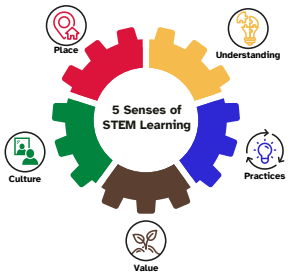
The Five Senses of STEM Learning

The *Five Senses of STEM Learning* is a framework and approach to teaching, learning, curriculum, and pedagogy that is built up on the CEISL Throughlines (Price et al., 2020). The *Five Senses of STEM Learning* are therefore deeply grounded in Culturally Relevant Pedagogy (Ladson-Billings, 1995, 2016) and Universal Design for Learning (Meyer et al., 2013; Rose & Meyer, 2002) while also incorporating a range of ideas and concepts that are specific to STEM learning and strengthen the connections to the particular contexts of the science, technology, engineering, or mathematics learning environment.



Assumptions about STEM Learning and Teaching

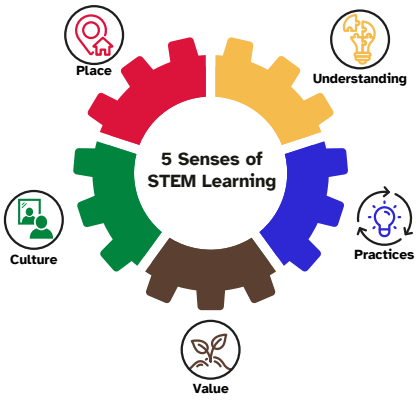
As a collaborative, **we work to facilitate a pluralistic STEM learning and teaching environment**. This involves recognizing the complex and contextualized tapestry of ways of knowing and doing in the relationships we have with our natural and built worlds, including the "conventional" STEM approaches connected with the European Enlightenment as well as a range of indigenous ways of knowing and doing. We support an approach that recognizes that there are multiple epistemological frameworks that each tell us something about the world in a different way, and each of these frameworks is intrinsically valuable.

Orienting ourselves toward this aim, we operate based on the following assumptions:

- **STEM Learning is about Big Ideas rather than specific methods and identities.** Rather than focusing exclusively on particularities, we assert that STEM learners and educators should be focusing on concepts such as curiosity, asking questions, exploring phenomena, and working towards change in natural and technological environments.
- **STEM neither exists nor operates in isolation.** STEM is one way of approaching the natural world and interacts with other ways of understanding. STEM education should necessarily follow a transdisciplinary approach that intersects with other "traditional" school subject areas and other culturally relevant ways of knowing and doing.
- **STEM is based in a range of cultural repertoires of practices rather than a limited set of algorithmic methods.** Solving a math problem and engaging in scientific inquiry are activities that are grounded in culturally-embedded sets of practices and norms that can be applied systematically and pragmatically rather than on a universal fixed process that can be indiscriminately replicated. This assumption requires interrogating the "scientific method" and simple algorithmic approaches to mathematics.
- **STEM can be used to solve problems, share information, and bring about improvements.** STEM is a powerful vehicle for identifying, understanding, addressing, and exacerbating the pressing issues of our day. It is therefore important to recognize that drawing on STEM provides access to the codes of power in society (Delpit, 1988).
- **STEM can be used to build towards multiple ends.** There are multiple—sometimes conflicting—reasons to understand and engage with STEM. Learners, educators, and communities may be invested in STEM because of interest, preparing for a career, engaging in political activism, citizenship. Each of these should be acknowledged, understood, and incorporated to provide multiple pathways for each STEM learner.

Outlining the Five Senses of STEM Learning

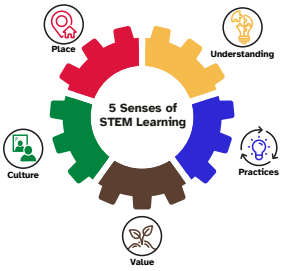
The Five Senses of STEM learning is an approach that helps us to build on our assumptions of STEM learning and teaching and work toward a pluralistic STEM learning and teaching environment. **The Five Senses concept is a set of guideposts** rather than a rigid set of standards. While each Sense does not need to be present at all levels—from individual activities or lesson plans to unit projects—each one should be reflected in one fashion or another in the learning experience as a whole. The five senses are Understanding, Practices, Value, Culture, and Place.



- **Understanding** refers to the deep exploration, analysis, and use of STEM crosscutting concepts, core disciplinary ideas, and principles (National Council of Teachers of Mathematics, n.d.; National Research Council, 2011). Understanding can happen in many forms, from the "conventional" STEM inquiry process typically taught in schools as the standard to a range of indigenous ways of understanding the natural and built worlds.
- **Practices** represent the ways that STEM is done to ask questions, identify and work through problems, and communication ideas (National Council of Teachers of Mathematics, n.d.; National Research Council, 2011). Practices refer to the skills and to the deeper ways of employing STEM as a human being.
- **Value** relates to the ways in which core and authentic activities and problems are utilized for STEM learning (Storksdieck, 2016; Strobel et al., 2013). The activity structures are worth engaging with not just to provide the learner with a specific skill or object of knowledge, but because they build toward a broader and longer-term aim for career, citizenship, justice, or sustainability (Calabrese Barton et al., 2020; Calabrese Barton & Tan, 2019; Price & McNeill, 2013).
- **Culture** illuminates the notion that engaging in STEM is engaging in culturally-contextualized systems of activities (Sannino & Engeström, 2018). As such, STEM learners should be provided with both windows into the European Enlightenment-bound knowledge and practices of what many consider to be the core of STEM—in part because such an exposure provides all students with access to codes of power (Delpit, 1988)—and mirrors into the epistemological pathways that exist prior to and alongside contemporary Euro-/white-centric STEM (Rezvi et al., 2020; Sims Bishop, 1990). In addition to the "typical" norms and representations of STEM culture, learners should be able to see themselves and their communities in the STEM learning process.
- **Place** allows the centering of the learners' local natural and social environment in STEM learning. This adds value and authenticity in the engagement of STEM understanding and practices and roots the engagement in local culture. Drawing on authentic interdisciplinary methods such as exploring natural histories, engaging in cultural journalism, and participating in action research grounds STEM learning in place (Gruenewald, 2003a, 2003b).

