Enhancing the STEM Framework

Combining Science, Technology, Engineering, and Mathematics with Stamina, Transdisciplinarity, Engagement, and Mindfulness prepares students for real-world problems.

By Jennifer A. Manak and Enrique A. Puig

As we write this article amid the COVID-19 pandemic, we are more aware than ever of the overlapping and interconnected nature of science, literacy, and real-world issues. This pandemic is not simply a problem to be solved by expertise in any one discipline but necessitates a transdisciplinary approach requiring the integration of many fields including biology, virology, economics, politics, engineering, education, and psychology. As we adapt instruction to educate students and support social-emotional learning, we must collaboratively seek new solutions to these dynamic, real-word issues in our global society. As educators preparing the next generation of global solution-seekers, how can we foster our students to become engaged, motivated, and literate citizens who work across disciplines, cultures, and identities?

We propose building on the STEM acronym (Science, Technology, Engineering, Mathematics) with Stamina, Transdisciplinarity, Engagement, and Mindfulness crosscutting STEM subjects to foster students' acceleration of critical thinking of disciplinary practices across core ideas. Within the concept of three-dimensional learning, we situate stamina, transdisciplinarity, engagement, and mindfulness as a framework for enhancing instruction across the disciplines to engineer solutions to real-world issues. Similar to the major goals of the *Next Generation Science Standards* (*NGSS*), this framework focuses on students constructing, deconstructing, and reconstructing concepts in a coherent manner and progression. Within the rest of the article, STEM will refer to our enhancement of the acronym. In addition to building upon STEM and what it means to educators, we will include classroom implementation tips as guideposts for teacher-colleagues, teacher-leaders, and to support our argument.

Over time, educators come to the realization that proficient learners are transdisciplinary literate. Transdisciplinary learners crosscut information and knowledge from various disciplines to function, inform decisions, make sense, and create. Reflecting the NGSS, our goal is to prepare global-ready students to build upon traditional STEM by focusing on: (1) building student stamina for learning, (2) using knowledge across disciplinary core ideas, (3) engaging students in becoming transdisciplinary literate, and (4) developing learners who are mindful of the world around them. Ultimately, our goal for globally-minded students is to be make informed decisions on personal and real-world issues (Tucker 2017). To inform three-dimensional instruction, the essential pragmatic questions are:

- How do we use stamina, transdisciplinarity, engagement, and mindfulness as a framework to scaffold STEM instruction?
- How do we teach for stamina, transdisciplinarity, engagement, and mindfulness?
- What implications do stamina, transdisciplinarity, engagement, and mindfulness have for professional learning to improve instruction across the disciplines?

Acknowledging the intersectionality of science, literacy, society, and history, we used a constructivist lens to guide our thinking (Freire 1970; Vygotsky 1980). While it may begin with disciplinary literacy, at the classroom level it is about creating conditions of learning to motivate students to look, wonder, and reflect across disciplines and to integrate their developing literacy knowledge and lived experiences as they engage in their world (Crouch and Cambourne 2020). We recognize that coherent curricular change at the classroom level is multifaceted, complex, and time-consuming (Froelich and Puig 2010). Although stamina, transdisciplinarity, engagement, and mindfulness function as an interdependent system to support broad-spectrum learning, in the next few sections we discuss each one sepa-

rately for clarification and implication to enhance instruction.

STAMINA

Stamina is the endurance or ability to actively engage in a task for an increasing duration without becoming fatigued. From a three-dimensional learning perspective, increasing students' stamina provides them with more focus and energy to engage in solution-seeking, critical thinking, communication, and self-management practices throughout the day. Additionally, using a wide range of texts and resources including reference books, maps, historical fiction, newspapers, oral communications, published stories, online websites, and digital documentaries is essential.

Increasing stamina for learning requires students to be willing to try new experiences and expand upon their previous abilities; however, this requires interest and motivation. Students' academic strengths and needs play a critical role in developing stamina over time (Puig 2019). Based on our personal teaching experiences and hours of classroom observations, five instructional practices can be implemented in classrooms to develop stamina in our students:

- Understand students' strengths and needs based on formal and informal assessments.
- Make tasks universally accessible for students at various developmental levels so both success and productive failure can be experienced.
- Collaborate with students to set explicit goals for motivation that highlight their strengths yet point them toward developmentally appropriate and reachable learning targets.
- Provide extended time for reading authentic texts (e.g., narrative and informational) and genuinely communicating (e.g., writing and discussing).
- Engage students with a wide variety of texts across disciplines that include online and offline resources.

A hallmark of an effective learning environment focused on stamina and inquiry is reading and participating in meaningful discourse with ample opportunities aimed at constructing and creating new knowledge for transdisciplinary solution-seeking.

