EDUCATION COMMISSION OF THE STATES

POLICY GUIDE

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Enhancing STEM in P-3 Education

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Until more recently, states often introduced programs supporting science, technology, engineering and math in the secondary grades. Yet the evidence of STEM's positive impact on young children's development makes a compelling case for engaging learners in pre-K through third grade in consistent, authentic and high-quality STEM experiences.

High-quality P-3 STEM learning need not — and should not — be viewed as an add-on to an already crowded set of learning objectives. Instead, states can integrate early STEM opportunities to advance developmentally appropriate practice and young learners' growth in literacy and numeracy, executive function and 21st century skills:

- **Developmentally appropriate practice.** Research suggests that hands-on, play-based and inquiry-based experiences — all cornerstones of developmentally appropriate practice in P-3 learning environments — are a natural component of high-quality early STEM experiences, which build upon children's innate curiosity about the world around them.

> Young learners (even before preschool) are curious, experimental and engage in a variety of STEM-related activities (e.g., testing hypotheses).

> Early STEM education provides the opportunity for P-3 students to engage in developmentally appropriate and authentic learning opportunities.

> State policymakers have several policy options to consider in developing early STEM opportunities in their states.

- **Achievement and engagement in STEM and non-STEM subjects.** Ample research underscores the significant, positive impacts of early math and science exposure on students' later school success both in individual STEM disciplines and non-STEM subjects, including literacy. Given the recent fourth grade results reflecting stagnant low scores in reading and math on the National Assessment of Educational Progress, a focused effort on developing STEM skills in the P-3 grades may support a systematic approach to improving future fourth grade NAEP scores.
- **Executive function.** Research demonstrates a connection between young learners' exposure to high-quality early learning environments (an organized classroom with positive engagement and open-ended questions are examples) and their growth in executive functioning (which is integral to learners' cognitive and emotional development) and later academic success, which sets them up to successfully meet the evolving demands of the future workforce.
- **21st century skills.** Authentic and developmentally appropriate STEM experiences help young learners acquire such key skills as problem-solving, flexible thinking and critical thinking. Often collectively referred to as 21st century skills, soft skills or employability skills, these skills are essential to lifelong success.

Local examples demonstrate that offering all P-3 learners high-quality early STEM opportunities is not only possible but happening. For example, **Iowa**'s Computer Science Is Elementary project is redesigning a dozen high-poverty elementary schools across the state to integrate computer science into all grades they serve by the 2020-21 school year. Two of the schools are P-3 buildings; the other 10 are K-5 schools.

There is currently a lack of practical guidance for education policymakers to better understand and develop high-quality P-3 STEM systems, and factors unique to the P-3 space can complicate early STEM education efforts. These challenges include the inconsistent quality of early childhood education providers, inadequate preparation programs and administrative oversight bodies for those educators and programs, and the often-lamented disconnect between pre-K and K-3.

As a result, many P-3 learning environments are providing early STEM experiences on the periphery of what is possible. For example, while math instruction is all but ubiquitous in K-3 classrooms, math is commonly taught as a stand-alone subject, rather than through a transdisciplinary approach that can deliver engaging instruction in two or more subjects without putting additional time into the school day.

Given the limited base of state practice and research to inform policy, Education Commission of the States convened a Thinkers Meeting of state and national leaders in STEM and early learning policy and research to identify policies and actions a state can adopt to ensure equitable access to ongoing, high-quality STEM experiences for P-3 students. (The Thinkers are identified on page 9.) Participants proposed a broad array of state policies and actions that call for explicit articulation between early STEM standards, assessments, teacher training and professional development. They fall into four areas: equity, equality and access; state and regional coordination; educator preparation, credentialing and professional learning; and curriculum, instruction and assessment.

Defining Terms

In this Policy Guide, **early STEM** is pre-K through third grade, or P-3. Participants in the Thinkers Meeting readily acknowledged the complexity of using the P-3 continuum, since settings, constraints and opportunities differ between the pre-K and K-12 realms.

- **Transdisciplinary** — or crossing the boundaries between STEM subjects, disciplines and other subject areas, including the humanities and the arts. For more on this, see the federal, five-year STEM plan from 2018.

These learning experiences are delivered as suggested in the Erikson Institute's Early STEM Matters report, in which one discipline is presented "in the foreground (i.e., the focus of the activity) and one or more disciplines [serve] as background."

This Policy Guide also intentionally uses the following terms:

- **Experiences**: Meaningful and relevant lessons that generate both breadth and depth for students.
- **Activities:** Isolated STEM lessons that may or may not yield significant learner benefits.
- **Educators**: Indicating a broader set of education providers beyond teachers, including parents and others providing out-of-school learning experiences.
- **Leaders**: Building leaders who support instruction and other processes, including principals, center directors and others.

