Delight in the World:
Reimagining Earth Science Education in New York State

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Abstract

Earth Science is not a diverse field. Women are awarded less than half of undergraduate Earth Science degrees and underrepresented minority groups are awarded less than 10%. This thesis project investigates the way Earth Science is taught at the middle/high school level and how those standards and curriculums affect who chooses to engage with the geosciences in college and beyond. This project was conceptualized as a two-part, survey-based case study, the first targeting middle/high school Hudson Valley Earth Science teachers and the second targeting current Earth Science college students, although the latter survey was unsuccessful. The Teacher Survey aims to assess how state standards and expectations affect classroom curriculum. Only 12% of teachers contacted responded to the survey, but those who did represented a wide range of districts and academic levels. Their responses emphasized how the current Earth Science standards consume the vast majority of their classroom time, with little room to expand upon those concepts past what any exams require. Science education that integrates community needs and values, especially through local partnerships and outdoor education, helps students stay connected to Earth Science.

Introduction

Earth Science, while seemingly an essential field due to its wide range of applications, is not a common, stand-alone course taught below the undergraduate level. While Earth and Space Science concepts are present in middle and high school science standards for curriculum in every state in the U.S., only eight out of fifty states require a course with those concepts as a prerequisite for high school graduation (Center for Geoscience and Society, 2018, p. iv). Twenty-nine states will count Earth Science credits toward graduation requirements, and thirteen of those states insist that the science class must be laboratory-based. Many other states specify science course requirements, but they do not mandate exact course content. (Center for Geoscience and Society, 2018, p. 4). In comparison, 26 states require a full year of physical science and 32 require a year-long life science course (Center for Geoscience and Society, 2018). This means that many students never have the opportunity to learn the mechanisms of their environment beyond the preliminary or fundamental levels.

In New York, Earth Science is a non-mandatory science course with its own corresponding assessment exam, called the Regents Exam. According to the New York State Department of Education, Regents "are achievement tests that are aligned with New York State's learning standards" (High School Regents Examinations, n.d.). Every state uses a different set of standards or expectations of what a student should know and be able to do at each grade level. Every set of state-level standards can then be combined with any other set of standards designed for the national or individual school level in order to develop classroom curriculum. New York State (NYS) is one of many states that is in the process of adopting the recently developed initiative, *Next Generation Science Standards* (NGSS), which includes Earth Science as an equal and official part of their state science curriculum. Currently, standards in NYS remain inconsistent, with teachers abiding by any of the following: *National Science Education Standards* (NSES), *New York State Learning Standards for Mathematics, Science and Technology* (NYS Standards), the *Core Curriculum on Physical Setting/Earth Science*, *The Framework for Science Education,* or the new *NYS P-12 Science Learning Standards*. Beyond the basic outlines these systems provide, teachers are usually left to design curricula on their own, assuming they follow their prescribed guidelines. While NYS then tracks how well students in the entire state understand that material through the Earth Science Regent exam, the priority of content provided to prepare students for each exam is up for interpretation by individual districts (Contino and Anderson, 2013). Earth Science, if taught before college, is usually a part of either the 8th-grade or 9th-grade science curriculum. Because these two grades are often taught at very different levels, it increases the risk that not all students will graduate with the same Earth Science competency.

Everyone has their path to becoming a scientist, but somewhere along that path, there are some disparities between who stays involved in the sciences in the long run. Studies already show that there is a lack of diversity among geoscientists, more so than in other scientific fields. Less than 7% of undergraduate geoscience degrees are awarded to "traditionally underrepresented minorities," and only 41% of those degrees are awarded to women (Stokes et al., 2013). This disparity continues into graduate studies and the workforce where less than 45% of graduate degrees are awarded to women, who then go on to hold only 30% of geoscience careers (Stokes et al., 2013). This disparity has always existed and has not significantly improved in decades. The geosciences fields are the least diverse STEM disciplines, and while other programs move towards incentivizing more diverse representation among their scientists, Earth Science is stuck in the past (Bernard and Cooperdock, 2018).

