National Science Teaching Association Position Statement

Professional Learning in Science Education

The Vision for High-Quality Professional Learning in Science Education

NSTA's vision statement declares, "Science literacy and education are vital to the future of our society, enabling us to make informed decisions about the collective challenges we face." To achieve these ends, teachers need to move away from having students learn about science and move toward figuring out science (National Research Council [NRC] 2015). Additionally, all students need to have equitable access to high-quality K –12 science/STEM learning experiences aligned to A Framework for K –12 Science Education (National Academies of Sciences, Engineering, and Medicine [NASEM] 2021). Students experiencing this Framework-focused education will be actively engaged in sensemaking to figure out how the world works (in science) and how to design solutions to problems (in engineering) (NRC 2012).

However, the standards alone will not improve K –12 science education (NRC 2012). Robust professional learning (PL) for science educators, grounded in science education research, is crucial for a Framework-based education to succeed. High-quality PL must focus on students, be designed as transformative learning experiences, develop teachers' pedagogical and content knowledge, be equitable, engage science educators with high-quality instructional materials, and be aligned with other district or state initiatives.

Enacting the Vision: Key Principles for High-Quality Professional Learning in Science

PL experiences should hold the following key principles in mind.

1. **Professional learning experiences should have students and their learning be the endgame.**
   For this critical learning to occur for all students, we must transform our educational system to one in which all students are engaged in high-quality science learning. The Framework highlights the importance of access to science learning for all students, stating, "Arguably, the most pressing challenge facing U.S. education is to provide all students with a fair opportunity to learn" (NRC 2012, p.14). To transform our educational system for all students, formal and informal science educators need to have equitable access to the high-quality PL they deserve. Effective science PL provides science educators opportunities to reflect on how students learn science and how to create instruction that can facilitate this learning (Loucks-Horsley et al. 2010). When PL places students' learning first and supports science educators' continued growth and capacity to facilitate impactful and effective learning experiences, we can begin to meet the needs of all students.

2. **Professional learning should be designed as transformative learning experiences.**
   High-quality PL should be designed as transformative experiences, with teachers' short- and long-term professional growth in mind. Transformative PL involves teachers as active doers, not receivers, and is

intentionally designed to support changes in beliefs, knowledge, and habits of practice (Desimone 2009; Short and Hirsh 2020). Whether in the form of coaching, workshops, or professional learning communities, PL needs to incorporate active learning and build on the assets teachers bring to their own learning (NASEM 2021).

Effective PL engages teachers directly by allowing them to participate as learners, engage in sensemaking, and reflect on how these experiences translate to daily classroom teaching practices. Facilitators model strategies and provide time for teachers to think about and receive input on their science instruction, supporting teachers in making changes to their practice as they move toward the expert visions of practice (Darling-Hammond et al. 2017). Effective PL provides strategies for eliciting, interpreting, and making use of students' reasoning to inform their science teaching, and it must take place within a broader system of support that includes time to reflect and collaborate on shared strategies and student learning in science (Luft et al. 2020).

3. **Professional learning should develop educators' pedagogical and content knowledge.**
   Effective PL supports teachers in deepening their pedagogical content knowledge and their subject-area content knowledge (Desimone 2009; Hill et al, 2020; NRC 2012). PL programs that are tailored to help develop educators' understanding of the disciplinary core ideas and science and engineering practices are much more likely to have longer-term impacts (Luft et al. 2020). Additionally, when PL is focused on meaningful exploration of science teaching practices, teachers are much more likely to find the PL relevant and connected to their work (Loucks-Horsley et al. 2010). Given that the educator has a large impact on student learning (e.g., Hattie 2003), improving science educators' pedagogical practices is crucial for student learning (Loucks-Horsley et al. 2010).

   One way to simultaneously develop pedagogical and content knowledge is to use an anchoring experience (Luft et al. 2020). Anchoring experiences often feature a case example that science educators can use in their work with students. These experiences can help science educators learn the content, understand their students' perspectives, and develop pedagogical knowledge (Luft et al. 2020). Importantly, the anchoring experiences must align with the role of the science educator (e.g., elementary, secondary, informal) to help science educators effectively transfer PL experiences to the classroom (Luft et al. 2020).

4. **Professional learning should attend to equity.**
   As stated in Short and Hirsh (2020), "equity articulates and advances high expectations for all students and applies culturally relevant pedagogies and content consistent with a shared vision for learning and teaching" (p. 20). When all educators have high expectations for students' learning, they can be prepared to engage students in all aspects of science learning (Jeanpierre et al. 2005). Promoting equity entails paying explicit attention to historical inequities, which can help students identify with the scientific field (Bang and Medin 2010). PL should integrate strategies and practices that support standards-based teaching and learning for all students, prepare educators to connect science learning with students' interests and experiences, and integrate strategies that promote equitable participation in science learning for all learners (Penuel et al. 2020).

5. **Professional learning should include high-quality instructional materials.**
   Adopting high-quality instructional materials (HQIM) is a way to align instruction to standards and boost student learning. The use of these materials can relieve teachers of some of the curriculum development

responsibilities and lets them focus their energy where it matters most for student outcomes: on classroom instruction. (Short and Hirsh 2020). Even when using HQIM, locally relevant content, place-based phenomena, and teacher autonomy are important considerations in science education, so educators may find they need to make adjustments to their chosen instructional materials while maintaining integrity to the program's intent. The availability of high-quality curriculum materials is an important factor in increasing access and grade-level learning for all students (NASEM 2022). HQIM can support standards-based instruction across the system (Doan et al. 2022).

