Redefining Progress: Advancing Equity in State-Level K-16 Computer Science Education Through a Collaborative Metrics Framework

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Abstract: This paper presents a framework developed through over a decade of collaborative systems change work, including mixed-methods evaluation, state-level empirical research, participatory action research, and applied policy design, aimed at broadening participation in computing (BPC) across K–16 education. This work draws on collaborations with state departments of education, nonprofit advocacy organizations, higher education institutions, and K–12 systems across 29 states and Puerto Rico over five cohorts, in the collaborative development of a common framework for defining, collecting, and analyzing data that drives policy and advocacy for equitable computer science (CS) education. This paper argues for a novel approach to progress monitoring—one that separates "advanced" from "non-advanced" CS coursework, as well as by course type (i.e. programming, cyber security, AI, robotics, etc.)—allowing states to better capture their unique contexts while remaining connected to local and national BPC goals. The CMP framework consists of collaborative definition development processes, equity-centered metrics disaggregated by course rigor and type, shared data infrastructure including dashboards, and continuous learning mechanisms that link data use to policy and advocacy decisions. This distinction, emerging from collaborative decision-making across states, contrasts with national models to measure progress that often homogenize CS course offerings. We describe how this flexible metric structure enables both within-state storytelling and cross-state comparisons, empowering local advocates to make informed decisions about the design and prioritization of CS and emerging AI education. By outlining the evolution of this work, shared definitions, and data sharing tools such as dashboards, we offer a scalable model for aligning grassroots data use with scalable policy change. Ultimately, this work invites computer science teachers, CS education advocates, and policymakers to reconsider how we define and measure "progress" in equitable CS education. Together, these components support responsive pedagogy, enable transformative learning for educators and policymakers, and provide a scalable model for equity-centered systems change in computer science education.

Keywords: Equity in Computer Science Education, State-Level Systems Change, Broadening Participation in Computing (BPC), Collaborative Metrics Framework, Progress Modeling

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Introduction

The past decade has witnessed significant growth in K-12 computer science education across the United States. Yet this expansion has not uniformly benefited all student populations. Despite substantial investment in CS education initiatives, persistent disparities remain in who has access to CS courses, who enrolls in them, and who succeeds in computing pathways. These inequities are particularly pronounced for students from historically marginalized groups, including Black, Hispanic, and Indigenous students, as well as girls and students from rural and low-income communities.

Traditional approaches to measuring progress in CS education have often relied on aggregate enrollment numbers or binary measures of course availability, obscuring the complex realities of educational equity. National data collection efforts, while valuable for tracking overall trends, frequently treat all CS courses as equivalent and fail to capture the nuanced differences in course rigor, content focus, and pathway connections that matter for student outcomes and career preparation.

Beyond methodological limitations, traditional measurement systems can function as mechanisms of institutional power. When progress is defined through aggregated enrollment counts or narrow definitions of computer science, the lived realities of students in marginalized communities are rendered invisible. These data practices can unintentionally reproduce deficit narratives, obscure inequitable access to rigorous coursework, and normalize disparities as inevitable. In this way, measurement itself becomes a site where systemic inequities are reproduced and legitimized.

This paper presents an alternative approach developed through the Expanding Computing Education Pathways (ECEP) Alliance's Common Metrics Project (CMP), a collaborative initiative involving 29 states and Puerto Rico over five cohorts between 2019 and 2024. Rather than imposing a top-down measurement framework, CMP emerged from grassroots collaboration among state education leaders, researchers, and advocates working to advance broadening participation in computing (BPC) goals within their unique contexts.

Over the past decade, this work has included mixed-methods evaluation, empirical research on state-level CS education systems, and applied policy design. The ECEP Alliance’s systems change approach combines data collection and analysis, facilitated learning communities, and action research. Each cohort has drawn participants from state departments of education, nonprofit advocacy organizations, higher education institutions, and K–12 systems, representing a broad ecosystem of CS education stakeholders. This collaborative network includes policymakers, researchers, and practitioners who collectively define problems, design interventions, and use shared data for decision-making.

