digital Tools and Collaboration." Selecting a high-quality, comprehensive course for middle school should answer the question: what is the minimum knowledge required to prepare students for an array of high school-level CS applications? Code.org has developed a middle school curriculum that includes courses like "CS Discoveries," which focuses on how CS can be used "as a medium for creativity, communication, problem solving, and fun." On the other hand, Rhode Island developed a home-grown course specifically to serve as an option for middle school, while meeting state standards.

There is already a precedent for legislatively introducing requirements at the middle school level in Massachusetts. In 2018, a law was enacted to require all public schools to provide students in middle school with a civics project. The Act also created a Civics Project Trust Fund to ensure there are resources to support civics education.

Other states have developed policies to encourage uptake of CS courses in middle school. In Tennessee, middle school students are required to receive one standards-based CS course for a full year. In 2021, Hawaii passed Act 158 (SB 242), which requires that CS courses or content be offered in at least 50% of elementary and middle schools per complex area (district) by 2023, and in all state elementary and middle schools by 2024–25.

While requiring a middle school to offer CS might increase access to CS courses, there is also a potential to exacerbate existing disparities — highlighting the need for a carefully designed policy and strategy at the district and even school level that emphasizes equity. Students from higher socioeconomic status (SES) backgrounds may be more likely to enroll in middle school CS courses, thus giving them an advantage in high school — especially with a high school graduation requirement in place. Legislation requiring middle schools to offer CS should contain a provision to ensure enrollment in those courses reflect the demographics of student population (race and gender). The legislation should also include a mechanism to reassess the policy based on equity measures. Legislators could consider attaching a racial equity impact assessment (REIA) to the proposed policy before implementation. REIAs are "a systematic examination of how different racial and ethnic groups will likely be affected by a proposed action or decision" and can help mitigate adverse outcomes. Organizations like Race Forward have created toolkits for conducting racial equity impact assessments on policy proposals.

Ensuring a requirement for middle schools to offer CS is implemented equitably will ultimately rely on districts having equitable access to resources and flexibility to adhere to the requirement in a way that meets the needs of their student population. Additionally, a monitoring and evaluation mechanism is necessary for tracking and identifying disparities in access and outcomes. We discuss Massachusetts' data infrastructure later in this report.

Sustainable and Equitable Funding

In Massachusetts, there has been a long history of (mostly ad-hoc) investment in CS initiatives, spanning grants from state and federal sources as well as one-time infusions of money from the legislature with varying requirements and focuses; however, more reliable and equitably distributed funding is needed to ensure CS programs are sustainable and effective. Massachusetts has offered grants to districts to support their DLCS infrastructure, such as the Digital Literacy Now (DLN) grant and the CS Engage grant. The DLN grant awarded districts up to three years of funding for DLCS visioning, curriculum selection and PD. During the course of the grant, 36 districts participated for at least one year, 393 teachers attended summer curriculum-focused PD sessions, and nearly 25,000 middle school students were in classes taught by DLN-trained teachers. DESE and CSforMA also developed three new PD workshops — one for counselors, one for administrators, and one for teachers new to CS. Though these programs enabled districts in Massachusetts to make critical progress in CS education, more is needed to equitably enhance CS instruction in the state.

Legislators in Massachusetts Should Appropriate Funding to DESE to Support Regional CS Specialists

Massachusetts has made great strides in implementing CS programs and associated grant programs, but a lack of coordination and existing burdens on districts serve as a barrier to progress. Focus group and webinar participants indicated that though grant funding is available, under-resourced districts may not

have the capacity to apply for grant funding in the first place. Grant programs have been useful for many districts but they require the capacity for someone (often a teacher) in a district to identify the grant opportunity and the administrative capacity to apply for and manage the grant. Findings from the landscape report suggest that funding state agencies directly can promote a more efficient and coordinated infrastructure. Other states, for example South Carolina, New Hampshire, and Indiana, have provided funding to their Departments of Education to manage and implement CS programs. Additionally, CS specialists funded through DESE can enhance equity. An equitable funding policy would involve guaranteed funding based on a district's particular circumstances and demographics. In order to coordinate programs and more equitably distribute funds, Massachusetts legislators should provide funding to DESE to employ or contract with regional CS specialists to provide support to districts, connect them with funding and professional development, coordinate programs, facilitate resource distribution, and ensure data monitoring efforts. Regional CS specialists would help districts determine how much funding is needed instead of district staff having to apply for grant funding on their own, thereby reducing the burden on those districts. Specialists would provide assistance to districts enrolled in Phase 1, in addition to supporting districts with other CS programs in the state.

