

EMERGING CONNECTIONS

Building Consensus for Integrated STEM and Social-Emotional Development: From Convening to Implementation

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“What is the responsibility of the practitioner, the researcher, and the parent? There are a lot of responsibilities, but it really comes back to ensuring that every young person believes that they can, even when they cannot. Our responsibility is to ensure a strong foundation, and reinforce that foundation...using SED as a lever.” – A Parent and Executive of a National Youth Serving Organization

Uniting social, emotional, and academic development is necessary to ensure all young people develop the thinking and feeling skills needed to succeed in a STEM-driven future. Scientific discoveries and technological innovations are transforming society, and while they may improve our quality of life, they also introduce social and ethical quandaries that young people must be equipped to navigate. For example, there are both opportunities and risks to using artificial intelligence, genetic engineering, and renewable/alternative energy sources. Although the public discourse supports bringing STEM and social-emotional development (SED) together, and demands evaluation and measurement of outcomes, integrated STEM+SED in educational research, practice, and policy is largely abstract and aspirational. Given that jobs of the future will be STEM-focused and will require SED/21st-century skills—such as working in diverse teams, solving complex problems, and persevering through failures—it will be important to implement and measure STEM+SED together at the teaching and learning levels.

To move the field toward meaningful integration of STEM+SED practices and skills, we convened a National Science Foundation (NSF)—funded virtual conference: Mapping Connections Between STEM and Social-Emotional Development (SED) in Out-of-School Time (OST) Programs. This conference—attended by 49 stakeholders from STEM and SED research, policy, and practice—focused on identifying the measurable STEM+SED qualities and skills important for youth success and prioritized by both fields. From this conference emerged consensus for a common frame to explore STEM+SED integration—focusing on Active Engagement, Agency, Belonging, and Reflection—which we and our partners are using to generate knowledge, resources, and tools to advance the integration of STEM+SED in formal and informal learning environments. The preliminary findings and recommendations from this conference provide a starting point for areas to prioritize, explore, and set the stage for more rigorous, relevant, and high-quality research on integrated STEM+SED.

We begin by telling the story of our conference, including our initial focus on OST, our choice of the term “SED,” and our approach. We then show how discoveries during and after the conference push this essential STEM+SED agenda forward in research and

practice. We conclude with recommendations by and for researchers, practitioners, and policymakers to promote synergy between the fields of STEM and SED across all learning environments.

The STEM+SED Conference and Beyond

This section summarizes the scope, goals, and context of the STEM+SED conference. In the subsequent sections, we describe key findings from the conference, recent developments, and recommendations for the field.

Why focus on out-of-school time?

Over the past two decades, educational priorities and policies raised the importance of STEM learning opportunities outside the formal school day (e.g., National Research Council 2015). The out-of-school time (OST) STEM agenda builds upon positive youth development–oriented programming, which provides activities that encourage youth to grow physically, intellectually, artistically, socially, and emotionally in fun, low-pressure environments. Research finds that the social and emotional skills developed in OST programs (STEM and non-STEM-focused) set children up for success in college, career, and life (Allen et al. 2019; Durlak et al. 2010). As a result, more youth are engaging in STEM learning in OST programs centered on thriving, where they can practice such skills as teamwork, problem-solving, leadership, and communication (Noam and Shah 2014).

Why the term social-emotional development?

We chose the term social-emotional development (SED) to highlight the connections between learning, growing, and thriving from childhood to adulthood. SED is a broad term that includes social-emotional learning (SEL), social, emotional, and academic development (SEAD), and 21st-century skills, all linked to youth development practices that are foundational to many OST programs (Witt and Caldwell 2018). We emphasize *development*, which is enhanced by SEL, defined by the Collaborative for Academic Social and Emotional Learning (CASEL 2023) as the “process through which all young people and adults acquire and apply the knowledge, skills, and attitudes to develop healthy identities, manage emotions and achieve personal and collective goals, feel and show empathy for others, establish and maintain supportive relationships, and make responsible and caring decisions.” We also emphasize that SED is more than a list of skills. Children grow social-emotional skills at different ages, and these skills become specialized (Noam and Triggs 2018). Significant progress has been made to define social-emotional skills and connect SED frameworks (Jones et al. 2019). SED has a research history with precise definitions and many assessments, and it is researchable in all learning contexts because it is embraced in both school and OST settings (Jones et al. 2019).

