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Cultivating Pedagogical Courage through Wonder-Infused Pedagogy

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Introduction

I imagine if I were visited by the spirits of John Dewey, Rachel Carson, and Richard Feynman, I would have to give them the unfortunate news that things are not going so well. The erosion of democracy, the increasing commodification of learning, and the withering of wonder in our day-to-day lives are all making for an increasingly bleak present. Simply becoming a teacher is a courageous act in these days of increasing teacher-proof curricula and draconian accountability measures. Yet we persist.

It is also no secret that we face long-standing challenges in preparing future elementary teachers to teach science. Elementary teachers often carry negative past experiences, which limit their desire to both teach and learn science (Tytler and Ferguson, 2023). This overall lack of interest and difficulty with science content drives a preponderance of teacher-centered approaches, which only continue to push students away from science (Shemwell et al., 2015; Zhai & Tan, 2015). However, what is lost in these studies is the remarkable abilities and desires that many preservice elementary science teachers carry with them, as well as their willingness to engage with science when we are able to find pathways that reestablish positive emotional connections to the content (Gilbert & Suh, 2026; Haverly & Davis, 2023).

Science also carries with it a dual role of both the content of science (definitions, laws, etc.) and the process of actually doing science (data gathering, testing, argumentation, etc.). Schools rely on the vision of science as a noun, where they fill up students with factual knowledge, while opportunities to engage children with science as a verb occur far less frequently. The question becomes how, then, do we, as teacher educators, prepare future teachers to broaden their visions for what is possible in the science classroom while simultaneously rewiring their relationship with science itself? The following highlights one possible pathway toward developing the courage to think about science learning and teaching that better aligns with what we know excites both children and scientists alike, which Richard Feynman (1999) referred to as “the joy of figuring things out.”

Wonder-Infused Pedagogy

Building from a place of wonder frames a desire to answer a question, to construct ways to test it, and to provide the emotional connection to pursue those answers even when it becomes difficult. Furthermore, evoking wonder as an entry point for science content can significantly impact student achievement (Hadzigeorgiou, 2022). Using wonder as a pedagogical

tool taps into the uniquely human process that connects our intense need to know with scientific practices such as observing, data gathering, hypothesizing, etc. In the broadest sense, wonder "is connected to not knowing, wanting to know, getting to know and everything in between. It is deeply emotional, but still bound to thinking" (Glăveanu, 2020, p. 22). It is from this place that I challenged myself to make both my teaching and research better match why scientists do their work to begin with…to make sense of the natural world.

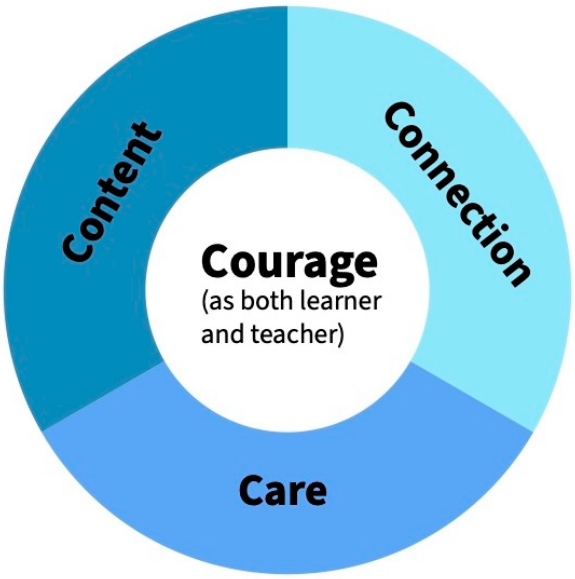
Wonder-infused pedagogy is a broad term that arose out of research that utilizes wonder as a pathway to provide engagement within the sciences, particularly for those preservice teachers (PSTs) who have long-standing content fears (Gilbert & Byers, 2017; Gilbert, 2023). This is done through engaging future teachers in authentic science experiences related to their wonderings and is built squarely upon a foundation of social constructivist theory. However, certain conditions must be met before engaging future teachers meaningfully in wondrous classroom approaches.