Inequitable funding policies are a pervasive issue for the modern education system and new funding policies should be designed to avoid unintended consequences. An analysis from the Center for American Progress found that "high-poverty school districts in only four states—Minnesota, Louisiana, Tennessee, and Vermont—receive more local funds per pupil than more affluent districts." In other words, school districts that need resources the most are often not receiving them likely due to existing policies (for example, property taxes linked to school funding) and barriers to applying for grant dollars. This highlights the need for intentional policies that support under-resourced districts in applying for funding — for example through regional CS specialists at DESE.

Districts have implemented a spectrum of programs to promote CS education — some are further along, while others will require more support. CS specialists could help districts uncover how many resources they need to create comprehensive and accessible programs. Focus groups included participants from districts that have CS graduation requirements, those with fully developed K–12 CS pathways in place, and those that have no recognizable CS programs. Any policy will need a robust system of support across the state, recognizing that districts will need different levels and types of support.

Other states already employ or contract with CS specialists through their Departments of Education. Arkansas has a state director of CS supported by seven state-wide CS specialists who serve regionally to support the 150,000 high school students in the state. Though statewide specialists in Arkansas focus primarily on providing PD, specialists in Massachusetts would serve different functions — including connecting districts to PD provided by nonprofit organizations in the state and other resources. One such PD provider in Massachusetts is CSforMA, Inc., a 501C3 that serves as the Massachusetts Computer Science Education Hub, committed to ensuring that every K-12 student has access to high-quality CS coursework. It works across the Commonwealth to broaden participation and success in CS fields, especially among females, students of color, rural learners, and other underserved populations. In its 4 year tenure, it has provided 60 workshops that have served just over 1000 teachers across 118 districts. The CSforMA Professional Learning Institutes feature intensive train-the-trainer courses in emerging technologies that track closely to the MA Digital Literacy and Computer Science standards and licensure requirements. CSforMA provides these workshops at no or low cost thanks to significant grants and

contributions from our business partners, curriculum partners and DESE. CS Specialists could connect districts with organizations like CSforMA for PD.

CS specialist support for districts in allocating and distributing funds equitably can be informed by regional projects and national analyses. Boston Public Schools (BPS) created the Reimagine School Funding Project (REPT) to develop a vision for distributing school funding more equitably. One of the project team's main findings was to center the community Steering Committee (made up mainly of community members, parents, and advocates) in providing recommendations on budgetary matters. Similarly, regional CS specialists could help districts center community voices in funding plans.

In an effort to attract CS specialists with knowledge of the education system in Massachusetts, educators should still be able to accrue retirement while serving in the role at DESE. Of course, if CS specialists are full time employees of DESE, they would continue to earn benefits. However, if DESE chooses to contract with CS specialists, the agency must be mindful of existing policies that would prevent contractors from earning benefits. For example, a current contracted position at DESE includes a stipulation in the job description that states, "please note that pursuant to Massachusetts general law, contracted employees are not paid for the eleven scheduled holidays, do not receive any paid, vacation, personal leave benefits, or contribute to the state retirement system or social security." In order to ensure teachers still receive benefits and accrue retirement, this position could either employ CS specialists on a full time basis or contract with a district to buy time from educators while they continue to receive benefits through their district (similar to a sabbatical).

Legislators in Massachusetts Should Create a Recurring Line-item of State Appropriations to Support CS Programs in the State Budget

Without reliable and predictable funding, state entities may have difficulty launching and sustaining CS programs that make a significant impact. Moreover, recurring funding is more important than ever given expiring pandemic-era funding. During the pandemic, Congress authorized Elementary and Secondary School Emergency Relief Fund (ESSER) dollars to provide school districts with emergency relief funds to address educational needs. Counties in Massachusetts claimed approximately $1.87 billion in ESSER funds. Districts are now facing a fiscal cliff — creating a greater demand for more sustainable funding. Some districts and schools built up programs, but no longer have funding to maintain them, and predictable funding would allow them to sustain and create programs. Participants in webinars and focus groups stated that districts will be making significant cuts to the number of teachers on staff due to expiring ESSER funding and worry that building or expanding a CS program without additional staff funding feels unpalatable.

