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Executive Summary: A Systematic Review of STEM and Social Emotional Development in Out-of-School Time

Introduction

There is growing interest in understanding the social and emotional dimensions of learning science, technology, engineering, and mathematics (STEM) to help all young people develop the knowledge and skills needed to succeed in a STEM-driven future (Allen & Noam, 2023). Out-of-school time (OST) programs are increasingly integrating methods to support social-emotional development (SED) in STEM learning, such as through collaborative activities that challenge youth to problem-solve and persevere through failure. However, until now, there has not been a comprehensive examination of how skills at the intersection of STEM and SED are conceptualized, put into practice, and studied for effectiveness.

This executive summary highlights key findings from a National Science Foundation (NSF)-funded systematic review that provides evidence to support the field's understanding of STEM and SED in OST programs. We systematically searched, assessed, and synthesized two decades of research, evaluation, and practice literature focused on skills important to STEM and SED among youth ages 5 to 18 in OST settings (e.g., afterschool clubs, summer programs). We chose OST programs as they often place a dual focus on STEM learning and youth development. Our definition of SED includes 21st-century, resiliency, and social-emotional learning (SEL) skills, and we used Harvard's Explore SEL taxonomy to ensure representation of all SED terms. This study maps the landscape of STEM+SED skills and provides an organizing frame to advance essential research on this topic.

Study Highlights

- This study systematically reviewed references from over twenty years of research, evaluation, and practice at the interface of STEM+SED in out-of-school time (OST) programs for youth ages 5 to 18.
- Authors cited hundreds of theories and frameworks, and programs leveraged more than a dozen strategies (hands-on experiences, collaboration opportunities, youth expression activities, etc.), to help youth grow over 100 STEM+SED skills.
- 105 quantitative studies reported significant growth in youth SED skill(s) after STEM programming, and 330 qualitative studies identified SED themes among youth engaged in STEM. However, only 35% to 55% of these study designs were rated as strong or exemplary.
- The extensive list of STEM+SED skills can be mapped to five focal areas/domains; this flexible organizing framework based on the Clover model can help unify research, policy, and practice.

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Study Background

Context & Purpose

This systematic review was designed to strengthen the evidence base supporting the integration of STEM and SED in the OST field. Integrating STEM and SED has many practical purposes, including increasing youth interest, motivation, identity, and attitudes towards STEM education and careers, particularly for youth who have historically been underrepresented in STEM. This study builds on recent projects and resources that promote the intentional, explicit, and evidence-based integration of STEM and SED in ways that support program improvement and better youth outcomes (Allen & Noam, 2023; NRC, 2015; The Aspen Institute, 2018).

Research Questions

- How are skills at the intersection of STEM and SED conceptualized, implemented, and measured among K-12 youth in OST STEM programs?
- Does the conceptualization, implementation, or measurement of STEM+SED vary over time, by student background, or by type of learning environment?

In 2020, the Institute for the Study of Resilience in Youth (ISRY) at McLean Hospital and Harvard Medical School convened a two-day virtual conference to explore the connections between STEM and SED (STEM+SED) in OST (NSF Award #1940155). A key recommendation highlighted by attendees, consisting of 49 experts from 37 organizations, was the need to create a unified vision for STEM+SED – one that intentionally integrates diversity, equity, inclusion, and access (DEIA) – to bolster capacity of the OST field in research, policy, and practice (Allen & Noam, 2023). Attendees underscored the need for a rigorous, evidence-based approach to guide decision-making regarding the integration of STEM+SED. This would empower the field to better equip young people with the essential skills needed for success in STEM fields and 21st-century life. To address this need, ISRY developed a three-pillar approach to understand how STEM+SED is conceptualized (Pillar 1), implemented (Pillar 2), and measured (Pillar 3) in OST programs (**Table 1**).

Study Methods

A health science librarian searched five academic databases to identify all references related to K-12 youth in OST STEM learning environments available between January 1, 2000 - July 8, 2022. These searches, guided by the PICO model (Population, Intervention, Comparison, Outcomes), yielded 31,085 references that passed through multiple stages of review based on rigorous inclusion/exclusion criteria (**Figure 1**).