Some students love science enough to turn it into a career, and some will reject it from the start, but is there a way to maximize the number of students who want to be able to study science all the way through to being able to pursue science as a part of their career? As seen in prior work, at the undergraduate level the geosciences already lack diversity, and it is no wonder that the careers that follow should show the same pattern, which means at some point before college, students stopped being interested in studying Earth Science. As Bernard and Cooperdock (2018) put it:

> As a community, we need to think deeply and seriously about why the underrepresentation of some groups is so persistent, and what initiatives we can develop to make sure students from all backgrounds feel welcomed, excited, empowered and capable of succeeding at higher education in the geosciences. (p. 294)

This thesis project focuses on how the way Earth Science is taught affects who goes into the geosciences and why. Using a survey targeted at current earth science teachers in the Mid-Hudson Valley region of New York to a case study of practical applications of Earth Science curriculum in New York State, can the curriculum still be designed to ensure no student feels that they are being left behind by the practical applications of the science they want to study?

Literature review

The Practice of Teaching Earth Science

There is no single method for how any subject should and could be taught. Even the best practice of teaching Earth Science is going to vary between every single teacher, day, and class. On an institutional level, each state has different standards, resources, and students, each of which has the potential to throw a wrench in the study of how Earth Science is taught. The Geological Society of America (GSA) calls for the standardization of teaching Earth Science because as it currently stands there is none. Simply, the GSA believes that Earth Science can and should be taught at all grade levels, from kindergarten through 12th grade, because a fundamental understanding of the world's systems is beneficial for all students (2021). In good news, all U.S. states already include Earth and Space Science concepts in middle and high school science standards, but only 16% of states require a full course on those subjects. Testing surrounding Earth and Space Science is also not universal; there is no AP test solely focused on these concepts. Even if AP Environmental Science covers some Earth Science material, less than two-thirds of U.S. states assess Earth and Space Science concepts at the middle and high school level (Center for Geoscience and Society, 2018). If those are the aspirational goals, then it is important to focus on what Earth Science content is even being discussed.

Before diving into the efficacy and practicality of different learning requirements, there is a long history of influential science education standards over the last thirty years. The *National Science Education Standards* (NSES), written in 1996, aimed for "a vision of a scientifically literate populace" (National Research Council (U.S.), 1996). These standards are for all students, regardless of "age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science" (National Research Council (U.S.), 1996, p. 2). Even at the time of writing, the National Research Council recognized that there would need to be significant changes in science education to reach their goals. They emphasized the importance of hands-on learning in addition to a style of teaching that also engages students' minds. The *National Science Education Standards* are not a curriculum but a set of criteria for deciding "whether particular actions will serve the vision of a scientifically literate society" (National Research Council (U.S.), 1996). As a broad guideline, these standards provide little assistance in designing curricula. New York State followed with its own *NYS Learning Standards for Mathematics,* *Science and Technology* (1996). There are only seven standards listed, and at first glance, they are quite vague (Appendix 1). For instance, only one standard (#3) names specific subject skills such as geometry, algebra, data analysis, probability, and trigonometry. Students will "understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science" but what those concepts specifically are is not listed (New York State Department of Education, 1996; Appendix 1, Standard 4). Both of these documents are foundations for curriculum, in the sense that they set benchmark requirements, but they do not specify the specifics of how students then are able to meet those vague goals.

The *Core Curriculum on Physical Setting/Earth Science* comes in many forms and editions, written by multiple authors over its iterations, and includes the accompanying content not mentioned in *NYS Learning Standards*. This document is specifically targeted at the information needed to prepare students for the Regents exam. For teachers, it is a guide for the minimum needs of curriculum, instruction, and assessment required for a student to graduate. It includes multidisciplinary standards (mathematical analysis alongside scientific inquiry) but is still just a scaffold for teachers to then build actual curricula over. The *Core Curriculum* includes some topics and concepts that must be covered in the classroom, but similar to previous standards, it does not specify how that information should be taught (New York State Department of Education, 2001).