The sustainability of state funding for existing CS programs varies across states. States often use an infusion of grant funding or private dollars to explore new models of teacher PD, curricular or pedagogical practices, or district engagement with the hopes of scaling more widely. Some states make one-time investments in programs that accelerate CS education efforts. Other states have made funding for CS recurring line items in their state budgets, which can support more sustainable CS programs. South Carolina, for example, has appropriated $500,000 every year since FY 2020 to fund educator PD regarding CS standards.[118] The Governor has prioritized recurring dollars for CS education in South Carolina, especially through Education Improvement Act funds.

Though there are many ways to manage funding, recurring funds for CS programs should be allocated to a trust fund to allow for strategic and long-term planning, while maintaining flexibility. Currently, funding has to be reauthorized or appropriated on an annual basis after expiring in June — creating problems for planning purposes. New recurring funding for CS programs could be allocated to an existing DLCS trust fund or, alternatively, a new trust fund could be created to serve this purpose. Recurring funding in a trust could be distributed to nonprofits and other entities in the state responsible for supporting and implementing CS programs (for example professional development or teacher licensure programs).

DESE Should Encourage the Use of Existing Funding for CS Programs Where Appropriate

Existing funding streams are an opportunity for policymakers and administrators to incorporate CS into the programs they support. One such investment, Governor Healey's "Reimagine High School" program funding, could contribute to CS efforts. In addition to Perkins funding, the FY2025 budget includes $47.8 million for high school pathways programs like Innovation Career Pathways, Early College, and Career Technical Education. Funding for programs like these creates an opportunity to encourage CS uptake in high schools.

There is room to make an intentional push towards CS within the pathways program. The Innovation Career Pathways program, which was launched in 2017, gives high schools or districts a designation based on their plan to address guiding principles and develop structured partnerships with industries through MassHire. These guiding principles include: equitable access, guided academic pathways, enhanced student support, connection to career, and effective partnerships. Industries that align with the pathways include: manufacturing, information, business and finance, environmental and life sciences, healthcare and social assistance, and clean energy. These industries increasingly utilize computational technologies, and these efforts should be recognized as part of the overall landscape of CS in Massachusetts.

As of 2024, there are approximately 40 schools that have chosen to focus on the "information" sector as part of their designation. For example, Randolph High School received an Innovation Pathway grant to create a CS pathway that allows students to "create, collaborate, and communicate using computer science." Additionally, Taunton High School has a healthcare and informational technology pathway. With new funding for 2025, more schools could use pathways dollars to encourage CS education for students.

Building Educator Pathways

The quantity and quality of CS educators in Massachusetts can make or break a graduation requirement. Though state graduation requirements are nascent, Massachusetts can learn from efforts of other states to create a more robust teacher pathway. An analysis from Brookings on Arkansas's implementation of a CS graduation requirement found that clear certification pathways and financial incentives for educators are critical to supporting high quality CS programs at the state level. Arkansas made teacher CS professional development and recruitment a priority, and since 2016, over half of the 30,000 K–12 educators licensed in the state obtained some form of CS training. The Arkansas Department of Education's Office of Computer Science established goals in five categories: "standards, curriculum, and pathways; educator development and training; licensure; outreach and promotion; and program growth

and student success." Massachusetts can use lessons from states like Arkansas to encourage, train, support, and retain CS educators in the state.

Massachusetts has created new pathways for teacher licensure, but more is needed. The DLCS grades 5–12 subject area Massachusetts Tests for Educator Licensure (MTEL) for DLCS licensure was launched in September of 2021. In the initial two years since the MTEL became available, 210 teachers obtained licenses for DLCS 5–12, achieving an 84% pass rate in 2022. Before the exam was introduced, over the preceding three years, 359 teachers received DLCS licenses for grades 5–12 through a Competency Review process. There are also Massachusetts teachers who teach CS under out-of-field exceptions or with a legacy Instructional Technology K–12 license. Moving forward, the state will need to consider how to expand teacher capacity to meet an increased demand for DLCS instruction. We created a new model examining each school in the state (excluding Chapter 74 schools which are stand-alone vocational-technical schools and which would be exempt from a graduation requirement) to calculate the number of full-time equivalent (FTE) teachers needed to ensure every high school student can take one DLCS course before graduation. Using conservative assumptions for the number of students taking CS across all grades, average class size, and geographic location, 284 unique individuals would need professional development in CS to implement a graduation requirement.

