EDUC267E
Development of Scientific Reasoning and Knowledge
Stanford University, PreFall/Fall Quarter 2026

Wednesdays Aug 19, Aug 26, Sept 2, Sept 9, Sept 16 – 2:15-5:15 pm
Tuesdays Sept 22, Sept 29, Oct 6, Oct 13, Oct 20 - 3:15-6:00 pm

Instructors:

Stina Krist
Office: Raikes 217
stinakrist@stanford.edu
Office Hours: By appointment

Laurence Tan (LT)
ltan11@stanford.edu
Office Hours: By appointment (Zoom)

Julia Poel
jpoel@stanford.edu
Office Hours: By appointment

Course Description:
In the Development of Scientific Reasoning and Knowledge, we will explore and investigate aspects of teaching science in the elementary classroom. Our overarching goal is to develop your competence and confidence to teach science. We will be emphasizing: (1)The use of phenomena as a method of exploring the world around us, (2) Interpreting and implementing the vision of the NGSS and (3) Integrating child-centered and culturally relevant content into our lessons. The course will help you integrate science into your teaching. We hope that you will see science as the wonderful, all encompassing, fascinating subject that it is and can be. Like us, our children are so interested in the world around them and they are fantastic question askers. We want to explore how we can facilitate this questioning and investigating of the world and to see what it looks like in our classrooms.

As we explore objects and phenomena, we will listen to ourselves wonder, describe, classify, explain, and predict in order to hear what scientific understanding sounds like. We will argue, use scientific models and write about our investigations as a model for what we can do with students. Our discussions will focus on how teaching can foster such understanding in children. We will also discuss how all children can wonder and think about the world we live in and the phenomena they experience every day. Unfortunately, there are many students who are marginalized in science despite their interest and creativity. Some of these learners are not given access to robust and rich science curriculum. Throughout this course, we will be focusing our lens on aspects of equity and how all students can engage in and access scientific content and practices.

The course is divided into roughly three segments:
1. Delving into the Next Generation Science Standards and the Science and Engineering Practices
2. Exploring various approaches for justice-centered science teaching
3. Envisioning possibilities for transdisciplinary science teaching that engages students as change-makers in their communities

Additionally, we will focus on strategies for adapting existing materials to move them incrementally closer to 1-3 above, and on how you as teachers can build up your own content knowledge.

Fall Quarter Goals

1. Analyze existing curriculum materials to understand the structure and content of materials that you may be using in your classrooms.
2. Practice skills, strategies, and routines for teaching science (productive talk moves, literacy strategies, eliciting student ideas, leveraging phenomena and student questions to drive instruction, anchoring phenomenon routine, investigation routine) and include them in your plans.
3. Understand student's everyday and initial ideas about science topics and phenomena and leveraging them to shape teaching and instruction.
4. Customize a lesson from an existing curriculum to make it more equitable, more aligned to the vision of the NGSS, and better support the needs of your students.

Course Requirements

Students are required to attend classes regularly and to complete all readings prior to each class. The course will be highly collaborative and active participation is essential. Attendance is extremely important and is required at all class meetings. Students are expected to arrive on time, refrain from leaving prior to the end of the class, and participate actively in class activities and discussions. Students who miss class will be asked to complete an activity or meet with the instructors to review the materials. Classes will include mini-lectures, small group activities, presentations, and discussions of key themes from the assigned readings. We expect that people will remain off of their phones and social media during class and stay focused and engaged with your classmates.

Grading Policy:

Our intention is that all teacher candidates will become more comfortable teaching science and in their own science understandings. Assignments which do not meet criteria will be returned for revision. Please communicate questions or concerns with instructors directly. We encourage you to ask for extensions in advance as needed.

Instructor Communication:

We utilize Canvas for all course information, including emails and announcements. Please make sure that you have your Canvas notifications set to send you emails.

Course Assignments:

Discussion Posts: There will be an assigned discussion question for each session that will build on the readings. Please complete these discussions 24-48 hours before each class. Please answer for yourself and feel free to also build on other people's responses.