The *Framework for Science Education* (2012) and its immediate successor the *Next Generation Science Standards* (NGSS) (2013) are the foundation of the new *NYS P-12 Science Learning Standards* (2016). The NGSS breaks its standards into three components: the Disciplinary Core Idea (DCI) in orange, Science and Engineering Practices in blue, and

Crosscutting Concepts in green (Appendix 2). They separate themselves from prior standards by avoiding setting a bar for what students should know and instead implementing performance expectations that describe what a student should be able to do that demonstrates they understand a concept (The National Research Council, 2013). The NGSS hopes that their standards will not limit curriculum, but rather “provide a foundation for rigorous advanced courses in science or engineering that some students may choose to take” (The National Research Council, 2013, p. 2). These standards cover topics of Physical Science, Life Science, and Earth and Space Science, of which there are three sub-topic units: Earth’s Place in the Universe, Earth’s Systems, and Earth and Human Activity. As of the time of writing, a new Earth Science Regent exam is set to be implemented in June 2025 to be in line with the terms of the *NYS Next Generation Learning Standards for Mathematics and English Language Arts* as well as the *NYS P-12 Science Learning Standards* (Warner, *n.d.*).

Contino and Anderson, in a 2013 study, start to examine the gap between the literature surrounding teaching standards for Earth Science and classroom implementation. There are large disparities between the interpretation of the *National Science Education Standards,* classroom practice, and students’ related achievement on the Earth Science Regent Exam. Teachers interpret standards and incorporate their own teaching needs and requirements into a local curriculum, many without any guidance from districts or administrators (Contino and Anderson, 2013). The core curriculum itself does not weigh any topic by its significance to the Regents Exam. Contino and Anderson (2013) also suggest that better aligning the *Core Curriculum* and the Regents would then see an improvement in testing scores. The success of students could wildly vary based on what topics are given the most attention or simply on what is most engaging at the time. This system leaves a lot of space for students to become disinterested, lost, or unsuccessful in the geosciences.

Diversity in the Geosciences

Diversity in geoscience studies and careers is low and always has been. Out of all the scientific fields, it is the whitest and most male-dominated. In 1995, 3.9% of geoscience degrees were awarded to members of underrepresented groups in STEM, and by 2001, that number was only up to 6.3% of degrees (Huntoon and Lane 2007). This information is reported through the Integrated Postsecondary Education Data System (IPEDS) Completions Survey by Race within a program at the National Center of Education Statistics (NCES). This data set pulls from a variety of institutions, including two and four-year institutions, and is not weighted in any way. The U.S. population has been growing and even though more people are awarded bachelor's, master's, or doctorate degrees, the scientific workforce has not kept up with the same pace of growth. The higher one travels through the education system, to achieve master's and doctorate degrees, the proportionally less diverse the STEM fields become. In terms of gender diversity, there has been some success in recruiting women to the geosciences, especially to the point of getting a bachelor's degree, since the mid-60s (Huntoon and Lane 2007). Bernard and Cooperdock, both women in the geosciences themselves, wrote an updated review of diversity in the geosciences (2018). This study looks at data on geoscientists from the 70s to 2015 as provided by the National Science Foundation's National Center for Science and Engineering Statistics and the Survey of Earned Doctorates (SED). The SED notes specific subfields within the geosciences including Atmospheric Science and Meteorology, Ocean/Marine Sciences, and Geological and Earth Sciences. In recent years, women have started to earn almost the same if not more PhDs than men in geosciences as a whole, but in Ocean Sciences, women have been earning more PhDs since about 2006. While this could mean good things for more female faculty and a continuing trend of balancing out gender diversity, the real problem remains in an obvious lack of racial diversity. Even with a 60% increase in the number of PhDs earned from 1973 to 2016, white non-Hispanic people still make up 85% of all geoscience doctorates (Bernard and Cooperdock, 2018).

Sherman-Morris and McNeal followed these trends to the undergraduate level to see what factors may be influencing current students in their choices to follow their geoscience studies to higher levels of education (2016). Much of their concern was focused on undergraduate students' opinions and perceptions of geosciences majors and careers. For instance, prior studies have shown that African American students perceived geoscience careers as unhelpful to their communities and Hispanic students just were not familiar with geoscience careers. (Whitney et al., 2005). They concluded that prior knowledge of the major and whether that study would then lead to a job post-graduation were relevant factors for students even before they declared a geoscience major. Students also believe that geoscience majors would help the earth but not make a lot of money. "Important influencers, sustained identification with or interest in that major, descriptors of the major" will be just a handful of the many intertwined factors that multiple researchers call on as important factors to the geoscience pipeline (Sherman-Morris and McNeal, 2016, p. 147).