Webinar and focus group participants noted that the CS courses themselves are often cost-effective. Most districts have the technological infrastructure to support CS courses, particularly as many of the curricular materials and software are freely accessible and web-based 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 (such as PLTW) and cannot independently maintain the cost of the courses.

The Massachusetts Legislature Should Enact Funding to Ensure CS Teaching Candidates Receive Incentives

The greatest barrier to CS education surfaced in focus groups and webinars was teacher capacity. Meeting the need for CS teachers would require addressing the needs of in-service teachers, preparing preservice teachers, and creating opportunities for career transitioners. There are many options for CS teacher professional development, but many of these programs run under capacity. When asked what might incentivize greater participation the following ideas emerged from webinar and focus group participants:

- Paying for professional development time in a way that makes educators feel valued
- Offering debt forgiveness for pre-service teachers that 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 license
- Supporting graduate credit for CS professional development, which may allow for salary increases on some district union pay scales
    - The participants reported that it may be difficult to create differentiated pay scales for CS due to the collective bargaining structure of teachers in the state. However, there is precedent for districts differentiating pay levels for specific subject areas through stipends (of up to $10,000) rather than a salary difference. In Springfield, teachers received

> increased compensation in their contracts through stipends for teaching certain subjects, "in addition, the contract also creates career advancement opportunities for vocational instructional teachers and expands the stipend for teachers who specialize in high-need areas, such as special education, math, and science, for example, from $2,000 to as much as $10,000."

The legislature should enact funding to ensure teachers receive incentives, whether they are in the form of stipends, classroom materials, or graduate credit, in order to encourage them to pursue CS professional development and licensure opportunities.

Allowing teachers to receive graduate credit for professional development may increase their earning potential, and funding from the legislature could allow districts and PD providers to support educators in gaining these credits. Districts tie salaries and additional incremental increases to years of service and graduate credit earned. Supporting teachers to pay for college credit resulting from professional development could result in a salary bump that is attractive to educators. While it is up to a district to determine how they pay for education level (every district negotiates with their teacher's union), additional funding may allow more districts to pursue enhanced pay for teachers who earn college credits.

DESE Should Allocate Funding from the Legislature to CS Programs to Expand Teacher Prep Options in the State Through Partnerships with Higher Ed Institutions and Nonprofits

Massachusetts only has 5 post-secondary institutions that can provide CS certification, limiting options for teachers who want to pursue careers in CS education. Programs in MA are often geared towards graduate level teaching degrees or certificates. There is a need for affordable options for content and pedagogy for teachers not seeking a full degree but who do want some course opportunities to build a stronger CS teaching background or to gain enough background to be ready for existing test preparation courses.

Webinar and focus group participants emphasized two critical aspects for successful teaching: content knowledge and teaching pedagogy. Without both, 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 robust 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.

Other states, both with and without graduation requirements, have created online prep courses and could partner with educational institutions within Massachusetts to help develop capacity within the state. For example, UT Austin has a teacher prep online course and has partnered with other states like Indiana to increase access to teacher prep options. According to their website, UT Austin is the "first university-backed coding boot camp in the state of Texas." There is potential to create something similar in Massachusetts.

Other preparatory programs in Massachusetts, like Cambridge College, focus on MTEL test preparation. While this is appropriate for teachers who already have CS knowledge, teachers who have no background in CS would need a course similar to UT Austin.

The legislature should ensure that there are appropriate funds available to support teachers through educational programs for licensure. One path to accomplish this is the legislature supporting DESE in creatively meeting licensure demand by creating additional approved programs, including learning from structures present in other states, such as UT Austin.

Expand the Data Infrastructure to Monitor Implementation and Measure Outcomes

With Funding from the Legislature, Regional CS Specialists Should Support Schools and Districts to Measure and Track Implementation and Ensure Data Integrity

Massachusetts has a robust data infrastructure, but could do more to support districts with coding and inputting data. In April 2024, DESE released an updated DLCS data dashboard that allows interested parties to look up CS course participation by gender, race/ethnicity, and other variables. However, DESE currently does not have the capacity to support district data inputting practices, compromising the integrity of cross-district data. Once regional CS specialists are in place, they could conduct site visits, with permission from districts, to ensure their on-the-ground experience aligns with how data is being represented in the system. More accurate data can help districts and DESE monitor and evaluate emerging issues, especially related to equity.