TRANSDISCIPLINARITY

Echoing the concept of three-dimensional learning, teaching for transdisciplinarity is a holistic, student-centered mode of instruction focused on creating conditions to motivate and empower students while drawing knowledge from a variety of disciplines (Kaufman, Moss, and Osborn 2003). Transdisciplinary instruction blurs disciplinary lines to provide a multifaceted view of a topic or focus of study (Klein 2006; Kaufman, Moss, and Osborn 2003; Nicoescu 2011). At the classroom level, transdisciplinary learning comes to fruition through project-based and inquiry-based learning. Teachers with a transdisciplinary orientation scaffold students' critical understanding of the scientific processes involved in making meaning and constructing new knowledge.

We have found that there are five critical universal lesson design considerations that should be incorporated into instruction to promote transdisciplinary learning:

- Read from diverse disciplines and genres to seek answers to complex problems that can be summarized, synthesized, and communicated on a variety of platforms or styles.
- Use curriculum content that is age-appropriate, appealing (visually and aurally), and relevant.
- Focus on transdisciplinary learning that is intensely collaborative and grounded on the concept that knowledge is socially constructed through facilitating intentional, meaningful discourse.
- Combine multiple knowledge sources to create new knowledge that serves as a springboard for further transdisciplinary investigations.
- Develop facilitative skills that tap into learners' multisensory orientation by focusing on students' external (taste, smell, touch, sight, hearing) and internal (curiosity, imagination, metacognition, monitoring, timing) sensory mechanisms.

We all come to teaching with our own funds of knowledge from a variety of disciplines (Moll, Amanti, Neff, and Gonzalez 1992). When teaching for transdisciplinarity, stamina along with engagement are critical factors in any classroom where students are being asked to read the world and the word (Freire 1970).

ENGAGEMENT

A critical condition for any learning is the condition of engagement. Crouch and Cambourne (2020) tell us that learners are more likely to be engaged when (1) they understand what's in it for them; (2) they know it's okay to take risks; (3) they know that if they take a risk there will be someone around to help them succeed; and (4) demonstrations or experiences are provided by someone

that they respect and admire. As students read and communicate across disciplines in supportive learning environments, they find topics that interest them, ideas to explore, and challenging texts that excite them with newfound knowledge.

To increase student engagement when planning lessons, we have found the following instructional practices to be effective:

- Utilize multisensory instruction to provide students multiple sources of input that incorporate online and off-line resources.
- Incorporate all forms of the arts (e.g., theater, painting, sculpting, dancing, music) across disciplines to highlight the interconnectedness of concepts.
- Use texts with recurring themes so students can develop familiarity and an intimate relationship with content, context, and texts.
- Create a learning environment where productive failure is honored as part of the process of learning across disciplines.
- Consistently highlight for students the purpose and benefits of learning across the content areas.

At the core of all learning experiences is engagement (Crouch and Cambourne 2020). Students' engagement in learning can make or break any transdisciplinary learning experience (Puig and Froelich 2011). We have also found that in addition to stamina and engagement, students' mindfulness can augment the three-dimensional learning experience.

MINDFULNESS

Mindfulness practices can help students feel present in their bodies, build attention and executive functioning, observe thoughts and emotions, understand social interactions, and extend understanding and self-awareness to others (Rechtschaffen and Rechtschaffen 2015). Teachers can foster mindfulness by guiding students to engage in various meditative practices, relaxation techniques, breathing, and self-compassion exercises. Developing mindfulness in the classroom can also foster students' ability to be open to new ideas or points of view (Albrecht, Albrecht, and Cohen 2012).

Teachers emphasizing mindfulness practices will help students become more successful learners in the classroom as well as thoughtful, compassionate individuals committed to a more just society. Within classrooms, mindfulness can be cultivated in a variety of ways throughout the curriculum to develop students' learning. The following are reflection points for employing mindfulness practices in the classroom:

- Build students' ability to maintain focus and attention.
- Foster cooperation and collaboration through social-emotional learning.
- Develop students' critical literacy by guiding them to evaluate and challenge texts.
- Nurture self-awareness of the role students play in the world they live in.
- Model for and guide students to self-regulate and self-monitor.

While mindfulness, stamina, and engagement are multifaceted factors, there is power in the interconnectedness to promote transdisciplinary learning and instruction. Taking our discussion of stamina, transdisciplinarity, engagement, and mindfulness into account will assist in curriculum design when enhancing STEM education.

LOOKING FORWARD

Three-dimensional learning embraces literacy and content area instruction that intertwine reading and writing as tools to deepen learners' understanding of core ideas across disciplines. Enhancing STEM instruction, as defined in this article, engages students in meaningful discourse with their peers, like scientists and engineers in the field, as they make sense and design solutions to real-world issues. Our world is in a polycrisis, initially caused by COVID-19, which has led to a series of overlapping, interconnected problems that can best be answered from a transdisciplinary perspective. Preparing students to become motivated solution-seekers who collaboratively work across disciplines, cultures, and identities to address the dynamic, real-world issues of our global society is critical.

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