Our research team identified and extracted data from 709 (of the original 31,085) references and then synthesized the data according to the three "pillars" for building coherence in STEM+SED integration: "phenomenon," "implementation," and "assessment" (**Table 1**). Coherence refers to clarity and consistency of conceptual understanding (phenomenon), practice (implementation), and measurement (assessment) of STEM+SED. The pillars intentionally focus on DEIA. For example, we examined how implementation of STEM+SED can inform culturally responsive approaches that lead to progress in STEM inclusion. See p. 8 for additional information and resources, including access to full Methods and a Reference Database.

Figure 1. PRISMA flow diagram

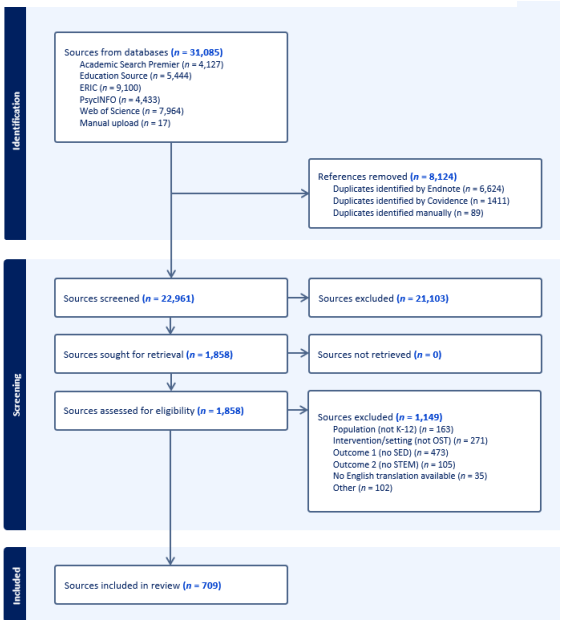


Table 1. Definitions and examples of pillars of coherence to promote STEM+SED integration

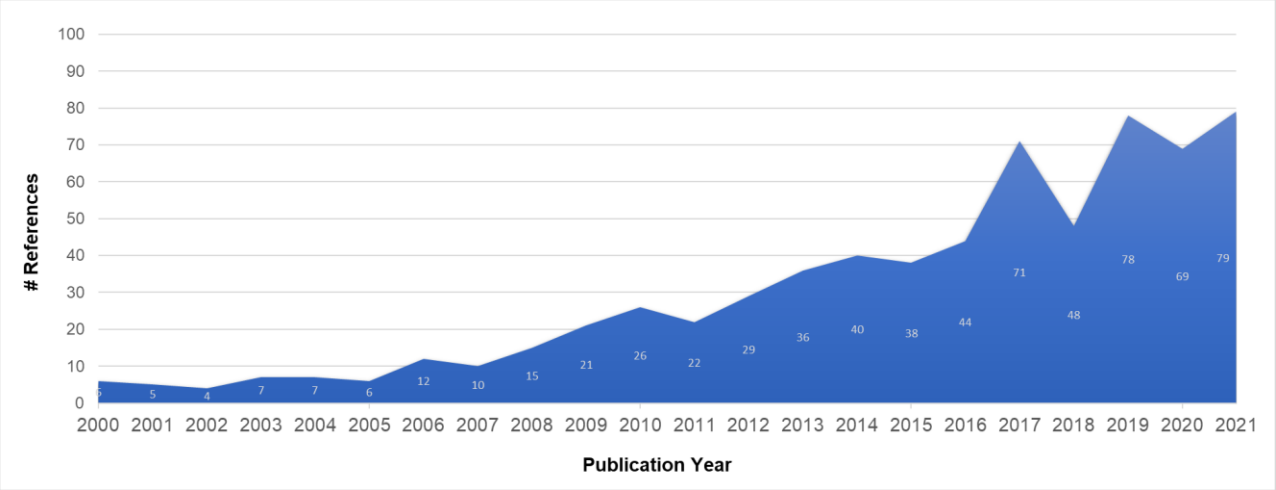
Pillar	Definition
Phenomenon	What the field *knows about* STEM+SED, including theories, models, or frameworks that inform programming
Implementation	How the field *practices* STEM+SED, including curricula and strategies that promote teaching and learning
Assessment	How the field *measures* the quality and outcomes of STEM+SED, including strength of study designs and results

Key Findings

Growing Focus on STEM+SED

Initially, we expected to find a relatively small number of eligible references. Instead, we found there is an active and growing body of literature examining the intersection between STEM+SED (see **Figure 2**). Since 2000, the number of references grew by more than 1000%.