Assignment 1: Learning About Your Students

The goals of this assignment are to (a) get to know your students; (b) identify the "seeds" of science and scientific thinking in their everyday interests and activities; and (c) map those "seeds" to the various instructional segments (science topics) per grade level.

This assignment includes 3 major tasks. They are:

1. Chat with students in your placement class and write down the things they are interested in and care about. If you don't know much about something they love, do some research! **(Do this between now and Aug 30th).**
2. Start to identify some potential science content connections. What science concepts and ideas are inherent in the things they love? For example, if kids know a lot about playing soccer, they probably know a lot about how to kick a ball for it to go into the goal at just the right angle/forces and motion or how your body reacts to heat/body systems. **(Submit your write-up about this by Sept 1st).**

3. Mapping those concepts to the NGSS instructional segments **(we will do this in class on Sept 2nd)**.

Assignment 2: Science Talk
In this assignment you will leverage a science probe question as a context to engage students in a Science Talk. The goals of this Science Talk are (a) to practice listening closely to the science ideas students have, especially identifying the right parts of any "wrong" answers; and (b) to gain low-stakes practice facilitating students in engaging deeply with their own and others' science ideas.

This assignment builds from an in-class activity where we will select and try out science probes with each other. After identifying the probe and how you will use it, you will carry out the Science Talk with a small group of 3-4 students. If allowed, audio-record the talk using Voice Notes or other tool on your phone that will generate a transcript. You will use this transcript for your reflection on the Science Talk.

Your Science Talk will need to be completed by **Week 5 [Sept 15].** This will give you sufficient time to complete and submit your reflection by **Sept 22**. We will discuss your reflections in class that day.

Assignment 3: Lesson Customization
The goal of this assignment is to take a lesson that you might reasonably be "handed" to teach and customize it to incorporate the vision and strategies for science teaching presented in class. The idea is not to create a "perfect" lesson, but to practice making relatively small changes that can have a big impact for student learning.

You can select any lesson from existing science curriculum materials (e.g., Twig, Amplify, FOSS, OpenSciEd, Mystery Science). The more familiar you are with the curriculum, the easier this will be; if you can, choose a lesson that you have taught before, seen taught in your placement, or is from a set of materials you are familiar with (e.g., an Amplify 5th grade lesson when you are familiar with the Amplify 3rd grade curriculum). It will also be an easier task if the curriculum is generally considered "high quality (HQ)" and claims to be NGSS aligned. That said, you might choose to make this a realistic challenge and use materials you know you will be using in the future even if they are not HQ or NGSS aligned. If you are unsure if a lesson would be a good fit, check with the teaching team!

What to Submit:
- Original lesson plan
- Your customized lesson plan, in a modified EdTPA format (see Template link on Canvas)
- Written justification elaborating on your customizations, including references to class readings, activities, and discussions

The criteria for a successful final lesson plan are:

- Students are the ones doing the "figuring out" of the core ideas by engaging in one or more science practices; you are providing sufficient support for them to engage in those practices effectively
- Content is aligned in working towards a DCI/PE from an appropriate instructional segment (grade level or one below)
- Content is effectively customized to your particular students (consider phenomenon choice, opportunities for students to share their ideas and experiences in ways that meaningfully contribute to science knowledge building, connections to societal and/or justice issues)
- Pedagogy utilizes UDL and strategies to support multilingual learners as appropriate
- **Stretch goal A: Intentionally integrate the "less science-y" 5 pursuits:** identity, criticality, and joy
- **Stretch goal B: Make it a justice-centered, civic action-oriented lesson:** connections to societal and/or justice issues anchor and drive the lesson; the lesson reflects some portion of the CAtS cycle

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We will have time in class during Weeks 7, 9, and 10 to work on your customization and justification. The complete assignment is due one week after our final class session [due on **Oct 27**].