Factors Affecting Geoscience Participation

Many variables influence who even chooses to study geosciences. Carter et al. (2021) looked at the significance of altruistic factors, personal achievement, or work environment on how they chose a major and whether it differs based on gender, minority status, or being first-generation to attend college. Altruistic factors are community goals characterized by a desire to help people, society, or the environment. Personal factors for choosing a career path include "wanting to make a lot of money" or "having prestige" (Carter et al., 2021, p.3). This study found that female study participants, for example, value altruistic factors more than personal achievement factors and prefer working outside versus in an office. Students of all backgrounds rate altruistic values as the most important for their ideal career, but this is not the rhetoric employed to recruit into the geosciences (Carter et al., 2021). Considering there are so many routes post-graduation, with opportunities to work in the field, lab, or anywhere around the world, one might assume that a large variety of people would study geosciences, but that is not the case.

In the theoretical world, a 2007 pipeline model identified key factors at the middle school through graduate school level that could have a significant impact, positive or negative, on a student's choice to pursue a career in geosciences using a critical incident study (Levine et al.). There are classroom factors such as how engaging and effective geoscience instruction is to students, and social factors such as access to mentors, familial factors, the state of the economy, and students' encounters with racism. Students' relationships with their K-12 science teachers and classrooms, their undergraduate experiences, and any prior familiar influences on their major and career choices can vary wildly between white students and their underrepresented counterparts (Sherman-Morris and McNeal, 2016, p. 156). When students are younger, geoscience awareness and science instruction are important indicators, but by college and graduate school, career access and development, as well as the culture of the geosciences become more important. Stokes et al. (2013) elaborate on the list of indicators from Levine et al. (2007). (Appendix 4). Stokes et al. (2013) call to light two geoscience issues; not only is there a lack of diversity in the geosciences, but there is a shortage of geoscientists in the workforce. For women, factors that made students feel like outsiders or pushed away were deterrents. Programs with a lack of female mentors, implicit or cultural discrimination against women, or just unsupportive classroom environments or advisors implicitly dissuade women from further studying or pursuing a career in geoscience fields. As Baber et al. (2010) put it, “When students are able to ‘find themselves’ in the curriculum or academic projects, they are more likely to be open to new learning experiences and modify previously held beliefs and attitudes about geoscience” (p. 32). Looking at the historical state of diversity in geoscience majors and careers, it would be hard for minority students to find a sense of belonging. In practice, finding ways to fill the gaps in the pipeline will look different depending on the community that is unable to participate in the geosciences, as well as what the current standing practices are to get community members involved. In a long-term case study example, The Pathways summer program in El Paso, Texas, as studied by Carrick et al (2016), originally targeted students already interested in studying science but eventually broadened their recruitment to the program to encourage more students in minority groups to get involved that would otherwise not have known about the program. 55% of participants surveyed after Pathways had fallen into the geoscience pipeline (measured as choosing a major within a STEM discipline) and 20% had become geoscience majors. In terms of wider scope effects, 75% of participants said that they would at least take a geology course. While these issues can be approached from numerous angles, studying the content and theory behind the curriculum is one way to address the problems at the root more so than what one extracurricular program could address.

