‘Tis a Time for Transformation in Earth and Environmental Sciences Education
NGSS, CTE, and STEM

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Abstract

Across the western United States, the natural landscape and diverse ecosystems present provide numerous opportunities for critical examination in pedagogical settings. Yet structurally, we have often not recognized this fact in our systems for preparing future teachers, implementing new national science standards in K-12 arena (the Next Generation Science Standards, NGSS), or in recognition of the value of the geosciences and environmental sciences to core degree components as well as major programs of study. Geology and Natural Resources programs have been eliminated at the Bachelors level while interest in ecosystem and public health, renewable energy, climate change, geophysical hazards, and habitat loss grows.

Public interest is very high across the geosciences and in environmental issues, and these topics are enmeshed in the NGSS area of earth and space sciences. Yet, in Oregon, which was a leader in the development and implementation of NGSS, it is typical for programs to continue to emphasize biology, chemistry, and physics only, with a few bones thrown in for the earth sciences. There is also no teacher certification for earth science or environmental science in the state. Another emerging trend in Oregon recognizes increased value in the Career Technical Education (CTE) fields, which are often not associated with STEM, but foundationally, ought to be.

Issues associated with environmental degradation and environmental justice as well as climate change and renewable energy development all have practical application in areas as wide as technology development and electronics to land resource stewardship. And governmental policy is (hopefully) engaged in adapting to new technological development and scientific findings. The energy expressed in new movements embodied by organizations such as *Our Children’s Trust* and the *Sunrise Movement* may provide hope for environmental and earth science educators who may at times feel anxiety or resistance from policy authorities. Imagine what could be done with that enthusiasm and energy if we could help to lay the groundwork for science-based understanding in our curricula in liberal education as well as in teacher preparation programs? And also to move many of these same students into our major programs without the obstacles that society often presents to women and people of color, who continue to be poorly represented in our fields.

I advocate here for inclusive and more deliberate linkages between CTE and STEM (Science, Technology, Engineering, Mathematics), something which is already being advanced in Oregon’s STEM hubs, for example, but may not yet be fully developed within the higher education systems in my state and elsewhere. Too many influential stakeholders view STEM pathways narrowly, only within a calculus-based educational framework, neglecting some desirable pathways in allied health professions, advanced technology, or field-based programs in natural resources and agriculture. This is important for all of STEM and CTE, but often not thought to be related to the geosciences, and is an absolute must for us to move forward with an equity agenda. I will survey some of these issues and potential solutions, and seek input for systemic action that could move the discussion forward.

Keywords: geoscience, STEM, CTE, climate change, education, environment, equity, inclusion

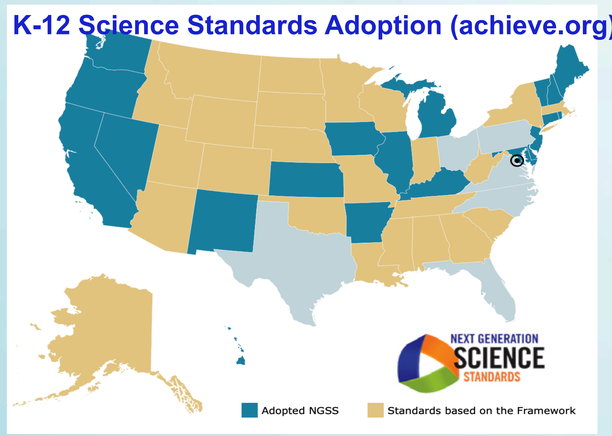
Earth & Environmental Sciences
A Place of Education Inequity and Opportunity for Students

- What Advanced Placement Test? (Earth Sciences)
- The (Implementation of the NGSS)
- College acceptance of high school science classes as rigorous
- Teacher preparation and pedagogical content knowledge in Earth and Environmental Sciences
- Lack of exposure to subject areas of interest in critically important laboratory and or field settings.

Table 1.
College Credits Awarded for Advanced Placement Exams
Credits Awarded (based on Quarter System)

AP Subject Exam	Score	Lane CC	Oregon State U	SUNY Oneonta	Florida State U
Biology	3-5	8	12	4.5-6	6-12
Chemistry	4-5	6	15	4.5-6	6-12
Earth Science	no credits/exam	0	0	0	0
Environmental Science*	3-5	4	4	4.5	4.5
Physics 1	4-5 (Phys B)	15	5	4.5	6
Physics 2	4-5	5	5	4.5	6

*not considered a lab science in most crediting schemes, even if taught as a lab
quarter credits are 1.5 times semester credits
BS degree = 120 semester hours = 180 quarter hours
inequities
common AP STEM availability
Full year college credit option in a science



References – stating the problem + solutions

Achieve.org – Next Generation Science Standards (NGSS)
Bernard, Rachel E. and Emily H. G. Cooperdock (2018) *Nature Geoscience* https://doi.org/10.1038/s41561-018-0116-6
Goldberg, Emma (2019) *NY Times* https://www.nytimes.com/2019/12/23/science/earth-science-diversity-education.html?smid=nytcore-ios-share 12/23/2019
Dutt, Kuheli (2019) Race and racism in the geosciences. *Nat. Geosci.* doi:10.1038/s41561-019-0519-z

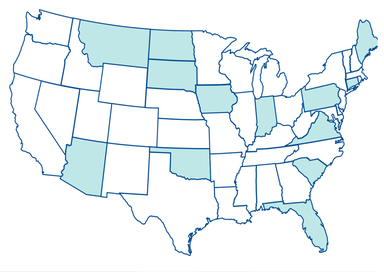
Are Earth & Environmental Sciences Rigorous?

- NGSS says yes!
- Many states say no!
  - Example: California – only biology, chemistry, physics qualify as a rigorous laboratory science
- Many districts can’t find well qualified teachers* (definitions vary)

Are teachers adequately trained to teach earth sciences and/or environmental sciences? (We know students are interested!)

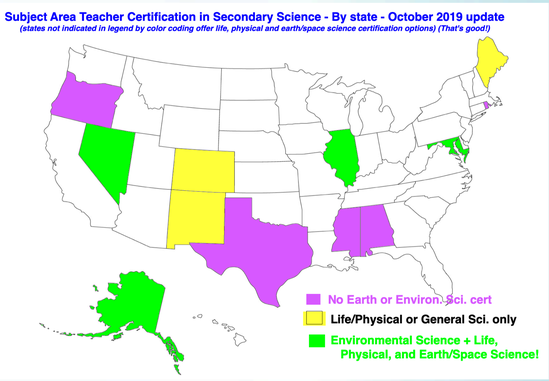
Controversial issues map (NCSE)

NCSE National Center for Science Education
http://ncse.ngo/



States where the teaching of evolution and/or climate change were under attack in 2019

Teacher Cert Map



Equity and Diversity in Geoscience – A Long Way to Move the Bar!

- Does not start in graduate school or top geoscience departments.
- Community college students represent a more diverse population than found in most universities, with our without geoscience programs.
- Community college students often (~40%) proceed into STEM majors as a CC student or upon transfer – do they stay in STEM/Geosciences?
- Research experiences do not have to be limited to universities, but can be strengthened by both institutional investment at the CC and with transfer partners (see my poster on Wednesday afternoon!)
- Increased recruiting for REUs, etc., at CCs would pay dividends in terms of representation; UCAR and other programs are a start but are limited. Could the agencies that support REUs, summer hiring programs, etc., open up new possibilities to increase diversity? Even in today’s politically charged climate?
- Are the agencies themselves ready for a more diverse workforce? Recent news about gender discrimination offer some troubling thoughts here.