Honor Code:
Students are expected to adhere to Stanford's honor code. According to the Office of Judicial Affairs (OJA) website, "For purposes of the Stanford University Honor Code, plagiarism is defined as the use, without giving reasonable and appropriate credit to or acknowledging the author or source, of another person's original work, whether such work is made up of code, formulas, ideas, language, research, strategies, writing or other form(s)." For further information, please consult the OJA website:
http://www.stanford.edu/dept/vpsa/judicialaffairs/students/plagiarism.sources.html

Students with Documented Disabilities:
Students who may need academic accommodations based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is made. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066, URL: http://studentaffairs.stanford.edu/oae).

Detailed Session Information (Also linked on our Canvas site)

Session 1: What Does it Mean to Be a Scientist? - Wednesday August 19, 2026, 2:15-5:15

Essential questions/Goals for the day: How do we motivate science units with questions that come from students?
Equity Focus: What are we bringing into the classroom and how can we dream toward science teaching for dignity and justice?
Science Focus: Pacifica cliffs

Tasks/In-Class Activities:
- Intros - Science journey
- Reading discussion: Our visions for science learning
- Review syllabus and assignments
- Introduce Assignment 1 (due Sept 2)
- Science exploration: Pacifica cliffs

Resources Used in Class:
- *A Framework for K-12 Science Education* Chapters 1 and 2
- Interactive Summary of: National Academies of Sciences, Engineering, and Medicine 2021. *Science and Engineering in Preschool Through Elementary Grades: The Brilliance of Children and the Strengths of Educators*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26215

Session 2: Frameworks, Standards, Curriculum, and Equity - Wednesday August 26, 2026

Essential Questions/Goals for the Day: How do we read the NGSS standards and what is both in them and missing from them?
Equity Focus: What are some additional ways we can frame teaching science for justice?

Science Focus: Pacifica cliffs

Tasks/In Class Activities:

- Continue science exploration: Pacifica cliffs
- Reading and Using the Next Generation Science Standards
- Reading discussion: Equity approaches and applications to curriculum materials
- Check in on Assignment 1 (due Sept 2)

Readings:

- Bang, M., Brown. B., Calabrese-Barton, A., Rosebery, A. and Warren, B. (2017) Chapter 3: Towards a more Equitable Learning in Science: Expanding Relationships Among Students, Teachers and Science Practices. *Helping students make sense of the world using next generation science and engineering practices*, pp. 33-58.
- Gholdy Muhammad. Chapter 2, pages 49-61. *Cultivating Genius. An equity framework for culturally and historically responsive literacy*.

Resources Used in Class:

- California Science Framework. https://www.cde.ca.gov/ci/sc/cf/cascienceframework2016.asp
- California Science Standards. https://www.cde.ca.gov/pd/ca/sc/ngssstandards.asp
- NASEM Report from Week 1 - Using tables 1.1 and 1.2 in class

Additional Resources:

- Mindshift Podcast. Gholdy Muhammad: How do you cultivate genius in all students? (24 min) https://www.kqed.org/mindshift/58492/how-do-you-cultivate-genius-in-all-students
- Mensah, F. M. (2019). Teaching culturally and ethnically diverse learners in the science classroom.

Session 3: The Role of Talk in Science - Wednesday September 2, 2026

Essential questions/Goals for the day: What does productive talk look like in science? How can I create a learning environment where students can engage in productive talk?
Equity Focus: Ensuring equitable discussions
Science Focus: Pacifica cliffs; Hetch Hetchy & Elwha Dam

Assignment 1 Due

Tasks/In-Class Activities:

- Reading discussion: Talk in science
- Listening to students' science talk: Videos and vignettes
- Mapping student interests to instructional segments
- Finish science explorations: Pacifica cliffs
- Introduce science explorations: Hetch Hetchy & Elwha Dam

Readings:

- Chapter 5: Children's Talk in Bloom, J. W. (2006). *Creating a classroom community of young scientists*. Routledge.
- Gotwals, A. W., Wright, T. S., Domke, L., & Anderson, B. (2022). Science talk in elementary classrooms: A synthesis of the literature. *The Elementary School Journal*, *122*(4), 642-673.