Relevant Education Models and Theories

Larkin's (2022) essay on teaching science poses that the current structure of contemporary schooling "run[s] counter to [the] stated aims of science instruction" (p. 1061). Specifically, in the dream world of science education, there would be equal opportunities for all students to be "robust science learners" but the reality is that clearly some students are at a disadvantage from the start. Larkin (2022) then breaks apart teaching into two categories; there is successful teaching when students learn, versus good teaching, when teaching is in accord "with high standards for subject matter content and methods of practice" (p. 1063). This concept specifically highlights how complex it is to manage all the components needed to become a successful teacher. The essay suggests two essential components to science education for teachers and students: a knowledge of the nature and practices of science and an understanding of sociocultural contexts (Larkin, 2022). The idea that science teachers should understand not only how science works but have an understanding of the scientific knowledge processes and practices does not seem exceptionally difficult, but that might require some prior familiarity with research or the most up-to-date science news, which is not always possible for the average, overworked teacher. Secondly, Larkin suggests that teachers should understand the sociocultural context in which their students live. Again, not an outlandish concept. While a teacher knowing facts about a community is helpful, incorporating that knowledge into a lesson in a way that is relevant to students is a separate task entirely. A research-practice partnership between teachers, curriculum designers, learning scientists, and experts in social justice can then become the foundation for a curriculum incorporating concepts of environmental racism into a middle school science classroom (Bradford et al., 2023). The designed units intended to bridge concepts of racial inequalities with a scientific concept relevant to the middle school students they would be taught to. Two teachers helped design a “standards-aligned science teaching” curriculum to then teach it and provide feedback to the researchers on the challenges they faced in the application of that curriculum (Bradford et al., 2023, p. 1). Incorporating social justice theories into science is no simple feat and, in many cases, can require years of collaboration and feedback between institutions. Students already seem to be aware of social trends of injustice and so it is critical to address them clearly and in ways that give them the agency to address their questions and to be informed enough to act. This specific unit aims to “elicit student observation of the causes and impacts of an environmental hazard” and then to “distinguish who in the community is impacted” and “form connections to explain causes” (Bradford et al., 2023, p. 4). One teacher summarized their goals clearly:

> I don’t expect all of my students to become scientists, but I hope they learn about how to use science, or graphs, or read something to understand why and defend why they should have certain policies and or vote in a certain way. (Bradford et al., 2023, p. 15*)*

Successful, not just good, teaching requires a connection to the practice of science and the people the science is for, not just an understanding of concepts and material. Then the question becomes: what are ways to teach earth science that break away from the current, American structure of education?

As mentioned before, the variety in standards in New York might lead to a variety in classroom curriculum. Added here are some other curriculum models on how to teach Earth Science that are not specific to New York but could be applicable if a teacher, school, or district so desired. A multi-level analysis by Zhang et al. (2023) looked at the efficacy of the citizen science model of education in rural communities. Citizen science is “a longstanding collaboration between scientists and the public, working together to address critical and complex research questions” (Zhang et al., 2023, p. 1326). The model encourages students to be engaged citizens of their community as an essential part of practicing science. Projects will vary widely based on the community citizen science is practiced, but by engaging with all parts of the scientific process, students understand its full scope. This analysis focused on undergraduate students from Amherst College who helped design the pedagogy and then worked alongside current science teachers. Because some collaborative lessons are taught not by classroom teachers but by researchers, it results in the teachers, including the undergraduate students working alongside them, gaining higher self-efficacy with scientific content throughout the process alongside their students (Zhang et al., 2023).

Moving outside the classroom, quite literally, also has measurable benefits for students as well as their teachers. The idea of outdoor education stems from the hope that students can “experience science learning opportunities in authentic settings” (Carrier 2009). In this case, most preservice teachers have not yet had any formal science training, and so incorporating outdoor education into their curriculum improves their familiarity with the subject and therefore their future confidence in teaching it. In terms of student impact, outdoor education tends to allow students to deepen their connection to their learning. Students surveyed after just a three-week course reported that they asked more questions, were less afraid of the outdoors, and generally more aware that it was good for them to be outside in the first place (Ayotte-Beaudet et al., 2023). This study in particular found that once students have a better understanding of their school environment, they then become more interested in protecting the organisms there, but many of the students’ observations were very context-specific and did not expand past the limited scope and scale of this course. While traveling the world to make students want to protect it is not feasible for most classrooms, finding ways to immerse the students into the environment they are surrounded by provides the inertia to perhaps a long-term involvement with environmentalism.

Methodology and Results

This thesis attempted a case study using two surveys: one aimed at current college Earth Science students ("Student Survey"), and one at current Middle/High School Earth Science teachers ("Teacher Survey"). Both surveys were drafted not to collect any personal data that would be shared in the final results, so all diversity data referenced reflects the whole school district and not individual schools. The student survey was sent via email to the Earth Science faculty at eight colleges in New York (Marist, Dutchess Community College, SUNY New Paltz, The City College of New York, Hunter College, Queens College, York College, and Brooklyn College) to then be distributed to their earth science students. Identifying questions include what college the student attends and their major. Questions identified the following criteria: did students attend public or private middle and/or high school in New York State, did students have Earth Science classes before college, when was Earth Science taught (if applicable), what sorts of activities were present in their earth science classes? This survey was intended to gather data modeled after Stokes et al.'s 2015 study and Sherman-Morris and McNeal's 2016 study but to focus specifically on New York State schools and students. The survey only received one response and was deemed unsuccessful and not pursued further.