Background and Related Work

The ECEP Alliance and Systems Change

The ECEP Alliance, funded by the U.S. National Science Foundation (NSF) as a Broadening Participation in Computing (BPC) Alliance, focuses on state-level systems change to increase equitable access to and participation in CS education. The Alliance operates on the premise that sustainable change requires coordinated efforts across multiple levels of the education system, from individual classrooms to state policy, guided by ECEP's Model for State Change, which emphasizes coalition-building, data-informed planning, and systemic implementation [2].

Central to ECEP's approach to data utilization is the CAPE Framework (Capacity, Access, Participation, Experience) [1], which provides a holistic model for examining equity in CS education. The CMP framework recognizes that for students to have positive experiences in CS education, they must first participate in CS courses. For participation to occur, students must have access to courses, and for access to exist, educational systems must have the capacity to offer CS education through qualified teachers, appropriate resources, and supportive policies.

The Evolution of the Common Metrics Project

CMP began in 2019 when leaders from six New England states expressed interest in developing common approaches to measuring the progress of CS education advocacy. This initial cohort revealed both the potential and challenges of a cross-state data exercise. While states shared similar goals around BPC, they operated within vastly different policy contexts, data systems, and definitions of what constituted "computer science education."

Early attempts to create uniform definitions across states proved problematic. States with established CSEd programs often had narrow, programming-focused definitions, while states newer to CSEd included broader technology and digital literacy courses. Rather than forcing consensus around a single definition, the project evolved to embrace this diversity as a strength.

The concept of distinguishing between "basic" and "advanced" CS coursework emerged from early analyses that revealed misleading progress indicators. States showing large increases in CS enrollment were often expanding introductory, non-programming courses rather than advanced, credit-bearing ones that lead to postsecondary or career pathways. This realization led to the development of "progress modeling," a layered system that disaggregates course types by rigor, content, and progression potential, offering a truer picture of how students move through computing pathways. Over five years, CMP expanded to include 29 states and Puerto Rico, organized into five cohorts. Each cohort built upon the lessons learned from previous groups, ultimately leading to the flexible framework described in this paper.

Methodology: Collaborative Definition Development

The Challenge of Operational Definitions

One of the most significant challenges in creating a common metrics framework was developing operational definitions that could work across diverse state contexts. Traditional approaches to standardization typically involve experts creating definitions that are then imposed on participating organizations. CMP took a different approach, using collaborative processes to develop what we term "common enough" definitions, frameworks that provide sufficient consistency for comparison while maintaining flexibility for local adaptation.

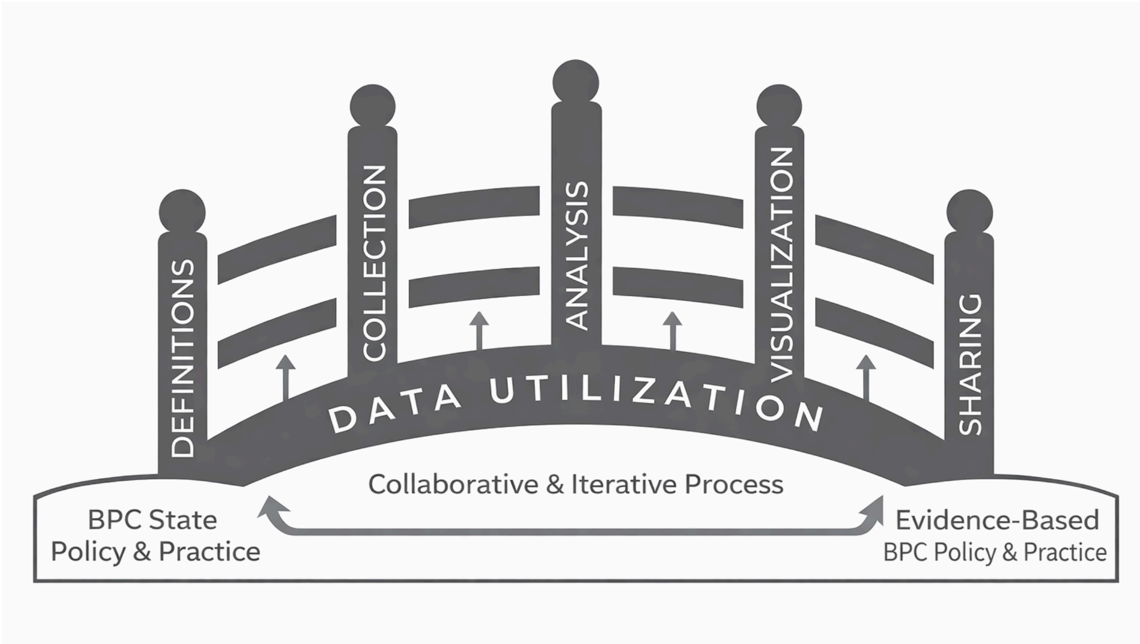
The process involved iterative cycles of definition development, testing with real state-collected data, and refinement based on practical implementation challenges. States worked through specific course categorization decisions in structured activities, revealing that disagreement often occurred at the category level (e.g., "Should cybersecurity be considered CS?") rather than at the individual course level (e.g., "Which specific cybersecurity courses should be included if we count cybersecurity as CS?").