Resources Used in Class:

- Talk Moves single page

- Video: Gyorgy's ideas about sound production [transcript]
- Vignette: Translanguaging when exploring electricity
- CA Instructional Segments (science topic clusters by grade level)

Additional Resources:
- Talk Science Primer
- Suárez, E., & Otero, V. (2024). Ting, tang, tong: Emergent bilingual students investigating and constructing evidence-based explanations about sound production. *Journal of Research in Science Teaching*, *61*(1), 137-169.
- Hudicourt-Barnes, Conversational Styles
- OpenSciEd Teacher Handbook - Supporting Discussions (pp. 36-40)

Session 4: Science Phenomena - Wednesday September 9, 2026

Essential questions/Goals for the day: What is the role of phenomena in science learning and curriculum materials?
Equity Focus: How can phenomena selection "de-settle" our assumptions about science and about students?
Science Focus: Hetch Hetchy & Elwha Dam

Tasks/In-Class Activities:
- Reading discussion
- Exploring probes as sources for phenomena
- Introduce Assignment 2: Science Talk - ***aim to complete in the next week;*** *writeup due Sept 22*
- Science explorations: Elwha Dam
- Curriculum review

Readings:
- Lee, O. (2020). Making everyday phenomena phenomenal. *Science and Children*, *58*(1), 56-61.
- McCourt, S., & Kelley, S. S. (2016). Assessing the unseen: Using music and literature to access and develop first graders' knowledge of sound waves. *Science and Children*, *53*(5), 54-59.

Additional Resources:
- Gallas, Karen. Chapter 8. Building a Curriculum from Children's Questions. Pp. 69-81
- OpenSciEd Teacher Handbook - What is the role of phenomena in OpenSciEd? (p. 8)
- Penuel, W. R., & Bell, P. (2016, March). Qualities of a good anchor phenomenon for a coherent sequence of science lessons [Practice Brief No. 28]. STEM Teaching Tools, UW Institute for Science + Math Education. https://stemteachingtools.org/brief/28

Session 5: Modeling as an Anchoring Practice in Science - Wednesday September 16, 2026

Essential questions/Goals for the day: How can modeling be part of sequences of activities that meaningfully engage students in exploring and explaining phenomena?
Equity Focus: How can modeling provide a range of entry points for students to show what they know and work with ideas?
Science Focus: Hetch Hetchy & Elwha Dam

Tasks/In-Class Activities:
- Reading discussion: Modeling

- Continue science explorations: Hetch Hetchy & Elwha Dam
- Unpacking Pacifica cliffs and Elwha Dam using the Anchoring Phenomenon Routine
- Check in on Assignment 2: Science Talk (*due Sept 22*)

Required Readings:

- Fitzgerald et al., (2022).
- Fackler et al. (2024).
- Passmore, C., Schwarz, C. and Mankowski, J. (2017) Chapter 6: Developing and Using Models. *Helping students make sense of the world using next generation science and engineering practices*, 109-134 – *Recommend summarizing or listening to this one on NotebookLM or similar*

Resources Used in Class:

- Anchoring Phenomenon Lesson element tracker

Additional Resources:

- Focus on pages 1-3. Learning in Places Collaborative. (2020). Framework: Modeling and Forming Explanations. Bothell, Seattle, WA & Evanston, IL: Learning in Places
- OpenSciEd Teacher Handbook - The Anchoring Phenomenon Lesson type (p. 14)
- German, S. (2019). Using the Anchoring Phenomenon Routine to Introduce a Science Unit. *Science Scope*, *42*(5), 32-35.

Session 6: Designing Investigations and Collecting Data - Tuesday September 22, 2026, 3:15-6 pm

Essential questions/Goals for the day: How do we co-design investigations with students to support science learning?
Equity Focus: Engaging students in productive uncertainty around designing investigations
Science Focus: Food Waste

Assignment 2: Science Talk writeup due

Tasks/In-Class Activities:

- Discuss Science Talks
- Readings Discussion: Investigations and Uncertainty
- Science Explorations: Food Waste

Readings:

- Manz, E. (2025). *Productive Uncertainty in Science Education: Engaging Students in Meaningful Science Practice*. NSTA Press. Chapter 1 and Chapter 2

Resources Used in Class:

- Investigations Project case: Resourceful Decision-Making: Supporting Children's Engagement in Planning Investigations
- Modified Investigations Framework & Example Investigation Revisions

Additional Resources:

- Focus on Page 1 and 3: Scaffolding Observations and Data collection Learning in Places Collaborative. (2020). Framework: Observations and Data Collection for Making Sense of Phenomena. Bothell, Seattle, WA & Evanston, IL: Learning in Places.