Why emphasize research and evaluation?

Following models of continuous improvement, OST programs are increasingly designed to improve the quality of learning experiences and youth outcomes in ways that are valued by both the STEM and SED fields (Allen et al. 2019). Program goals are best informed by data, information that is also critical for identifying effective strategies. As more programs set goals for both STEM and SED, it is important to determine what relevant skills are measurable and useful for advancing research and informing the design, development, and evaluation of STEM+SED learning. Until recently, it was not possible to systematically investigate outcomes at the interface of STEM+SED, but new

work to collect, catalog, and vet measures for SED and STEM has occurred in both fields.

What were our goals for the conference and beyond?

To build the foundation for a new field of STEM+SED inquiry, The PEAR Institute: Partnerships in Education and Resilience at McLean Hospital and Harvard Medical School convened researchers and practitioners. (Note: The PEAR Institute is now known as the Institute for the Study of Resilience in Youth (ISRY), a teaching and research unit of Harvard that is separate from PEAR, Inc., the educational services benefit corporation that spun off from McLean in 2020).

Our work is driven by the following goals:

- Clarify the meaning of integrated STEM+SED in OST research and practice
- Increase collaborations to focus OST research and practice on STEM+SED
- Identify best practices for STEM+SED in OST
- Explore tools to measure STEM+SED and understand quality and outcomes in OST
- Initiate discussions on building an impactful STEM+SED research agenda

In building the research agenda, we include all these goals by studying theories and frameworks, identifying effective STEM+SED practices or designing and studying new practices, and measuring STEM+SED quality and outcomes.

Who participated and what was the context?

The conference was attended by 49 experts from 37 U.S. organizations/institutions, including national youth-serving organizations and collaboratives, state afterschool networks, STEM learning ecosystems, industry/nonprofit/university researchers and

evaluators, private and federal funders, and representatives from state and federal education departments. Ten attendees served as conference advisors and panelists. The conference was convened in May and June 2020—shortly after the pandemic began to impact the United States. Challenging social and economic conditions brought education to the top of both the national agenda and the conference agenda. On the first conference day, participants wondered what schools and OST programs would be like when students return, and how the integration of SED with STEM could support youth. Participants were concerned about systemic inequities that disproportionately affect Black, Indigenous, and People of Color (BIPOC). The issue of social justice and cultural competence within the STEM+SED dialogue was elevated further on the second conference day, which coincided with a collective action to protest racism and police brutality.

Key Discoveries

This section highlights the discoveries made during and since the STEM+SED conference. In the next section, we show how conference findings built momentum for the implementation of STEM+SED in research and practice.

Discovery #1: STEM fosters SED, and SED enhances STEM learning.

The relationship between STEM+SED was conceptualized by our conference participants as mutually enhancing. Simply stated, social-emotional practices and skills are needed to deepen STEM learning, and STEM experiences provide opportunities to exercise social-emotional skills. For instance, we discussed how humanizing “hard” STEM subjects makes the content more relevant. One OST STEM researcher from the southern United States shared his observations:

"The most successful science classes I have seen have included social and emotional learning experiences ... there is so much focus on the content ... and learning really has been blocked off from what is going on in the classroom. And I see out-of-school time playing a much stronger role to reconnect students with the social emotional part of what STEM means ..."

Humanizing STEM has been present in education discourse for at least two decades (Donnelly 2004). As a recent example, King (2022) conducted a critical analysis of educational spaces for Black girls, which concluded with a call to humanize STEM:

"In science education specifically, we often elevate content over context, and being correct over being morally just. This paper is a call to humanize science by prioritizing mattering over matter. When we teach the fundamental principles of our discipline, children are required to learn that 'matter' is anything that has mass and takes up space. This concept informs every branch of science with implications ranging from the particulate to astronomical aspects of our field. What if we reconceptualized the construct of matter in STEM learning spaces to include the wellbeing of all children?"
(p. 59)

Moreover, to show that young people matter (and are valued in STEM), the current vision for science education—both in the United States (e.g., NGSS Lead States 2013) and internationally (e.g., OECD 2020)—encourages educators to help young people connect STEM to their everyday lives.

As another example, STEM activities that build technical skills, like robotics or engineering, support SED by providing youth with opportunities to

connect with others (fostering belonging by practicing skills related to teamwork and collaboration),
express themselves creatively (encouraging reflection by exercising critical thinking and considering personal identity), and
take ownership of what they learn (building agency through decision-making and leadership).