The Teacher Survey was distributed via email to middle and high school teachers and administrators in ten school districts within Ulster, Dutchess, and Orange counties in the Mid-Hudson Valley region of New York (Appendix 3). The ability to find direct teacher contacts varied by district and school, as well as if they were listed as "teacher," "science teacher," or "earth science teacher," so many teachers were emailed who ultimately did not fit the criteria of the survey. Of the 63 teachers contacted, there were eight responses across six school districts. Meaning only 12% of teachers responded to the survey, and they covered 15% of the school districts in the Mid-Hudson Valley, including three major cities, and grades 8 through 12. No identifying data was collected about the teachers. School district demographics are available through New York State data. While not an exhaustive survey, this was enough to collect preliminary data on the region. The survey used qualitative questioning to identify the grades taught (Figure 1) and qualitative questioning to investigate adherence to teaching standards, activities used in the classroom, and access to classroom resources (Figures 2-7, and Questions 4 - 7). While the lack of responses from the student survey was disappointing, there are already some studies on the influences on undergraduate students' opinions on Earth Science majors and careers (see Carter et al. 2021; Stokes et al., 2015; Sherman-Morris and McNeal, 2016). When addressing diversity in the geosciences, it is important to look at the foundations: what students are being reached in the earliest possible steps of the pipeline and what are their resources in schools?

Table 1: Racial Demographics of Relevant School Districts Included Case Study (NYSED, n.d.-f, n.d.-e, n.d.-d, n.d.-c, n.d.-b, n.d.-a).

School District	Total Students K-12	% White	% Hispanic/ Latino	% Black/African American	Other Notable Minority Groups
Kingston City	5,859	50%	26%	10%	
New Paltz	1,760	72%	15%	4%	5% Multiracial
Poughkeepsie	3,761	5%	41%	46%	8% Multiracial
Red Hook	1,556	81%	13%	2%	
Spackenkill	1,537	53%	17%	13%	12% Asian or Native Hawaiian/ Other Pacific Islander
Wappingers	10,160	64%	22%	7%	

Table 2 - Other Demographic Data about School Districts in Case Study

Graduation Rate averaged from the past four years as of 2023, graduation rates split by gender reflect the percent of students of that gender who graduated (from that one website). District income all from USA.com (*Kingston City School District Income and Careers - USA.Com™*, n.d.; *New Paltz Central School District Income and Careers - USA.Com™*, n.d.; *Poughkeepsie City School District Income and Careers - USA.Com™*, n.d.; *Red Hook Central School District Income and Careers - USA.Com™*, n.d.; *Spackenkill Union Free School District Income and Careers - USA.Com™*, n.d.; *Wappingers Central School District Income and Careers - USA.Com™*, n.d.; NYSED, n.d.).

School District	**High School Graduation Rate***	**District's Per Capita Income**
Kingston City	79% (75% Male, 82% Female)	28,092 USD
New Paltz	92% (92% Male, 93% Female)	32,049 USD
Poughkeepsie	54% (47% Male, 60% Female)	23,923 USD
Red Hook	87% (88% Male, 86% Female)	33,777 USD
Spackenkill	95% (95% Male, 94% Female)	41,031 USD
Wappingers	92% (90% Male, 95% Female)	36,568 USD
New York State	86% (84% Male, 89% Female)	32,829 USD

Teacher Survey Results

The following are the individual questions included in the Teacher Survey and their responses. The survey includes 10 total questions, seven of which are included here. The other three were for internal sorting.

Figure 1 - Bar chart answering Question 1: “What grade(s) do you teach?” Teachers were allowed to check multiple answers if they covered more than one grade.