Session 7: Teaching Justice-Centered Science Topics to Elementary Students - Tuesday September

29, 2026
Guest Facilitator: Dr. Brian Gaston, EdEthics

Essential questions/Goals for the day: How do we design investigations to support student learning?
Equity Focus: How can we navigate the ethical dilemmas that arise when centering justice issues in science instruction?
Science Focus: Climate change, food waste

Tasks/In-Class Activities:
- Readings discussion
- "Seeing Green" case conversation
- Science explorations: continue Food Waste
- Introduce Assignment 3: Lesson Customization
- Prep for Jasper Ridge visit next week

Required Readings:
- Severson, A., Kohlmann, L., Adah Miller, E., & Anderson, K. J. B. (2024). *Cultivating Genius* for Science Contexts: Where does the pursuit of joy fit into science learning? *Science and Children*, *61*(4), 73–78. https://doi.org/10.1080/00368148.2024.2366014

Resources Used in Class:
- "Seeing Green" case

Session 8: Modeling, Justice-Centered Science, and "Should We…?" Questions at Jasper Ridge Biological Preserve - Tuesday October 6, 2026
******This class will be held at Jasper Ridge Biological Preserve******

Essential questions/Goals for the day: How do the science ideas and practices we've developed so far support our understanding of what we should do with the Searsville Dam?
Equity Focus: How can we leverage science knowledge and practices to advocate for change?
Science Focus: Searsville Dam

Tasks/In-Class Activities:
- Readings Discussion
- Wondering Walk
- Applying our Earth Systems Models to the Searsville Watershed

Required Readings:
- Jasper Ridge Story Map. This story map about Jasper Ridge was created by Stanford undergraduate Katherine Nolan for her Bio 105/Esys 105 project.
- Read about the Searsville Watershed Restoration Project
- *Focus on Pages 3-4: Types of Questions* in Learning in Places Collaborative. (2020). Framework: Wonderings, "Should We", and Investigation Questions in FieldBased Science. Bothell, Seattle, WA & Evanston, IL: Learning in Places.

Session 9: Designing for Civic Action through Science - Tuesday October 13, 2026

Essential questions/Goals for the day: How can we draw on social studies to prepare learners to take social action?

Equity Focus: How can we engage learners as co-creators of more just futures?
Science Focus: Food Waste

Tasks/In-Class Activities:

- Science explorations: Food Waste
- Exploring the Food Waste Unit and the CAtS Framework
- Work on Assignment 3 in class; apply the CAtS design tool

Required Readings:

- *Coming soon!*

Session 10: Wrapping Up - Tuesday October 20, 2026

Essential questions/Goals for the day: What have we learned about science teaching and equity?
Equity Focus: How will you make decisions about how you apply what you have learned to your teaching?
Science Focus: TBD

Tasks/In-Class Activities:

- Science Explorations: Our Favs
- Identity & Equity Reflection
- Concept mapping and applying what we have learned to our teaching
- Work on Assignment 3 in class

Required Readings:

- TBD

Additional Resources

Science and Engineering in Preschool Through Elementary Grades: The Brilliance of Children and the Strengths of Educators (2022)
https://nap.nationalacademies.org/catalog/26215/science-and-engineering-in-preschool-through-elementary-grades-the-brilliance

John Muir Laws Nature Journaling Curriculum, available as a free download. Please download and check out this wonderful resource.

And the recent report on equity in preK-12 STEM education expands the four listed in the elementary report to 5: https://www.nationalacademies.org/our-work/equity-in-prek-12-stem-education