However, these materials cannot generate student learning on their own. There is a growing body of evidence that suggests that the use of instructional materials that are of high quality, accompanied by PL supports, is associated with improvements in student achievement (Doan et al. 2022). According to Short and Hirsh (2020), curriculum-based professional learning (CBPL) are transformative learning experiences, anchored in high-quality curriculum materials. These experiences use curriculum as both a lever and a guide, helping link teachers' actions and ideas to new standards in a concrete, focused way. CBPL can support teacher buy-in and regular use of standards-based instructional materials, leading to teacher/student engagement in standards-based teaching practices and increased student learning (Short and Hirsh 2020). As teachers learn from and with the curriculum materials, they can adapt and implement the materials in principled ways that support many dimensions of their instruction, such as incorporating local and community-based connections and their targeted support of multilingual learners in science.

6. **Professional Learning needs to have a system-wide approach.**
   The vision of the Framework requires systems of support for high-quality science teaching and learning. This system includes high-quality PL, as outlined above, surrounded by support for formal and informal educators (Darling-Hammond 2017; Louck-Horsley et al.,2010; Luft et al. 2020). These supports include alignment of a vision for science across educators at all levels and roles in the system, policies that support science teaching and learning, and an alignment of science instructional practices with other district and state initiatives (Smith et al. 2022; Council of Chief State School Officers [CCSSO] 2023). Support should also include practical considerations such as the allotment of time for science in the elementary classroom, time for collaboration and reflection, support for materials implementation, and distributed leadership structures (Short and Hirsh 2020; CCSSO 2023). In short, educators should have opportunities to learn about and collaborate on what standards-aligned instruction looks like (Smith et al. 2022).

Sustaining the Vision: Supporting Continuous Growth Over Time

As we continue to reform science teaching and learning after the 2012 publication of A Framework for K–12 Science Education, PL is a key factor in supporting teachers in making this transition over time. Educators deserve access to sustainable, ongoing, equitable PL opportunities as part of systematic plans that progress and strengthen practice over time (NASEM 2022). The following two considerations will help educators create and engage in ongoing opportunities to plan, implement, and reflect on teaching strategies in science classrooms that engage students in three-dimensional science learning (NRC 2012).

1. **Differentiated for various audiences.** PL should offer differentiated support and experiences tailored for individuals or groups of educators, based on factors such as the following:
   a. **Level of experience.** As educators enter PL with different levels of pedagogical and content knowledge, PL must be nimble and consider the prior knowledge of PL participants (Luft et al. 2020). PL should be applicable to the participants who have different levels of knowledge and experiences.

b. **Roles and Context.** Sustained PL includes an aligned vision for, and understanding of, science and science pedagogy across educators at all levels and roles in the system. Additionally, PL should be available and differentiated for both formal and informal educators who play a role in crafting students' science learning experiences. This includes the following:
    i. Administrators, instructional leaders, and teacher leaders, who benefit from leadership and coaching strategies, as well as science content and pedagogy;
    ii. Non-science content specialists and support staff in the school system;
    iii. Elementary teachers, who often have additional barriers to effectively teaching science, including time and content knowledge (NASEM 2021);
    iv. Secondary science teachers who teach different science subjects from one another that each require specialized science content and pedagogical knowledge;
    v. School-level educator groups, who need opportunities to discuss and coordinate efforts to design and implement coherent teaching across multiple years (Shaw et al. 2018); and
    vi. Informal science educators who often interact with learners in a high-interest, high-choice environment (Astor-Jack et al. 2007; Blanchard et al. 2020).
c. **Teacher Voice and Choice.** Given the various roles, contexts, and experiences, teachers should have voice and choice regarding how they engage with PL. This may include time and resources for attending professional conferences, teacher feedback on what PL is offered and how they can use the PL in their setting, and honoring teachers' prior knowledge and experiences throughout the PL.

2. **Sustained in duration.** PL should aim to be sustained in duration and provide repeated opportunities to engage in professional growth over time. This includes the following:
    a. Phase of implementation. As educators implement new instructional materials and pedagogical approaches, they move through non-linear but relatively predictable stages of implementation, each with their own implications for professional learning (Rivet Education 2024). For example,
        i. Initial implementation,
        ii. Refining practice, and
        iii. Innovating on practice
    b. Opportunities for educator voice and agency in all phases of science implementation.
    c. Ensuring coherence between experiences as well as across other PL opportunities.
    d. A variety of methods and formats to promote educator collaboration, learning, planning, and reflection, such as these:
        i. Professional Conferences;
        ii. Engaging in practitioner inquiry (Cochran-Smith and Donnell 2012);
        iii. Research Experience for Teachers and Externships (Bowen and Shume 2018; Westerlund et al. 2002; Miranda and Damico 2013);
        iv. Opportunities to build community and collaborate (Luft et al. 2020);
        v. Workshops and Professional Learning Units;

vi. One-on-one coaching, virtual or in-person (Darling-Hammond et al. 2017);

vii. Schoolwide collaboration over one of more school years (Fulton et al. 2011);

viii. Building networks of teachers (Herman et al. 2019); and

ix. School-based collaborative teams or Professional Learning Communities (PLCs).

The vision for high-quality professional learning in science education emphasizes the necessity of equitable access to robust science and STEM learning experiences, aligned with the Framework, for all K–12 students. NSTA affirms that transformation to attain the vision of the Framework can only be achieved through systems of support for high-quality science teaching and learning. To sustain this vision, continuous, differentiated support tailored to educators' varying experiences and roles is essential. This systematic approach ensures that educators can continuously improve their practice and effectively provide equitable and inclusive environments supporting all students in vibrant three-dimensional science learning.

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