The Three C's of Wonder-Infused Pedagogy: Content, Connection, and Care

The following conditions have emerged through the curation of wonder-infused pedagogy over the last decade in both teaching and research, namely: *content, connection,* and *care*. These elements work in concert to help PSTs realize the potential they carry within them to become science learners, thinkers, and teachers.

Figure 1

Conditions needed for wonder-infused pedagogy that allows PSTs to build the requisite courage to take on a science-curious identity



Content

Ultimately, we are tasked with teaching science *content* and *process skills* that our future teachers must know. The memorization of science facts is what drives many future elementary teachers away from science, so the goal is to engage them in content in a way that respects how they exist in the world. Mainly, by honoring their questions while also immersing them in the modeling of what it means to engage in inquiry. This could be using a 5E approach or Phenomenon-based science instruction; the mechanism is less important than the actual experience of being immersed in science thinking.

The main goal is engaging learners in a sensemaking process, where PSTs work in teams to solve phenomenon-based problems that provide powerful pathways for content development (Alvidrez et al., 2024). Additionally, our PSTs are tasked with building their own science content knowledge while simultaneously learning to teach it to others. The processes described here represent common approaches in most elementary-level university methods courses. However, the subsequent conditions may stray from many common elements within methods course teaching.

Connection

This theme is a multifaceted effort to not only connect with PSTs on a personal level but also facilitate their *connection* to the science within the natural world. In addition, there are efforts to connect PSTs with science content in ways that do not overwhelm them, using pedagogical tools. Framing wondering as a tool for science engagement creates a low-stakes environment to think about science and noticing, such as the “See, Think, Wonder” observation strategy used to facilitate PSTs’ noticing and thinking during sense-making. In addition, the outdoors offers a key context for wonder approaches, including “wonder” walks, sound mapping, and nature journaling as key elements of wonder-infused pedagogy. These approaches utilize both indoor lab spaces and outdoor campus sites for witnessing and documenting scientific phenomena within their wonder journals (described in detail in a later section) and connect those back to content goals.

The second aspect of connection is of the human variety, or mainly, trying to connect with PSTs as people. These efforts include quickly learning the names of all students, providing feedback on assignments that are more designed to foster dialogue around their thinking, and getting to know what they value as future teachers. This approach to connection offers a mechanism for helping PSTs to feel seen during instruction. These efforts toward connection provide the needed context for PSTs to take risks and stretch themselves in terms of a willingness to take on challenges.

Care

The final condition for wonder to flourish is *care*. Starting with care and maintaining it through the semester builds the context that allows pedagogical and content courage to take root. Learning to become a teacher and entering schools for practicum and internship

placements can be difficult and intimidating. As teacher educators, we need to respect that challenge. These ideas permeate nearly every aspect of this classroom approach and support future teachers in understanding the role of ambiguity, unease, and contested ideas in the context of science learning. This requires a balance of support and availability while also trying to push those future teachers to consider a new vision for what it means to engage with science. Taken together, the conditions of *content*, *connection*, and *care* work in tandem to create a positive context in which future teachers can grow and nurture their courage for science teaching and decision-making. This courage is essential if we wish for future teachers to provide strong inquiry experiences for children in these times of increasing curricular control and scripted teaching approaches.

Operationalizing Wonder-Infused Pedagogy for Methods Courses

What does this approach look like across a fifteen-week semester? The typical class session includes engaging with a content topic that fosters a collaborative learning environment steeped in sensemaking and modeling of inquiry practices. This is what others may consider a standard approach to a methods course. PSTs also read professional and practical articles regarding science and science teaching practice, such as (Clark & Dean, 2025; Wilcox et al., 2024). The assignments described below are the main activities that PSTs cite as the most impactful during the undergraduate elementary science methods course.

Designing and Implementing a 5E Experience

The 5E process moves PSTs from thinking of content as an abstraction toward concrete understanding. Developing their final 5E units (Bybee, 2009) is often the most difficult part of the course for PSTs. All of the course readings and in-class experiences support the development of that unit construction. Future teachers build three connected lessons that scaffold across the 5E process and address both content and process standards for Virginia. These standards are influenced by the Next Generation Science Standards (NGSS), although the NGSS have not been adopted in our state. An essential feature is that PSTs design these plans and deliver these lessons in a local elementary school classroom through our professional development school model. Implementation could also be done in the methods class through small group or whole class microteaching, providing them a chance to test some of their designs. Importantly, the PSTs have been engaged with their wonders before, during, and after designing and delivering these lessons in a partnership school.