Figure 2. Increasing number of references focusing on STEM+SED in OST over time (2000-2021)



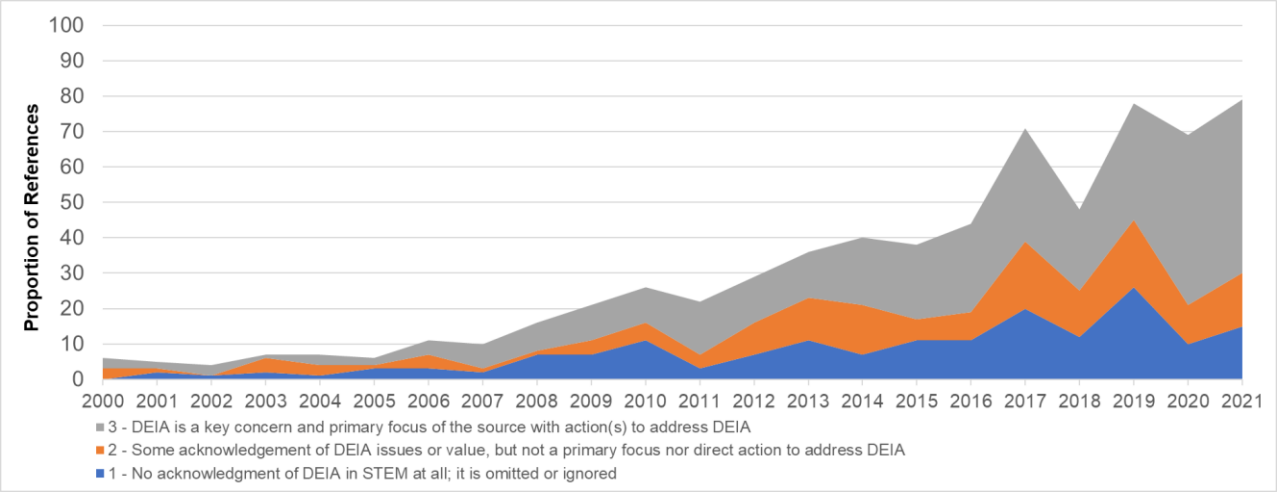
Note. Analysis of trends over time included all years with 12 months of evidence (Jan. 2000 to Dec. 2021).

The programs described by eligible references represented all grade levels of youth from elementary to high school, but they were more representative of adolescents than children, with 66.1% of references exclusively focusing on Grades 6 to 12, and 10% of references exclusively focusing on Grades K to 5. Additionally, programs represented more than 50 countries (the most common being: United States [79.4%], United Kingdom [3.6%], and Canada [2.8%]), and were located in all localities, including urban areas (59.5%), rural areas (13.9%), and suburban areas (6.7%). Programs used different formats (90.6% in-person, 1.7% virtual/remote, and 3.2% hybrid) and were convened in a variety of settings (the most common being at: a college/university [37.1%], school [30.8%], a summer camp [11.7%], outdoors generally [10.9%], a community center [10.4%], a museum [6.5%], or a science center [6.0%]). The programs represented all disciplines within or related to STEM (including each of the four disciplines within 'STEM,' computer science, earth and space science, environmental science, life science, and STEAM, etc.). The disciplines most frequently cited were science, engineering, and mathematics (respectively), each accounting for about 30% to 40% of references, or more than 200 references each.

Increasing Emphasis on DEIA

Overall, more than half of the references (51.5%) focusing on STEM+SED intentionally centered underrepresented and underserved youth in STEM as the driving force or purpose of the reference, which we labeled DEIA-driven (see **Figure 3**). To quantify the level of "DEIA-drive," reviewers assessed and assigned references to one of three levels of focus on DEIA in the context of STEM: Level 3 – DEIA is a key concern and primary focus of the source with action to address DEIA; Level 2 – Some acknowledgement of DEIA issues/value but not a primary focus nor direct action to address DEIA; and Level 1 – No acknowledgment of DEIA in STEM at all - it is omitted or ignored. We found a significant increase in the number of DEIA-driven references available from 2000 to 2022. There were about 15 times as many DEIA-driven references in the last full five years of this review (2017-2021) than in the first five years (2000-2004). Additionally, in the last full five years of the review (2017-2021), there were about twice as many references that identified DEIA as a key concern (Level 3) than references that provided some acknowledgement of DEIA (Level 2) or no acknowledgement of DEIA (Level 1). This evidence supports adding DEIA as an essential component of the STEM+SED equation. The four underserved or underrepresented groups with the most focus were: girls/women (46.9%), Black or African American youth (33.7%), youth of low socioeconomic status (32.0%), and Hispanic or Latino/a/x youth (31.7%), respectively. When making connections between STEM+SED, many of the references explored lived experiences, cultural assets, cultural context, and equity within STEM learning paradigms. It will be important to continue to track and evaluate how this literature develops.