Participants in CMP included over 250 state-level education leaders, researchers, and CS education advocates who met through structured learning communities, data summits, and virtual workshops over a five-year period. These sessions focused on developing, testing, and refining shared metrics using real state data. Each iteration involved a participatory design cycle where states submitted data, discussed inconsistencies, and collectively refined operational definitions.This participatory design approach ensured methodological rigor while maintaining responsiveness to local policy and data system constraints.

The CMP Framework in Practice

The CMP framework consists of four core components: (1) Collaborative Definition Development: an iterative process through which states co-create shared but adaptable definitions of CS education; (2) Data Infrastructure and Tools: standardized templates and dashboards for collecting, disaggregating, and visualizing CS education data; (3) Equity-Centered Metrics: multi-level indicators that highlight disparities in capacity, access, participation, and experience; and (4) Continuous Learning and Policy Feedback: mechanisms that enable states to use data insights to inform legislative, funding, and curricular decisions. Together, these components operationalize the ECEP Model for State Change by embedding data use within collaborative decision-making structures. To clarify how these components function together, Figure 1 conceptualizes the CMP framework as a bridge connecting state policy contexts with evidence-based practice through iterative processes of definition, collection, analysis, visualization, and sharing.

Figure 1. CMP Framework: Data as a Bridge



Note: The Common Metrics Project framework illustrates how collaborative processes of definition, collection, analysis, visualization, and sharing form the infrastructure for equity-centered data utilization, connecting state policy contexts to evidence-based decision-making.

Alt text: Diagram depicting a bridge labeled “Data Utilization” supported by five pillars: Definitions, Collection, Analysis, Visualization, and Sharing. The bridge connects “BPC State Policy & Practice” with “Evidence-Based BPC Policy & Practice” and is described as a collaborative and iterative process.

The bridge metaphor emphasizes that data utilization is not a linear reporting exercise but a collaborative and recursive process that redistributes interpretive authority across stakeholders.

The CMP framework translates from theory to practice through an integrated approach to data collection, analysis, and dissemination that serves multiple stakeholder needs. States participating in the project collect enrollment data using a common template that captures student enrollment by course category and level (advanced vs. basic), along with comprehensive demographic breakdowns including race/ethnicity, gender, economic status, disability status, and English learner status. Geographic information and school identifiers enable analysis across urban, suburban, and rural contexts while maintaining appropriate privacy protections.

This granular data collection approach enables sophisticated analysis that goes far beyond simple enrollment counts. Researchers and practitioners can examine participation gaps within specific course types, track student pathway progression from basic to advanced courses, and identify systemic barriers that prevent equitable access. The multi-dimensional nature of the data allows for intersectional analysis, revealing how multiple identity factors combine to shape students' CS education experiences.

The project has developed both Alliance-wide and state-specific data dashboards that incorporate the flexible categorization system, enabling users to customize their view based on specific needs and local definitions. State education agencies use these tools to track progress toward mandates requiring all high schools to offer CS, examine participation gaps between different student populations, identify schools or districts needing additional support, and compare their progress to other states with similar contexts. In addition, CS education coalitions, advocacy groups, and funders can use the dashboards to monitor statewide trends, identify opportunity gaps for students, and target investments or interventions that align with broader BPC goals. The dashboards serve as both accountability tools and strategic planning resources, supporting evidence-based decision making at multiple levels of the education system.