One participant authored a white paper on the relationship between engineering and SED (Sneider 2020). In research literature, Ingram et al. (2021) studied science content learning (arthropod biology) and SEL (empathy, self-reflection, and self-management) with a sample of 100 sixth- to eighth-grade students, finding that the curriculum built empathy for arthropods and other people. According to the authors: "By introducing the concept of 'otherness' using arthropods, we can then help students reflect on their perceptions or attitudes about otherness in humans" (p. 6). The SEL skills of interest map to the conference domains of belonging, reflection, and active engagement, respectively.

For some participants, the connection between STEM+SED holds greater societal significance. For example, a midwestern mathematics teacher and SEL consultant implored:

"It simply reinforces that STEM fields ought to be human-centered. If our 'progress' kills us, what good is it for? If our humanity is erased and obscured by advancement, where does that lead? If we cannot marshal the collective intelligence that begat our greatest technologies to feed, house, clothe, and cure us, what benefit do we claim?"

Discovery #2: A STEM+SED frame supports further research and practice.

To inspire deeper consideration for developing a common STEM+SED framework for measuring qualities and youth outcomes, we created and revised—with input from advisors, participants, and partners—several visuals (see Figure 1a-c). As a starting point, Figure 1a displayed overlapping skills based on a crosswalk of common theoretical frameworks for STEM and SED. For STEM, we began with the six strands of informal science learning from Surrounded by Science (Fenichel and Schweingruber 2010). For SED, we used several SED models cataloged by the Harvard Taxonomy Project (Jones et al. 2019) including CASEL (2020 2023) and the Clover Model (Noam and Triggs 2018). Additionally, ISRY conducted a pilot scoping review of empirical and

gray literature made available since 2000. By searching variations of the terms SEL/SED and STEM, we identified 116 unique references that described STEM+SED either in theory, research, or practice.

Based on the scoping review and participant feedback, the themes that emerged as most common, relevant, and important were: Active Engagement, Agency, Belonging, and Reflection (Figure 1c). We were advised to focus on the domain level because there are many synonyms for SEL and 21st-century skills, and this was an effective strategy. For example, using the Explore SEL Taxonomy, the domain Agency is related to the terms self-efficacy, growth mindset, personal power, confidence, and assertiveness. Although multiple models were included in the visuals, the last version—based on skills prioritized by stakeholders from both fields—most closely mapped to the Clover Model, also known as a research-based Developmental Process Theory (DPT) that has served as a common language for youth workers, educators, and families to discuss and understand phases of youth development (Noam and Triggs 2018). This is unsurprising given that the Clover Model is the theoretical basis of the Dimensions of Success (DoS), an evidence-based observation tool that defines quality STEM learning experiences using STEM and SED principles, and was developed with input from researchers and educators (Shah and Noam 2014; Shah et al. 2018). DoS represents Active Engagement as participation and engagement with STEM, Belonging as relationships, Agency as youth voice, and Reflection as STEM content learning, inquiry, and reflection (Shah et al. 2018), and these DoS qualities are positively correlated with youth STEM- and SED-related outcomes (Allen et al. 2019). Because Clover is at the domain level, it includes social-emotional skills identified by other SED models. For more detailed comparisons, see Harvard University's Explore SEL Taxonomy Project (Jones et al. 2019).

Participants conceptualized the STEM+SED relationship as an overlay of STEM+SED practices and skills (Figure 1c), as opposed to concentric circles or co-occurring practices and skills (Figure 1a and Figure 1b). This frame set essential boundaries that allow innovation and creativity while increasing the integration of STEM+SED in research and practice. Further study, such as a more rigorous systematic review of the

literature, is needed to substantiate which SED domains/skills more effectively support youth success when integrated with STEM.

Discovery #3: STEM+SED needs to be inclusive and equitable.