Figure 3. Increasing number of DEIA-driven references among STEM+SED literature over time (2000-2021)



Note. Analysis of trends over time included all years with 12 months of evidence (Jan. 2000 to Dec. 2021).

Emerging Organizing Framework for STEM+SED

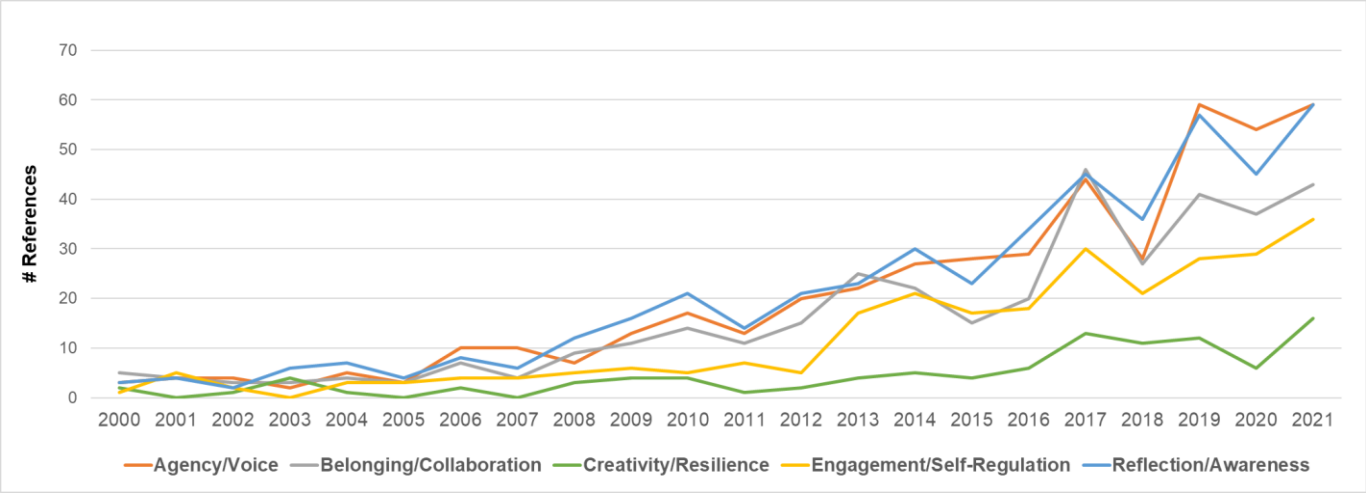
Among the 709 eligible references, we identified a total 3,030 mentions of SED terms. 198 mentions were terms used to label the SED field broadly, such as "social-emotional skills'' or "21st-century skills," and 2,832 were terms used to label specific skills that programs wanted to grow or measure in youth participants, such as "agency" or "collaboration." These terms represented a total of 106 unique SED skills, after accounting for variations of similar terms (e.g., creativity and creative thinking). Individual skills were mapped to one of five organizing domains, a novel framework for organizing the conceptualization of STEM+SED (see **Table 2**). The first four domains were initially identified by our STEM+SED conference (Award #1940155): Agency/Voice, Belonging/Collaboration, Engagement/Self-regulation, Reflection/Understanding, which align with the domains of a developmental process theory known as the Clover Model (Noam & Shah, 2014). The fifth is a new domain that emerged in the course of this work: Creativity/Resilience.