The CMP framework's practical value becomes evident in its policy applications. States have leveraged CMP data to support legislation expanding CS education requirements, strategically allocate professional development resources to schools with the greatest need, develop targeted recruitment strategies for underrepresented groups, and create compelling evidence-based arguments for increased funding. The flexible nature of the CMP framework has proven particularly valuable for policy advocacy, enabling different stakeholders to use the same underlying data to tell coherent stories that align with their specific goals and audiences.

Key Innovations and Transformative Contributions

CMP represents a fundamental shift in how educational measurement frameworks are developed and implemented, offering several key innovations that challenge conventional approaches to data standardization in education. Traditional educational measurement frameworks often privilege standardization over context, reinforcing dominant definitions of success rooted in historically exclusionary systems. These approaches can obscure structural inequities by flattening differences across schools, communities, and student identities. In doing so, they risk reproducing what ECSJ scholars describe as normalized institutional violence, where inequitable access, tracking patterns, and opportunity gaps become hidden within seemingly neutral data practices.

In many states, aggregate reporting masks patterns in which introductory or “basic” computing courses are disproportionately offered in schools serving Black, Hispanic, Indigenous, rural, and low-income communities, while advanced, pathway-bearing courses are concentrated in more affluent or suburban contexts. When these differences are collapsed into single enrollment counts, the structural organization of opportunity becomes invisible. Such invisibility is not neutral; it allows inequitable tracking and resource allocation patterns to persist without scrutiny. By distinguishing course rigor and progression potential, the CMP framework makes visible how institutional decisions distribute opportunity unevenly across classrooms and communities.

The CMP framework challenges this paradigm by redistributing power in how metrics are defined, interpreted, and used. Rather than positioning researchers as authorities and practitioners as implementers, the collaborative definition process centers the expertise of those working closest to students. This grassroots approach models a justice-oriented standard-setting process that builds ownership while maintaining coordination across contexts.

The CMP framework's multi-dimensional course classification system provides nuance in understanding CSEd landscapes. The distinction between basic and advanced courses, combined with subject-matter categories, enables tracking of student pathways and identification of access barriers at different levels of the CSEd system. This granular approach reveals patterns invisible in aggregate data, such as whether students have opportunities to progress from introductory to advanced coursework or whether certain types of CSEd are concentrated in particular school contexts.

Perhaps most significantly, the CMP framework's dynamic approach to operational definitions acknowledges that different purposes require different course inclusions, enabling the same data infrastructure to serve multiple stakeholder needs without forcing artificial consensus. This flexibility addresses a persistent challenge in educational measurement: the assumption that a single definition can serve all purposes and contexts. Instead, the CMP framework provides tools for transparent decision-making about which courses to include for different purposes, empowering local advocates while maintaining comparability across contexts.

Throughout the project, equity considerations have been central to both data collection and analysis decisions. The CMP framework explicitly examines participation patterns across multiple demographic dimensions and provides tools for identifying and addressing disparities. This equity-centered approach goes beyond simply collecting disaggregated data to actively supporting practitioners in using data for transformative change. The project has fostered the development of data literacy and culture among state education leaders, moving beyond simple data collection to building capacity for data-driven decision making and advocacy.

Implications for Computing Education

The CMP framework fundamentally challenges traditional approaches to measuring progress in CS education that rely on aggregate numbers or binary indicators. By providing more granular and contextual data, the CMP framework enables sophisticated analyses of equity and access that reveal the complexity underlying simple metrics. Rather than asking whether a school offers CS, the CMP framework enables deeper questions about what types of CS courses are offered, whether they provide pathways to advanced study, whether participation rates are equitable across student populations, and how course offerings vary by school characteristics.

This enhanced analytical capacity has proven particularly valuable for supporting local advocacy efforts. The CMP framework's flexibility allows advocates to customize their analysis based on local contexts and priorities, enabling more compelling and relevant storytelling about CS education needs and opportunities. Local advocates can use the same robust data infrastructure to address different audiences and purposes, from school board presentations to legislative testimony to grant applications.

With the basic and advanced course distinction and the subject-matter categories, states can identify gaps in their course offerings, ensure appropriate sequencing, and develop targeted interventions to support student progression through increasingly sophisticated CS learning experiences. This pathway perspective has also revealed themes that indicate a heavier emphasis of advanced courses in certain school types or the lack of progression opportunities in rural areas.