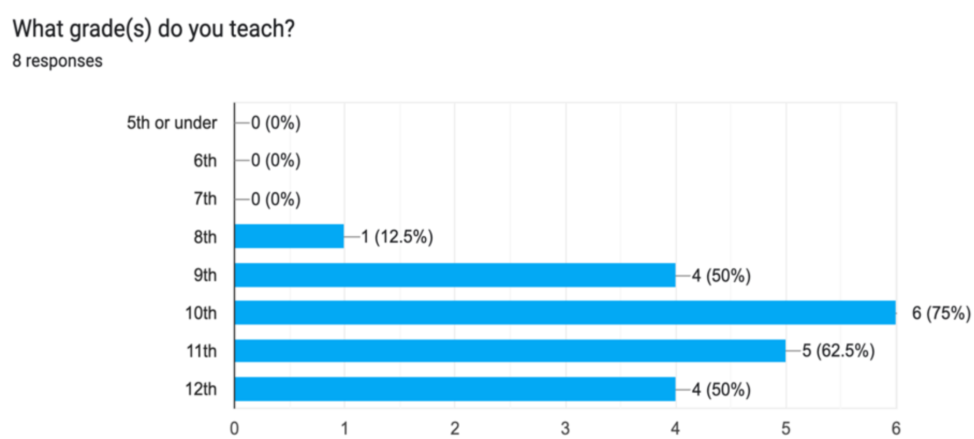
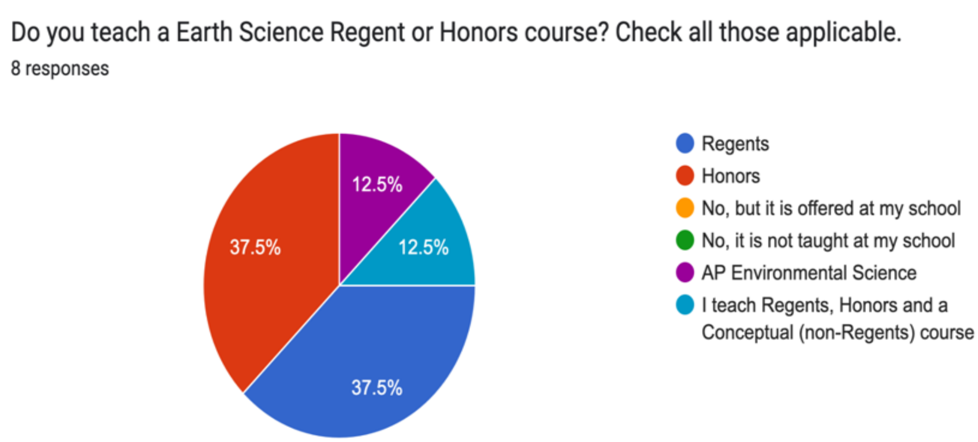
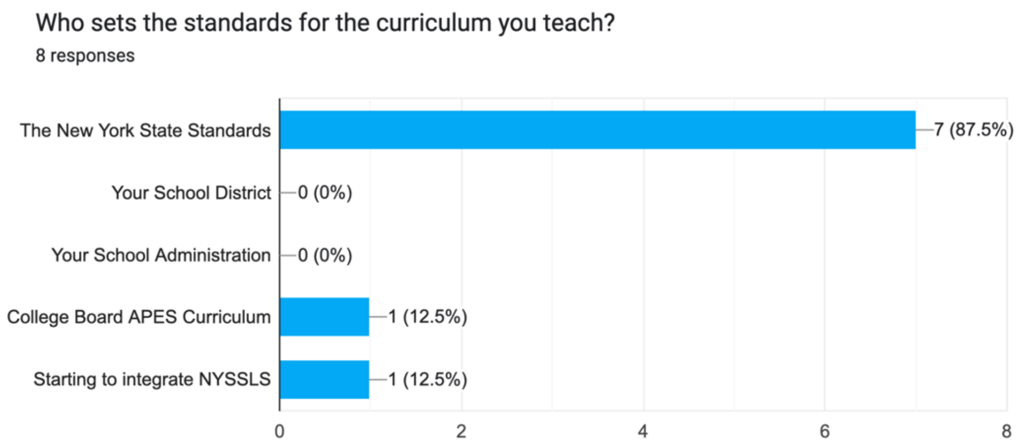


Figure 2 - Pie chart answering what kinds of Earth Science classes are taught by surveyed teachers. Covers Question 2a: “Do you teach an Earth Science Regent or Honors course?”