Table 2. Organizing framework for STEM+SED with the most common skills represented in the literature, by domain

Domain Name	Skills Youth Are Developing	Most Common Skills
Agency / Voice (795 mentions)	*Expressing & Empowering* themselves, especially through self-directed (or agentic) actions and self-confidence in learning and achieving learning goals.	Among 29 terms/skills identified: 1. Confidence (*n* = 206 references, 25.9%) 2. Self-efficacy (*n* = 156 references, 19.6%) 3. Agency (*n* = 79 references, 9.9 %)
Belonging / Collaboration (724 mentions)	*Connecting & Collaborating* with others, especially through social interactions (communication, teamwork) that create emotional bonds and attachments to place/learning spaces and others.	Among 28 terms/skills identified: 1. Relationships (*n* = 134 references, 18.5%) 2. Communication (*n* = 114 references, 15.7%) 3. Teamwork (*n* = 111 references, 15.3%) 4. Collaboration (*n* = 100 references, 13.8%)
Creativity / Resilience (128 mentions)	*Creating & Adapting*, especially through the creation of original ideas, evolution of ideas to fit new scenarios/situations, and the ability to be resourceful.	Among 5 terms/skills identified: 1. Creativity (*n* = 96 references, 75.0%) 2. Innovation (*n* = 11 references, 8.6%) 3. Resilience/Resiliency (*n* = 11 references, 8.6%)
Engagement / Self-regulation (383 mentions)	*Acting & Discovering*, especially through active participation in learning and managing the drive to participate in learning.	Among 9 terms/skills identified: 1. Motivation (*n* = 142 references, 37.1%) 2. Active Engagement (*n* = 47 references, 12.3%) 3. Self-regulation/management (*n* = 35 references, 9.1%)
Reflection / Understanding (801 mentions)	*Understanding & Becoming*, especially through thoughtful analysis of ideas (personal or academic) and an awareness of oneself, the immediate environment, and the world beyond (e.g., values, thoughts, emotions).	Among 35 terms/skills identified: 1. Problem-solving (*n* = 217 references, 27.1%) 2. Identity (*n* = 174 references, 21.7%) 3. Critical thinking (*n* = 104 references, 12.9%)

When mapping the number of OST STEM references by SED domains over time (see **Figure 4**), we found the majority of publications focused on the Reflection/Understanding domain (*n* = 500, 70.5%); the most common terms included problem-solving, identity, and critical thinking. This underscores how SED includes cognitive processes, in addition to the affective and social components inherent in the term "SED." STEM provides a bridge connecting these skills.

Figure 4. Mapping the number of OST STEM references by SED domain over time (2000-2021)



Note. Analysis of trends over time included all years with 12 months of evidence (Jan. 2000 to Dec. 2021).

Searching for Coherence in STEM+SED

Pillar #1: Phenomenon

When examining how STEM+SED is conceptualized (Pillar #1: Phenomenon), we found that more than three-quarters of the 709 references (*n* = 557, 78.5%) provided a theoretical foundation to support their STEM+SED work, with over 300 frameworks/theories cited. Specifically, 361 publications (50.9%) cited one or more theoretical models or frameworks that connected SED in the context of STEM. Within these 361 references, there were 363 unique theoretical models or frameworks. Many publications referenced multiple theories; there were 833 total mentions of at least one of the 363 specific ("named") theoretical models or frameworks. The most frequently cited theories were constructivism (*n* = 44 mentions), self-efficacy/self-efficacy theory (*n* = 40 mentions), and situated learning theory (*n* = 28 mentions). Only about one-third of references (*n* = 224, 31.6%) explicitly defined one or more SED concepts/constructs of interest. Although we are pleased that there is a diversity of terminology and theoretical support for STEM+SED work, this finding emphasizes the importance of using broad categories to organize terms, as we have done in this review. It also indicates a lack of consistency and consensus around SED terms and theory in the context of OST STEM.

Pillar #2: Implementation

When examining the different ways OST programs integrate STEM+SED in practice (Pillar #2: Implementation), we identified 13 categories of implementation strategies across 685 references. The most common implementation categories (>50% of references) were "Hands-on or sensory experiences" (e.g., hands-on experimentation, tinkering, *n* = 631) (92.1%), "Collaborative activities" (e.g., group work, pair shares) (*n* = 581, 84.8%), and "Youth expression opportunities" (e.g., presentations, journaling, artwork/mixed-media) (*n* = 376, 54.9%). More than 80% of references describing STEM+SED implementation strategies were dated between 2011 to 2022, indicating a significant increase in adoption of SED in STEM learning contexts in the past decade. These commonly used strategies can be characterized as inter-personal (not focusing on the individual). For example, many programs provided opportunities for youth to deepen STEM learning through social interactions, including by working with one or more peers to discuss ideas and troubleshoot problems, or to design and create solutions together.