Data entry staff at the district level may not have experience with CS, creating data gathering and input challenges. Additionally, definitions of CS may not be clear in the first place, leading to further confusion. Focus group participants noted that many people in the community will need to develop a more comprehensive understanding of what is meant by “computer science” and why it is important.

They surfaced relevant challenges for data integrity:

- Definitions of CS may not be clear; people default to programming rather than the breadth of DLCS.
- Content offered under existing course codes evolves over time and new codes are introduced, potentially leading to an outdated use of codes.
- The person assigning course codes varies across districts and range from a front desk administrator to a CS supervisor, leading to greater variation in how codes might be applied
- Anecdotally, we have also heard of people in other states deliberately reporting inaccurate data- to adhere to local policies. For example, using a math code even when offering a CS course to maintain “in-field” status.

Districts need additional support to ensure data is properly recorded and input. Maintaining data integrity requires consistent and timely data entry and regular reviews, and districts may not have the capacity to devote resources to this process. Districts must develop their own data protocols while adhering to state requirements. CS specialists could ensure that district staff develop pathways that promote data accuracy and integrity so that data dashboards reflect reality.

Connecticut has developed guidance for CS course reporting, which may serve as a model for CS specialist guidance to district staff. The Connecticut State Department of Education defined CS, what qualifies as a CS course in alignment with state standards, and how to apply course codes, in response to

a landscape scan that found accurate reporting of CS course participation was a barrier to expanding programs. Authors stated that, "Through comparing the EdSight[1] results with specific schools, it became clear that CS courses were incorrectly coded and some courses missing. Work needs to be done to ensure correct classification of CS courses to ensure advocacy efforts reach districts and schools in need." Ensuring accurate data reporting is foundational for creating equitable programs and policies.

The MA Legislature Should Initiate a Multi-Stakeholder Coordinating Body/Steering Committee to Define Meaningful Measures to Monitor All K–12 CS Efforts in the State

While Massachusetts' existing data dashboard surfaces key data on CS course participation stratified by various district, school, and student characteristics, a multi-stakeholder effort would ensure these data collection efforts are translated into policy action, promote equity, and continue to evolve. Additionally, a coordinating body could monitor currently siloed CS programs so that policymakers, administrators, teachers, and community members can learn from each other and avoid waste and redundancy. Advocating for and creating state CS programs requires partnerships with a diverse set of stakeholders. This group could be a subset of the PLC membership

Involving non-governmental partners in coordinating CS programs, defining meaningful measures, and data monitoring can help Massachusetts center equity. The Kapor Center's framework for Culturally Responsive Sustaining Computer Science Education, which is referenced in several state CS strategic plans, highlights the need for diverse professionals and role models to provide exposure to CS opportunities and incorporate community cultural assets into CS classrooms. Courses of action that support these goals include partnering with community-based organizations and building relationships with members of local and national tech communities. Including stakeholders with content and context expertise in data monitoring efforts can ensure that resulting policies and programs are inclusive and relevant to the communities they serve.

The Common Metrics project to develop a framework for monitoring CS education and broadening participation in computing (BPC) highlighted the importance of multi-stakeholder efforts to develop a data infrastructure that democratizes data and regular revisions of data systems in response to equity needs. Lessons learned included the importance of teams in equity-driven CS education efforts, with authors stating that "a well-rounded team that included K–12 educators and administrators, as well as data leaders from local education agencies (LEAs), and state-level data leaders would enhance the team's ability to understand where data existed, how to access the data, and how to adapt the data for utilization in the final stages of the project."

Many states have adopted partnerships with organizations that help coordinate the efforts in the state, often led by 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. Maryland, for example, used a user design process to involve a variety of stakeholders in the development of their data dashboard. Maryland's dashboard tracks high school student enrollment in computing courses along with their post-graduation outcomes (for example college enrollment and CS-related major declarations).