Connecting the Five Senses to the Throughlines of Practice

The Throughlines of Practice serve as the foundation for multiple frameworks and approaches to teaching and learning, including the Five Senses of STEM Learning. The following table provides an overview of these connections.

Five Senses of STEM Learning	Connections	Throughlines of Practice
	The rooting in place and culture along with the elevation of locally-embedded value involves empowering families and communities to engage on more equal footing around STEM education.	**Empowering Families and Communities**
	Engaging with place and culture in STEM learning and teaching necessarily requires building coalitions with communities, grassroots movements, and organizations.	**Coalition Building**
	By interrogating and resisting a restrictive and normative approach to STEM learning and teaching, and instead focusing on building pluralistic and inclusive systems, there is an emphasis placed on equitable practices and systems.	**Equitable Practices and Systems**
	The pluralistic approaches supported through understanding, practices, and value provide a framework for inclusive epistemologies and practices in STEM learning and teaching.	**Multiple Ways of Knowing and Doing**
	Purposeful practices and activities for understanding STEM require that technology be employed with intention and reflection.	**Intentional Use of Technology**
	STEM learning and teaching through the Five Senses is intended to include dimensions of depth and to provide opportunities for transforming oneself, one's community, and the world at large for the better and more just.	**Deep and Transformational Learning**

References

Calabrese Barton, A., & Tan, E. (2019). Designing for Rightful Presence in STEM: The Role of Making Present Practices. *Journal of the Learning Sciences*, *28*(4–5), 616–658. https://doi.org/10.1080/10508406.2019.1591411

Calabrese Barton, A., Tan, E., & Birmingham, D. J. (2020). Rethinking High-Leverage Practices in Justice-Oriented Ways. *Journal of Teacher Education*, *71*(4), 477–494. https://doi.org/10.1177/0022487119900209

Delpit, L. (1988). The silenced dialogue: Power and pedagogy in educating other people's children. *Harvard Educational Review*, *58*(3), 280–299.

Gruenewald, D. A. (2003a). Foundations of Place: A Multidisciplinary Framework for Place-Conscious Education. *American Educational Research Journal*, *40*(3), 619–654.

Gruenewald, D. A. (2003b). The Best of Both Worlds: A Critical Pedagogy of Place. *Educational Researcher*, *32*(4), 3–12.

Ladson-Billings, G. (1995). Toward a Theory of Culturally Relevant Pedagogy. *American Educational Research Journal*, *32*(3), 465–491. https://doi.org/10.3102/00028312032003465

Ladson-Billings, G. (2016). And Then There Is This Thing Called the Curriculum Organization, Imagination, and Mind. *Educational Researcher*, *45*(2), 100–104. https://doi.org/10.3102/0013189X16639042

Meyer, A., Rose, D. H., & Gordon, D. (2013). *Universal Design for Learning: Theory and Practice* (1st edition). Cast Incorporated.

National Council of Teachers of Mathematics. (n.d.). *Principles and Standards*. Retrieved October 30, 2022, from https://www.nctm.org/standards/

National Research Council. (2011). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. https://doi.org/10.17226/13165

Price, J. F., Magee, P., Santamaría Graff, C., Hall, T., Moreland, B., & Waechter-Versaw, A. (2020). *Project Throughlines*.

Price, J. F., & McNeill, K. L. (2013). Toward a Lived Science Curriculum in Intersecting Figured Worlds: An Exploration of Individual Meanings in Science Education. *Journal of Research in Science Teaching*, *50*(5), 501–529. https://doi.org/10.1002/tea.21084

Rezvi, S., Han, A., & Larnell, G. V. (2020). Mathematical Mirrors, Windows, and Sliding Glass Doors: Young Adult Texts as Sites for Identifying With Mathematics. *Journal of Adolescent & Adult Literacy*, *63*(5), 589–592. https://doi.org/10.1002/jaal.1038

Rose, D., & Meyer, A. (2002). *Teaching Every Student in the Digital Age: Universal Design for Learning*. Assn for Supervision & Curriculum.

Sannino, A., & Engeström, Y. (2018). Cultural-historical activity theory: Founding insights and new challenges. *Cultural-Historical Psychology*.

Sims Bishop, R. (1990). Mirrors, Windows, and Sliding Glass Doors. *Perspectives*, *6*(3). https://scenicregional.org/wp-content/uploads/2017/08/Mirrors-Windows-and-Sliding-Glass-Doors.pdf

Storksdieck, M. (2016). Critical information literacy as core skill for lifelong STEM learning in the 21st century: Reflections on the desirability and feasibility for widespread science media education. *Cultural Studies of Science Education*, *11*(1), 167–182. https://doi.org/10.1007/s11422-015-9714-4

Strobel, J., Wang, J., Weber, N. R., & Dyehouse, M. (2013). The role of authenticity in design-based learning environments: The case of engineering education. *Computers & Education*, *64*, 143–152. https://doi.org/10.1016/j.compedu.2012.11.026