Pillar #3: Assessment

When examining how STEM+SED is measured in OST programs (Pillar #3: Assessment), we found that the majority of eligible references had a research or evaluation focus (i.e., quantitative, qualitative, or mixed-methods studies, *n* = 528,

74.5%) compared with practice-focused references (e.g., program descriptions, activity guides, policy briefs; *n* = 181, 25.5%). Studies were most commonly found in journal articles (*n* = 449, 63.3%), conference papers (*n* = 90, 12.7%), and dissertations/theses (*n* = 81, 13.7%). The most common designs used to collect qualitative data were case study (*n* = 175, 45.2%) and ethnographic study (*n* = 49, 12.7%), and the most common designs used to collect quantitative data were pre-test/post-test designs (*n* = 229, 72.0%). Smaller percentages of studies involved participatory designs (those that involve youth, educators, and/or families in study design, implementation, and interpretation, *n* = 7, 1.3%) and longitudinal designs (*n* = 6 studies, 1.1%). The most common forms of data collection were student/youth self-report surveys (*n* = 324, 61.4%), individual interviews (*n* = 225, 42.6%), non-standardized observations (*n* = 173, 32.8%), and artifacts (*n* = 157, 29.7%), although not every study assessed a SED or STEM+SED outcome. A range of measures were used to examine the intersection between STEM+SED; there is not yet a consistent or standardized group of measures being used across the field (for example, see the Assessment Tools for Informal Science [ATIS] for a database of available measures).

The quality of all research and evaluation studies that examined youth outcomes was assessed by appraising the Weight of Evidence (WoE). WoE is essential for ensuring the reliability, validity, and transparency of the review process. The WoE appraisal was based on a 4-point rating scale ranging from 1 (Weak research design) to 4 (Exemplary research design) using rubrics developed for informal science education studies (Habig, 2020). Features of exemplary studies defined by this method include being grounded in a theoretical framework, including a control or comparison group, employing an appropriate study design, and having an adequate sample size. Our WoE appraisal of studies included in this review (*n* = 528) revealed that, on average, the evidence base is weak to adequate (quantitative: *M* = 2.36, *SD* = 0.996; qualitative, *M* = 1.94, *SD* = .916; mixed-methods: *M* = 1.92, *SD* = .882), although percentage-wise, about 35% to 55% of studies received a WoE rating of at least 3 ("strong") in design (quantitative: 55.1%, *n* = 76 studies; qualitative: 39.0%, *n* = 80 studies; mixed-methods: 35.4%, *n* = 62). None of the qualitative or mixed-methods studies received a WoE rating of 4 ("exemplary"). See **Table 3** for WoE appraisal and skills most supported by the evidence-base.

Table 3. STEM+SED domains and skills with statistically significant (quantitative) or meaningful (qualitative) outcomes

	Quantitative Studies		**Qualitative Studies**	
Domain	% of References with Statistically Significant Results (WoE)	Skills Most Supported by Quantitative Evidence	% of References with Meaningful Themes (WoE)	Skills Most Supported by Qualitative Evidence
Agency / Voice	**50.0%** (*n* = 66 studies total, WoE: 41 strong/exemplary studies – 62.1%)	Self-efficacy [32 results], Confidence [21 results]	**47.6%** (*n* = 157 studies, WoE: 58 strong studies – 36.9%)	Confidence [51 themes], Self-efficacy [27 themes], Agency [25 themes]
Belonging / Collaboration	**22.0%** (*n* = 29 studies, WoE: 21 strong/exemplary studies – 72.4%)	Relationships (with peers, adults, others) [15 results], Responsibility (social, Environmental, stewardship) [7 results]	**60.0%** (*n* = 198 studies, WoE: 79 strong studies – 39.9%)	Relationships (with peers, adults, others) [104 themes], Teamwork [42 themes]
Creativity / Resilience	**5%** (*n* = 6 studies, WoE: 3 strong/exemplary studies – 50.0%)	Creativity [6 results]	**5.8%** (*n* = 19 studies, WoE: 7 strong studies – 36.8%)	Creativity [18 themes], Adaptability/flexibility [4 themes]
Engagement / Self-Regulation	**15.2%** (*n* = 20 studies, WoE: 14 strong/exemplary studies – 70.0%)	Motivation (self, intrinsic) [12 results], Active engagement (in learning, action orientation) [9 results]	**21.8%** (*n* = 72 studies, WoE: 30 strong studies – 41.7%)	Engagement (active, hands-on, sensory, immersion) [63 themes], Motivation (academic, intrinsic, self-) [19 themes]
Reflection / Understanding	**44.7%** (*n* = 59 studies, WoE: 34 strong/exemplary studies – 57.6%)	Awareness (self, cultural) [17 results], Identity (STEM, cultural) [14 results]	**56.7%** (*n* = 187 studies, WoE: 64 strong studies – 34.2%)	Identity [76 themes], Problem-solving [32 themes], Awareness (self, personal, cultural, of world) [29 themes]