By providing a common framework that respects local variation, CMP enables the scaling of evidence-based practices across diverse contexts. States can learn from each other's successes and challenges while adapting approaches to their specific circumstances. This balance between standardization and customization has proven essential for moving beyond isolated pilot programs toward systemic change that can be sustained and scaled.

This work directly aligns with the ECSJ division's pillars by promoting equity-centered systems change in computing education. The CMP framework advances transformative learning by enabling educators and policymakers to interrogate systemic barriers to participation. It supports responsive pedagogy through data tools that allow teachers and leaders to tailor interventions to local contexts. Most importantly, it contributes to socially just systems by centering collaboration and shared decision-making across states and communities, modeling how equity can be operationalized in educational data practices. By interrogating how measurement systems can unintentionally reproduce inequities through omission, aggregation, and definitional bias, this work calls attention to the often invisible mechanisms through which institutional practices normalize disparities in access and participation.

At the classroom level, these measurement choices shape what becomes visible and actionable. When advanced coursework is not distinguished from introductory exposure, inequitable tracking patterns remain hidden, masking the uneven distribution of meaningful learning opportunities. By making progression pathways visible, the CMP framework helps illuminate how classrooms can simultaneously function as sites of exclusion and possibility. In doing so, it equips educators and advocates with tools to interrogate who has access to rigorous computing experiences and to challenge structures that limit participation.

Challenges and Future Directions

Despite its innovations, the CMP framework faces significant implementation challenges that illuminate broader issues in educational data systems. Data quality and consistency remain persistent concerns, as course coding practices vary widely both across and within states. At times, the same course might be categorized differently in different districts within the same state, requiring ongoing fidelity efforts and stakeholder education.

Resource requirements present another significant challenge, as implementing the CMP framework requires substantial investment in data infrastructure, personnel, and ongoing maintenance. Not all states have equal capacity to participate fully in data collection and analysis efforts, potentially exacerbating existing inequities in data availability and quality. Privacy and ethical considerations around the collection and sharing of student-level demographic data require a comprehensive understanding of state and federal policies governing data sharing. Careful attention must be paid to balancing transparency and accountability with appropriate student protections.

The long-term sustainability of the CMP framework depends on continued investment and support from state education agencies and other stakeholders. Changes in political leadership, data teams, and funding priorities challenge the continuity of data collection efforts, highlighting the need for embedding these practices in other structures rather than relying solely on individual champions.

Looking toward the future, several directions show promise for extending the CMP framework's impact. Expansion to elementary and middle school levels could provide insights into the full K-16 pathway, though this would require adapting the CMP framework to account for different course structures and learning objectives at younger grade levels. Integration with other education data systems, such as those tracking student outcomes in postsecondary education or employment, could provide insights into the long-term impacts of different approaches to CSEd. The collaborative approach developed through the CMP could potentially be adapted for international contexts, enabling cross-national comparisons while respecting different educational systems and cultural contexts.

Conclusion

The ECEP Alliance's Common Metrics Project demonstrates that it is possible to create measurement frameworks that balance the need for a unified system, consisting of definitions, practices, and data tools, with respect for local contexts and priorities. By engaging practitioners in collaborative definition development and embracing flexibility in operational definitions, the project has created tools that serve multiple stakeholder needs while advancing equity in CS education.

The CMP framework's emphasis on disaggregated data, pathway tracking, and dynamic definitions provides a model for other education measurement efforts seeking to move beyond simple metrics toward more nuanced and actionable insights. As the field of CS education continues to evolve, approaches like the CMP framework will be essential for ensuring that growth in CSEd translates into meaningful opportunities for all students. The work presented here invites the engineering and computing education community to consider how measurement frameworks can better serve equity goals and support local advocacy efforts. By centering collaboration, flexibility, and equity in approaches to data collection and analysis, it is possible to create tools that not only track progress but actively contribute to advancing justice in CSEd.

This framework represents more than a technical solution to data collection challenges, it embodies a philosophical approach to educational measurement that prioritizes local voice, collaborative decision-making, and equity outcomes. As we continue to work toward the goal of computing education for all students, such approaches will be essential for ensuring that our measurement efforts support rather than constrain our equity goals.

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