Equity, Equality and Access

Studies have found that girls' confidence in their math and science abilities declines around fifth grade and that most students make decisions about their science abilities before high school. Providing all early learners with high-quality STEM experiences may bolster their skills and sense of self-efficacy in STEM before adolescence, resulting in more females and students of color who pursue STEM credentials and careers. This principle holds regardless of which pre-K setting a child is in — with a parent or relative, or in a home-based, center-based or school-based environment. It also stands regardless of the geographic or demographic context of the early learning environment.

To prevent exacerbating disparities among learners who have and do not have access to high-quality pre-K and well-resourced elementary schools, state policies should provide equal STEM access for all P-3 learners, while also ensuring equitable opportunities and resources for historically underserved students. The following are ways in which states can broaden access to STEM for all P-3 learners.

Require STEM funding proposals to include an equity and diversity action plan

Requiring programs to commit to specific actions to support equity may foster constructive local conversations and prompt different P-3 stakeholders to align their efforts. Further, putting a plan in writing helps stakeholders hold themselves accountable for carrying out the actions to which they have committed. An equity and diversity action plan can also present an opportunity for coaching on what equity means.

In **Nevada**, for example, the application for a K-5 STEM classroom grant asks prospective grantees, "How will the project increase the number of students participating in STEM, particularly students from underrepresented backgrounds?" Additonally, all **Nevada** schools applying for a STEM school designation must demonstrate an explicit focus on equity. The 2019 application required applicants to "Describe to what extent STEM instruction is available on a fair and equal basis to all students in a culture that is welcoming, stimulating and nurturing." The 2019 rubric for evaluating STEM school designation applications demonstrates what an equity focus and differentiated instruction look like in a school that achieves "exploring," "developing," "established" and "model" status on these measures.

Develop a communications campaign on the importance of early STEM opportunities

To promote equity and access, it is critical to communicate the benefit of investing in early STEM education to all stakeholders, including out-of-school educators like parents and home-based and center-based pre-K providers. In **Iowa**, for example, the Governor's STEM Advisory Council has deployed radio and television spots, messaging through social media, media releases, billboards, event exhibits and presentations, in addition to communications toolkits for councilmembers. The council's annual report publishes data on the reach of these campaigns, including survey results on Iowans' attitudes and awareness of STEM.

State and Regional Coordination

Developing a shared definition and strategic plan are key elements to implementing a comprehensive and effective P-3 STEM education system. Additionally, states that have had success in developing K-12 STEM education systems have had clear and purposeful coordination at the state and regional levels.

Establish a single, clear and statewide definition of early STEM education

A single, clear and statewide definition of early STEM education can help ensure that throughout the policy development and implementation process, all stakeholders share a common understanding of what constitutes early STEM education. Creating a common language at the outset is particularly important considering issues that make the early STEM landscape uniquely complex:

- The multiplicity of disciplines that may be categorized as STEM, and differences in states and national entities regarding which disciplines constitute STEM.
- The multitude of pedagogical approaches that may be ascribed to STEM (inquiry-based, project-based, problem-based, etc.).

To develop a single, clear and statewide definition of early STEM education, states can engage state, regional or local STEM stakeholders, such as pre-K administrators, K-3 teachers, principals, postsecondary stakeholders, public STEM service representatives, school board members, parents and more. These stakeholders should be diverse both in terms of the P-3 and STEM role groups they represent, as well as geographically, demographically and culturally.

Develop a statewide P-3 STEM strategic plan

A statewide P-3 STEM strategic plan establishes state direction for early STEM policies and initiatives — based on the state definition of early STEM education — and helps to ensure an unwavering focus on equity and the long-term sustainability of efforts. Setting state direction is particularly important in a policy area like early STEM education that involves a diverse array of state and local actors. A strategic plan may set forth a vision/mission statement — and its rationale — for early STEM education in the state. This plan can also convey early STEM education as a key component to P-3 education and reinforce a state expectation that high-quality early STEM experiences should be available to learners regardless of geography or preschool setting.

Designate a state entity or entities to coordinate state and regional efforts

There is no one right agency to coordinate state and regional early STEM efforts. State leaders can start by determining if any STEM entities exist within their states. However, the designated lead, in the words of one of the participants in the Thinkers Meeting, "needs to be empowered and possess the ability to drive and achieve policy change." This entity or entities can help sustain momentum, clarify who is responsible for aspects of the strategic plan and communicate with all stakeholders about progress.