[1] a CSDE website that organizes and provides public access to a database of public school information

A multi-stakeholder coordinating body/steering committee could have members from organizations and industries that represent a spectrum of interests and perspectives. ECEP highlights the importance of including: “those who have expertise in relevant areas; those who champion values connected to computing education and those who are from the populations historically marginalized in computing education.” The MassCAN advisory board, for example, included representatives from professional societies, industry groups, researchers, and national organizations, but may have excluded voices from other key groups. A multi-stakeholder coordinating body should include stakeholders that represent a variety of perspectives that includes content and context expertise including those of students, teachers, administrators, employees, families, and community members.

Funding to convene key stakeholders to monitor and coordinate CS efforts would enhance equity and ensure that data dashboards evolve as new needs surface. If a data dashboard fails to evolve, it runs the risk of becoming irrelevant as data becomes outdated or insufficient for guiding policy and implementation. A coordinating body or steering committee could prioritize proper data visualization, coordination across CS programs, and data relevance as the educational environment shifts. Prior to 2020, most policymakers and administrators likely would not have predicted a global pandemic that had as far reaching of an impact as COVID-19. The type of data we collect and monitor, in addition to how we interpret that data, had to change in the wake of the pandemic. An unpredictable future necessitates an infrastructure that allows for the transformation and evolution of existing data dashboards and inclusion of various perspectives.

Conclusion

The future of Massachusetts' educational landscape hinges upon legislative action to enact robust policies aimed at advancing CS education in the state. These recommendations were developed to address the current disparities in access and participation, while also fostering an environment that encourages innovation, equity, and opportunity for all students.

When enacting policies, attention must be given to all that is required to implement said policies. These considerations for implementation include: high-quality instructional materials and curriculum adaptation, teacher training, equitable access, and community partnerships, to name a few. Massachusetts can position itself as a leader in CS education, preparing its students to thrive in the digital economy and contribute meaningfully to society. It is imperative that policymakers, educators, industry leaders, and community stakeholders collaborate closely to ensure the successful implementation of these recommendations.

Appendix

Methodology

Participant Recruitment and Engagement

To study the issue and gain a better understanding of various perspectives on CS education in Massachusetts, the HSCS project engaged community members through a series of interactive webinars and focus groups. 200 individuals from across the state interacted with the project team or attended both types of sessions. 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, by reaching out to 29 organizations serving and representing various stakeholder groups. Outreach aimed to include those concerned with compounding elements such as special education, English language learning, and other content areas as well as community organizers, service providers, out of school CS providers and religious organizations. However, our sample or participants was overrepresented by individuals who specifically care about computer science education, including many CS educators and school and district administrators. It is important to note that participants were not incentivized to join the study.

Data collection and analysis

SageFox and CSforMA conducted five interactive webinars to provide participants with an overview of the landscape report and insights from other states. These webinars included significant discussion on participant perspectives regarding policy options for Massachusetts. In discussions, participants heard and reacted to policies implemented in other states, their applicability to the Massachusetts context, equity concerns, and state policy levers. They also explored other innovative policy options. Participants were given opportunities to share ideas verbally and through written formats, including a collaborative virtual whiteboard. The interactive format allowed for real-time engagement and the collection of varied viewpoints on the subject matter.

The project team organized eighteen 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.

Each webinar and focus group session was recorded and transcribed to facilitate thorough analysis to inform this recommendation report. The transcriptions were used to surface themes that could be used to inform policy development. 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, including those concerned with special education and other compounding elements, we aimed to capture a broad spectrum of viewpoints.

While the sample was overrepresented by 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.

Geographic Representation

Participants from over 41% of Massachusetts' K–12 districts were represented in the study. A geographic map was created (see page 5) to visually depict where participants were employed and/or located, highlighting the widespread interest and concern in CS education across the state.

Additional key findings from focus groups:

- Participants were concerned that a requirement might be coupled with a high-stakes standardized test, particularly the MCAS. The MCAS is already a divisive mechanism within our state with concerns about equity and fairness. There is no support among our study participants for including a test as part of the requirement.
    - Some supported a capstone approach for students to demonstrate CS comprehension.
- Teacher burnout is also a significant issue. Many teachers are already at mental and physical capacity, particularly coming out of the pandemic and we should be mindful of increasing burden. Asking teachers to take on a new subject area needs to be appropriately supported and incentivized.