Among the 314 quantitative studies assessed for WoE (*n* = 138 quantitative studies, n = 176 mixed-methods studies):

- 132 (42.0%) reported a statistically significant result for at least one STEM+SED outcome.

Among these quantitative studies reporting statistically significant STEM+SED results:

- 105 studies (33.4%) found significant change over time (pre-test/post-test or retrospective designs, WoE: 53 strong/exemplary studies – 50.5%)
- 18 studies (5.7%) found significant differences between groups (OST intervention vs. control/comparison, WoE: 13 strong/exemplary studies – 72.2%)
- 9 studies (2.9%) found both time and group effects (WoE: 3 strong/exemplary studies – 33.3%)
- 80 studies (25.5%) reported results that were not statistically significant (WoE: 30 strong/exemplary studies – 37.5%)
- 102 studies (32.5%) did not perform statistical analyses although quantitative data were collected.

Among the 388 qualitative studies assessed for WoE (*n* = 211 qualitative studies; *n* = 177 mixed-methods studies):

- 330 (85.1%) identified at least one STEM+SED outcome as a meaningful theme (WoE: 123 strong studies among 75 qualitative studies and 48 mixed-methods studies).

The most common STEM+SED domains (and skills) accounting for positive quantitative and qualitative results are shown in **Table 3**. Quantitative studies more often identified statistically significant results for skills related to Agency/Voice (50.0% of references) while qualitative studies more often identified meaningful themes for skills related to Belonging/Collaboration (60.0%). Evidence for skills related to Reflection/Understanding were the second most common across both quantitative (44.7%) and qualitative (56.7%) study designs.

Summary and Conclusions

This study systematically reviewed references from over twenty years of research, evaluation, and practice at the interface of STEM+SED in informal/OST programming. The substantial increase in references dedicated to STEM+SED over time confirms rising interest in the integration of these fields to support youth development and success. While the diversity of terminology and theoretical support for STEM+SED work is encouraging, it emphasizes the need for a broader framework that organizes the long list of STEM+SED terms to support consistency and consensus.

The STEM+SED framework introduced in this executive summary, based on the most common and evidence-based STEM+SED domains/skills identified by our systematic review, provides a starting point for building consensus around terminology and priorities for research, evaluation, and policymaking. This is a rate-limiting step for more precise study. The finding that one-half to two-thirds of studies were in the weak/adequate range underscores the need for more investment in quality research/evaluation designs and measurement development. Developing and applying a common framework for STEM+SED will enable the field to design more cohesive studies and compare results more easily.

This review has contributed to the growing evidence base for the integration of STEM+SED in OST. The results and products of this project, including a detailed manuscript (forthcoming), are intended to expedite several essential steps forward: 1) assessing strengths and gaps in this growing field of connected STEM+SED, 2) defining overlapping or integrated STEM+SED practices, and 3) defining skills that are important to both fields and proposing robust assessments based on precise definitions. The five-domain organizing framework emerging from this study can help simplify the many overlapping skills of interest in the STEM and SED fields, without excluding any. This may encourage the creation of clear and cohesive logic models and theories of change, leading to higher-quality STEM+SED learning experiences (via quality program plans) and evidence of impact (via quality study designs).

Information & Resources

Suggested Citation

Allen, P.J., & Noam, G.G. (2024). *A Systematic review of STEM and social-emotional development in out-of-school time programs: Executive Summary*. Institute for the Study of Resilience in Youth. https://www.isry.org/s/STEM_SED_systematic_review_exec_summary.pdf

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Supplemental Resources

To support the field's access to STEM+SED knowledge, the following resources are available upon request:

- Extraction Database: A dataset with sortable variables for the 709 references included in this review.
- Methods: A detailed description of systematic review methods. A brief PowerPoint is available here.
- Reference Database: A complete list of 709 references (including citation and pdf files) in Zotero.

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