STATE EXAMPLES

A handful of states have state-level entities that coordinate state and regional STEM efforts, some of which include early STEM. Examples include:

- **Idaho** STEM Action Center
- **Iowa** Governor's STEM Advisory Council
- **Massachusetts** STEM Advisory Council
- **Nevada** Office of Science, Innovation & Technology
- **Utah** STEM Action Center
- **Washington** STEM

Educator Preparation, Credentialing and Professional Learning

The apparent chaos a principal or center director may observe when walking into an effective P-3 STEM experience might belie the high level of student learning in the moment. As a participant in the Thinkers Meeting commented, "Principals need to know STEM teachers and STEM teaching," just as teachers need to know that principals will give them the training and resources they need to deliver high-quality STEM experiences.

To help all educational leaders develop and sustain high-quality early STEM learning environments, states can encourage institutions and programs to employ several strategies.

Prepare all pre-service P-3 educators to integrate STEM into regular classroom instruction

Participants in the Thinkers Meeting discussed the value of training all P-3 educator candidates to blend STEM learning into regular classroom instruction and noted that while STEM content can ground lessons in authentic contexts that are relevant to children's experiences, teaching any two disciplines in an integrated way is a challenging proposition — one that requires thoughtful planning and training.

To prepare all pre-service P-3 educators to integrate STEM into regular classroom instruction states can require all early childhood and P-3 teaching candidates to complete coursework in STEM content and/or pedagogy and receive training on how to infuse STEM vocabulary into all learning experiences.

Such preparation is already offered at the Regents' Center for Early Developmental Education at the University of Northern Iowa, which serves regional pre-service and in-service teachers to use specific vocabulary and pedagogy to integrate STEM into young learners' play with those manipulatives. The manipulatives that most early learning environments already have — such as wooden unit blocks, pattern blocks, loose parts and water tables — can be STEM materials with the appropriate training.

States can also ensure pre-service training prepares candidates to deliver integrated STEM instruction that is relevant to students' daily environments. Simply showing teacher candidates how to provide standards-aligned instruction across two or more disciplines isn't enough. For example, for young learners in a landlocked state who may have never seen a large body of water, a hands-on investigation into the Exxon Valdez oil spill may be transdisciplinary but not relevant. However, understanding how playground equipment could be designed to be safer, and even more fun, could be a potential STEM project for a group of second graders.

Provide flexible pathways to early childhood and P-3 STEM certification

To increase the pool of early childhood and P-3 educators from traditionally underrepresented backgrounds, states have taken a variety of approaches. For example, grow-your-own programs are community partnerships among districts, postsecondary institutions and community-based organizations that develop and sustain local educator preparation programs for area residents. Such programs can address teacher pipeline and workforce diversity issues, particularly in rural and urban schools that struggle with teacher recruitment and retention. Flexible pathways like these can also accommodate career-changers who possess content knowledge but need training in pedagogy.

Another alternative to traditional prepartation programs is microcredentials — or "digital certifications that verify an individual's competence in a specific skill or set of skills."

An early STEM microcredential can certify that a P-3 educator has demonstrated the pedagogical skills and/or knowledge to integrate early STEM experiences into instruction in other subject areas. **Virginia** legislation passed in 2019 authorizes the state department of education to create a microcredential program allowing any certified K-12 teacher to earn microcredentials in STEM endorsement areas, including computer science.

Finally, co-teaching with a STEM specialist or coach is one way to provide job-embedded training. For example, P-3 educators can teach alongside science specialists, who can help them become experts in preparing students for science standards in the later grades. Specialists can also show classroom teachers how to embed science instruction with other subject instruction, like reading.

Curriculum, Instruction and Assessment

To understand whether P-3 learners are developing strong foundational skills in STEM subject areas, measuring outcomes is essential. Standards and curricula should be aligned and used alongside developmentally appropriate formative assessments that can clearly indicate students' competencies and needs, and inform future instruction.

Develop tools that support standards-based transdisciplinary STEM instruction

Providing teachers with state-developed tools that identify intersections across two or more sets of state standards can enhance teachers' capacity to deliver quality instruction that builds upon those intersections. Such tools may pinpoint intersections in state standards in STEM disciplines, as well as state standards in other subject areas — such as literacy, English and social studies — that may lend themselves to opportunities to engage in one or more STEM discipline standards.

To support implementation of these tools, states can couple them with professional development. Teachers who receive training in instruction aligned with two or more areas of standards are more likely to deliver such instruction effectively. Additional professional support can be provided through open educational resources and/or an online resource bank. In curating and making such materials available, states can build upon collective wisdom and resources already available.