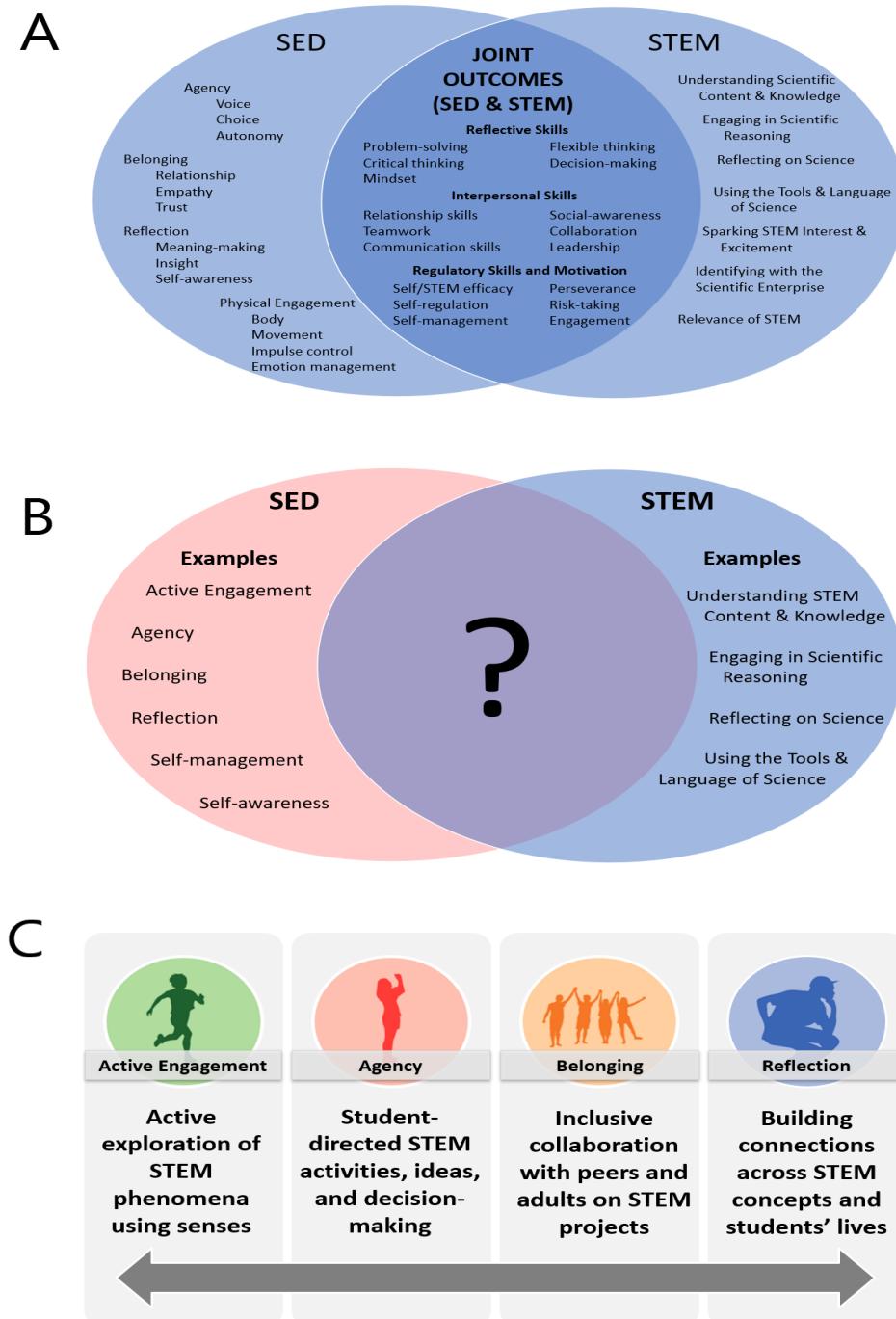
STEM+SED can be a catalyst for building resilience in vulnerable communities and supporting social justice and equity work. Conference findings (based on participant and panelist discussions, and pre/post-conference surveys) were strongly linked to the turbulent national context of 2020. Most participants reported increased recognition of the importance of SED, STEM, and their integration, noting that OST could support youth and families during COVID. According to one state policymaker from the western United States, this crisis represented an opportunity to advance the STEM+SED agenda:

"Learning is social and emotional ... I feel like it has taken the pandemic to allow this to surface and literally, in the last couple of weeks, I have had some of our most progressive, forward-thinking educators saying that we need out-of-school time—we need the youth development field more than ever with the re-opening of school."