Outdoors as Wonder Laboratory

The outdoors plays a vital role in connecting future teachers to science. Consistent time outdoors enhances mood and self-esteem, improves focus and creativity, and builds a connection to the natural world (Dabaja, 2022; Hepworth et al., 2024). These include developing noticing skills, sketching, hypothesizing through activities such as documenting objects they find beautiful, species counts, searching for patterns, mapping habitats, and wonder walks. This serves as a model for future practice since many local elementary school contexts are under-resourced in terms of science equipment and materials. The outdoors offers

a free, easily accessible science laboratory to teach important scientific practices of observation, hypothesizing, documentation, and crafting explanations of phenomena. In terms of wonder, it begins to facilitate future teachers in witnessing the extraordinary in the ordinary (Washington, 2019).

Wonder Journaling

PSTs are tasked with thinking about the science they see in the everyday. Over the course of the semester, they utilize a composition book/journal to make note of various things they observe in the natural world and list, sketch, question, observe, and record those things that capture their attention and imagination (Dean & Gilbert, 2022). These wonderings center on what they see, think, and feel about those things that fascinate and/or confuse them. There are very few rules; mainly, they must have 10 entries total, where each entry includes a hand-drawn sketch as well as a handwritten introspection of their thinking regarding that phenomenon or object of their wondering. That introspection can vary, but allows space for questioning, observing, hypothesizing, and building possible explanations as well as further questions. The key goal is to slow them down and engage deeply with their thoughts. Further, I ask them not to Google answers for at least 48 hours so that they get time to think about those questions, hypotheses, and possible answers. At the close of the semester, they choose a wonder from these journals and engage in a class-wide poster session.

Explicit Connection to Scientific Practices

As a means to foster understanding of scientific practices and nature of science (beyond the other aspects of the course that work toward this goal), PSTs read key chapters of "A Short History of Nearly Everything" (Bryson, 2004) and engage with a series of prompts for how scientists work, think, and build consensus. This volume presents scientists as humans struggling to better understand the world (just like the rest of us), rather than as omnipotent, infallible heroes that society and textbooks wish to portray. Connecting with scientists as humans sets the stage for their engagement with their wonders and working to better understand the science behind them.

Wonder Project Investigation

The goal of this project is to pursue an idea that my PSTs find vexing or fascinating. They choose a topic from their wonder journal and delve deeply into their thoughts and the science behind those ideas. The goal is not necessarily to prove a single answer, but to understand something more deeply and then consider all the new questions that come with that wondering and investigating. This thinking is then put into a poster (or other presentation format) to publicly engage classmates with their wonder during a class-wide Wonder Fair. These artifacts are presented in our final class session, and this event is typically cited as the most powerful aspect of the course. PSTs often choose topics that are dear to them. This can be something they have thought about for years and/or building a better understanding of a disease that might be impacting their families, etc. This shared vulnerability both builds a strong classroom community and connects PSTs to science content.

The Courage to Wonder

> *It seems to me that some of us value information over wonder, and noise over silence. And I feel that we need a lot more wonder and a lot more silence in our lives (Rogers 1994, n.p.).*

Children's Television pioneer Fred Rogers reminds us that our technological world is continually accelerating, which has profound impacts on modern life and the experience of children. We must remind ourselves that we have choices about how we operate in these data- and tech-driven times and how we connect with content in ways that might better align with how we have learned to engage with the natural world over the last few million years of human evolution.

This process of wonder-infused pedagogy is not born of whimsy or a simple process of merely depicting our wonders. Wonder-infused pedagogy sets the conditions for these future teachers to trust in their abilities, which drives them to put their very best into their work. This will be paramount in their future career success as well as working toward larger goals of civic engagement and equitable access to science. Overall, this process builds both content confidence and connection to the natural world, which forges a desire to learn science content. This wonder-driven process works to rewire learners' relationship with science, creating more positive associations with science learning and teaching. These new visions for the power and possibility of science are proving to be an effective mechanism for PSTs to develop the pedagogical courage to teach inquiry science in their future elementary classrooms.

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