Develop — and encourage educators to use — formative STEM assessment tools

In contrast to summative assessments, which measure a student's acquisition of knowledge and skills at the end of a unit or academic term, formative assessments linked to state standards in early STEM subject areas can strengthen teacher practice by helping educators identify concepts and skills learners have yet to fully grasp. Formative assessments can also illuminate students' affinity for and perceptions of self-efficacy in STEM subjects, and they can inform refinements in instructional delivery that may enhance students' perceived and real self-efficacy in STEM learning.

To maximize their effectiveness, these assessment tools can be aligned to pre-K and K-3 content area standards in STEM subject areas, offer both formative and standardized assessments, and potentially assess learners' confidence in and attitudes toward STEM. Additionally, training teachers can provide guidance on interpreting the data generated by these tools and using it to adapt practice to enhance students' understanding of and self-efficacy in STEM subjects. One example comes from the Advancing Coherent and Equitable Systems of Science Education — a 13-state initiative funded through the National Science Foundation — which developed an open educational resource to provide educators an introduction to using formative assessments to support equitable 3D instruction.

Integrating the Arts into STEM Subjects

Research demonstrates the positive impact STEAM education has on student outcomes, beginning as early as kindergarten. A study by American Institutes for Research found a significant, positive impact on kindergarten students' math achievement. For more information about the arts and STEM, see the following resources from Education Commission of the States:

- Preparing Students for Learning, Work and Life Through STEAM Education
- STEAM Infographic
- Policy Considerations for STEAM Education

Final Thoughts

Developmentally appropriate practice, executive function and the development of critical 21st century skills support the integration of ongoing, high-quality early STEM experiences in the P-3 years to provide young learners with essential skills that will support their success in later schooling, workforce and life. Recent NAEP data illustrates a need to more systematically improve fourth grade reading and math scores, which a focus on P-3 STEM may support. STEM can be a daunting concept for many early childhood education professionals and parents alike. However, early STEM education can be elevated and integrated into the daily routines of all P-3 educators and families — and become an integral part of the collective conception of what high-quality early childhood education looks like.

Thinkers Meeting Participants

FACILITATOR

- **Jeff Weld**, Executive Director, Iowa Governor's STEM Advisory Council

PARTICIPANTS

- **Kevin Anderson**, Science Consultant, Wisconsin Department of Public Instruction
- **Tamara Goetz**, Executive Director, Utah STEM Action Center
- **Angela Hemingway**, Executive Director, Idaho STEM Action Center
- **Alexis Lauricella**, Associate Professor and Director, Technology in Early Childhood Center, Erikson Institute
- **Abigail Levy**, Co-Director, Science and Mathematics Program, Education Development Center
- **Carlin Llorente**, Director, Strategic Partnerships, Washington STEM
- **Karen Marrongelle**, Assistant Director, Directorate for Education and Human Resources, National Science Foundation
- **Brian Mitchell**, Director, Nevada Office of Science, Innovation and Technology
- **Julie Neidhart**, Lead Science Instructor, Hutchens Elementary School, Mobile County (Ala.) Schools
- **Anthony Owen**, State Director of Computer Science Education, Arkansas Department of Education
- **Judd Pittman**, Special Consultant to the Secretary of Education for STEM, Pennsylvania Department of Education
- **Cara Sklar**, Deputy Director, Early and Elementary Education Policy, New America
- **Vincent Stewart**, Executive Director, California STEM Network
- **Beth Van Meeteren**, Director, Center for Early Education in STEM, University of Northern Iowa

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Matt Weyer

As a senior policy analyst, **Matt Weyer** focuses on early learning issues. Prior to joining Education Commission of the States, Matt worked for over four years covering early learning issues for the National Conference of State Legislatures, earned his doctorate in educational leadership and policy studies from the University of Denver and was a kindergarten teacher in a bilingual classroom at Denver Public Schools. When Matt is not working, he can be found snowboarding or trail running in beautiful Colorado. Contact Matt at mweyer@ecs.org or **303.299.3626**.

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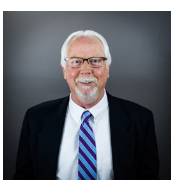

With more than 35 years' experience working in early childhood education, **Bruce Atchison** has specialized in early learning policy initiatives since joining Education Commission of the States in 2014. In prior roles, Bruce worked in two governors' policy offices on education, served as president and CEO of a nonprofit child care center, served on the faculty at the University of Denver and the University of Colorado teaching child development, and taught in the classroom for 10 years. Bruce has been honored as an Educator of the Year and also received the Edna Oliver Nancy Swank Early Childhood Lifetime Achievement Award. Contact Bruce at batchison@ecs.org.