Conference participants and partners since then have discussed how the inequities rooted in educational systems deny many youth—especially young People of Color and those living in poverty—access to high-quality, relevant STEM learning opportunities. Participants worried that existing inequities in STEM education will grow due to the disproportionate burden COVID-19 brought to already disadvantaged communities, but also expressed hope that SED could help youth, families, educators, and the larger community navigate injustices in STEM learning environments. For example, participants proposed that training educators on SED skills could support more inclusive and equitable STEM programming. By practicing reflection, educators can increase awareness of their own biases as well as those inherent in the STEM learning

environment. These ideas are supported by a recent empirical literature review that connects social and emotional learning

FIGURE 1. EMERGENCE OF A FLEXIBLE STEM+SED FRAME TO GUIDE RESEARCH AND PRACTICE



(especially Agency, Belonging, and Engagement) with social justice and equity (Jagers et al. 2019). The authors connect culturally relevant teaching with better educational outcomes in math and science, including increased motivation, creativity, attendance, test scores, and college-going.

The second conference session occurred on “Blackout Tuesday,” a collective action to protest racism and police brutality by going silent on social media. Attending the conference posed a conflict for many participants who expressed anger, anxiety, fear, and grief in response to these racially charged events, especially BIPOC participants. For example, a SED researcher in the Midwest urged others to action:

"We continue to utilize racist structures and fail to bring justice for the murder of George Floyd and so many other Black people...This group is committed to SED and STEM and should call this out... This is the context for learning for so many youth—it cannot be separated from SED or STEM learning."

One OST STEM researcher and practitioner in the southern United States shared how elements of SED are integral for equity in her STEM OST program:

"We are focusing on who our children are, and it [the STEM program] is antiracist. We are looking at a place where they can listen, they can speak, and most of all they can be heard. A place where they can feel, see, and be seen. Where they can live, complicate, and solve problems. Where they can love, and receive love, and develop authentic and nurturing relationships. So, we have work to do, and as we focus on social-emotional development and STEM, we have to remember that these cannot be divorced from issues of equity and social justice."

Participants advocated centering social justice in STEM+SED research and practice, as the advancement of the STEM and SED fields are inseparable from racial, economic,

and social inequities and opportunities. According to one STEM educational consultant and philanthropist in the eastern United States:

"The voices and lived experiences of young people and their families and those closest to the work—teachers, youth workers, and others—should inform the work of educational leadership, policymakers, and philanthropists, among other decisionmakers within STEM educational systems."

Discovery #4. STEM+SED is systemic and communal.

Conference participants and discussions with partners since have suggested that educational ecologies should integrate STEM+SED with action at the individual, interpersonal, institutional, and community levels. Several participants recommended widening SED to include adults who support children—including parents, teachers, and other educators. According to a SEL researcher in the Midwest:

"One of the things the field of SEL has come to pay particular attention to is the issue of adult social and emotional learning, especially how it relates to equity—meaning there is a recognition that adults are responsible and active agents in constructing learning environments."

Systems can be leveraged to enhance youth wellness and learning, and provide support in times of crisis. For example, one policymaker shared how OST programs in a western state helped children and families cope with the devastation of the pandemic by removing restrictions so programs could provide expanded learning time. The educational system in their state allowed many programs to partner with community organizations and schools to ensure that children were safe and supported socially, emotionally, and academically, and the programs were able to remain open. In advancing the STEM+SED agenda, it will be important to consider how STEM+SED can be built into educational systems and embraced by communities to support all children.

One promising strategy leverages STEM learning ecosystems, which have the capacity, resources, and partnerships to promote a common vision for STEM+SED in ways that can reach all youth and families (Allen et al. 2020; Traphagen and Traill 2014).

Building Momentum for STEM+SED

Since our national convening, interest in this STEM+SED line of inquiry is growing. Relevant publications like this special issue have increased. Funding and national attention have also increased, as in the Department of Education's "YOU Belong in STEM" Initiative (October 2022), targeting teachers' and students' sense of belonging in STEM. This is consistent with the outcomes of our conference, which named belonging as a priority domain for advancing quality and equity in STEM. The Department of Education is partnering with Beyond100K to increase teacher diversity in STEM classrooms and create classrooms that foster belonging in STEM.

Using our own work as an example, the conference's STEM+SED frame has proven useful for guiding projects that we are pursuing with partners. These include a systematic review to consolidate existing knowledge of STEM+SED, the development of an OST neuroscience curriculum for middle school that intentionally unites STEM+SED in strategies and activities ("Project Brainy"), the creation of an observation tool to support measurement of STEM+SED in middle school classrooms (the [Dimensions of Success for Middle School Science and Engineering, DoS-MSSE](#)), and the creation of a [family engagement planning tool](#) and framework (known as CARE: Connect-Act-Reflect-Empower) that expands the focus of STEM+SED from youth to families (see [Table 1](#) in Supplemental Resources). The systematic review is especially important as it will provide an evidence base to prioritize STEM+SED concepts and practices based on relevant high-quality studies.

When deciding on the best next step to advance the STEM+SED agenda, our team focused on projects that will help the field understand: (1) what is known about STEM+SED in theory (i.e., building knowledge by clarifying STEM+SED “phenomena;” (2) how to carry out STEM+SED effectively in different learning environments (i.e., designing and testing STEM+SED training, programming, and materials); (3) how to study and measure quality of STEM+SED implementation and outcomes (i.e., developing assessments, including observation protocols and surveys).

While the conference and ensuing work supported an emerging consensus for four domains of STEM+SED, it also demonstrated that the field needs a common research and evaluation framework. Clearly defined terminology will support STEM+SED across all learning environments by increasing precision in measurement (of quality, and youth/educator outcomes) and communications (to facilitate collaboration). A shared vision for STEM+SED across research, practice, and policy will support the development of strategies that build STEM+SED skills, which in turn will inform priorities for policymakers and funders to promote effective and equitable STEM teaching and learning. According to the director of a network of youth-serving organizations in the western United States:

"... before we jump into the what and how of research projects on this [STEM+SED], both OST practitioners and the research folks agreed that there should be some definite up-front energies on the 'why' to zero-in on that orientation of where we can get agreement but to provide a framework to give us good guardrails."

Summary, Outlook, and Recommendations

We hosted a national convening that examined the landscape of STEM+SED in OST to discover what efforts are being made to integrate them, how the quality and outcomes of these efforts are measured, and how the field can deepen research-practice partnerships for high-quality STEM+SED. The conference produced a frame that can support STEM+SED integration, consisting of four skill domains: Active Engagement, Agency, Belonging, and Reflection (Figure 1c). While more research is needed to evaluate this model, this frame is a useful guide within our own line of work, and we hope it will inspire others.

We are optimistic that the STEM+SED approach will help the field support more youth. This conference validated our commitment to connecting STEM and SED. Nearly two decades ago, we faced skepticism when discussing the social and emotional qualities of STEM, but we and our conference participants see the educational field embracing the combination today. However, many questions remain.

One question is: What is the best terminology? The phrase *social-emotional learning* (SEL) has become politicized, embroiling schools and OST programs in controversy. Alternative terms—such as *thriving*, *21st-century skills*, *whole child*, *resilience*, and *college/career-readiness*—have been proposed.

It also remains to be seen how these strands are practiced in formal and informal learning environments. Since the conference, we have adopted a hybrid term—STEM+SED/21st-century skills—to acknowledge the multiple skillsets that young people need in our increasingly complex society. This connection will become more important for jobs of the future, so we must help children develop relevant social, emotional, and academic skills.

We conclude with recommendations for ongoing efforts to integrate STEM+SED:

For researchers, the field needs: clear and precise definitions and indicators; more research and evaluation resources for practitioners (including STEM+SED methods, measures, and data-sharing, and studies that validate this relationship); a shift away from content knowledge acquisition to prioritize engagement, motivation, and attitudes; and an emphasis on tools to support

equity and quality improvement by focusing on *how* programming is being implemented and *for whom*.

For practitioners, the field needs: STEM+SED programs, materials, and practices that reflect the interests, needs, and lived experiences of youth and families—to reinforce the relevance of what young people learn and its importance for their futures; and the integration of cultural, social, and emotional development in existing frameworks and practices, as well as new learning paths for STEM+SED.

For policymakers and system-builders, the field needs a cultural change so decision making prioritizes social-emotional needs and includes SED in the definition of high-quality STEM; investments in STEM+SED research and practice; increased buy-in from all stakeholders to promote a common understanding of, and approach to, STEM+SED; and cross-sector partnerships that build the capacity of STEM communities and educational systems.

We believe that one can do SED without STEM, but one cannot do state-of-the-art STEM without SED. That idea has taken root, and funders and policymakers have taken notice. Now we must expand on innovative practice and systematic research and evaluation that demonstrates strong results.

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