This question was then clarified by a follow-up question (2b): What is/are the name(s) of the Earth Science or similar course(s) you teach? The course titles included in teacher responses were Honors Regents, Honors Earth Science, Regents Earth Science, Astronomy, AP Environmental Science, Meteorology, Earth Science Regents: Integrated / Ecology

Figure 3 - Bar chart answering Question 3: “Who sets the standards for the curriculum you teach?” While only 8 teachers responded, there was the option to check more than one box if applicable, which then accounts for the 9 total answers.



The following questions did not have relevant graphs but are listed here.

Question 4: Rate how closely you adhere to the New York State Earth Science Standards.

The teacher’s responses varied. Three out of eight teachers said they often adhere to the standards, and the other 5 out of 8 said they always adhere to their respective standards.

Question 5a: Do you utilize any hands-on activities, such as lab work, field trips, fieldwork, or building models, as a part of your teaching? 5b: If yes, what kind?

All the teachers said yes, they used some form of hands-on activity in their classroom. Their answers range from lab work (mentioned in 100% of responses), and modeling (mentioned in 7 out of 8 responses). Other, more specific answers included “stream table labs, deposition tubes, porosity/permeability tubes, rock and mineral labs, building 3d topo maps, and earthquake shake table structures”. Only two teachers mentioned fieldwork.

Question 6: Do you use any prepared kits? Are they bought from a company, made by the school, made by an individual teacher, or something else?

Many teachers (7 of 8) discussed using kits made themselves or by other teachers, while only 4 mentioned using prepared kids (and three of them discussed modifying the kits for their individual classroom needs).

Question 7: Is there anything you teach that is not a part of the above-prescribed standard? What, and why do you include it in your curriculum?

The resounding answer is no, there is no time (mentioned in 5 out of 7 responses). For the other two, the teachers try to dig in deeper when students have questions, but again, struggle with time. One teacher uses a long-term gardening project after the completion of the AP Environmental Studies exam.

Discussion

For the sake of this thesis, there are three, highly connected, questions to address. Who goes into the geosciences, as students and/or into their careers? Why? How does the way we teach ESCI engagement in the geosciences? What the learning standards neglect, but many researchers call to light, is the lack of gender and racial diversity in geoscience careers. If prior opinion and exposure to careers and programs are significant factors in a student’s own major decision, then there are ways to ensure all students have the opportunity to feel excited about geosciences before they even get to college.

What the Teacher Survey highlights is a resource/access issue; teachers only have so much time and available supplies to make their curriculum work. 70% of the surveyed teachers explicitly state that most of their class time is spent preparing for examinations and there is little time to go outside that plan (Question 7). All the teachers report that they adhere to whatever standards they are expected to follow, and therefore prioritize meeting testing standards. Out of all the teachers surveyed, the only ones who mentioned adding more to their curriculum could only include it once the AP Environmental Science Exam was completed because the rest of the year had been spent preparing for that exam (Question 7). Current testing practices in many states leave out Earth Science concepts. If other science test content takes up most of the year, there is likely no time for new, Earth Science material to be included. On the other hand, an easy way to get more high school students to learn about Earth Science could be implementing consistent standards or the development of an Advanced Placement (AP) Earth Science course (The Geological Society of America, 2021). Adding more curriculum onto the plates of overworked teachers is not a pretty solution. If Earth Science were always a distinct class, like Biology or Chemistry, with a correlating AP exam, it would have enough priority for schools to dedicate time to teaching it. Instead of worrying that they have wasted time on an irrelevant class, their Earth Science course could help them earn college credits, or other merits, just as any other Advanced Placement course would. There are ways to engage students and ensure they are learning the content necessary to succeed throughout their educational careers. Freeing up teacher time would allow for more flexibility in their curriculum. If their whole year is spent on test preparation, without adding more hours to the school day, achieving that goal would require deemphasizing the importance of end-of-year testing like the Regents.

For the few surveyed teachers who able to expand upon their curriculum, they reported doing so when their students were curious. For instance, the Pathways program in El Paso relies heavily on its access to geological sites and trips off campus. Because it is not limited to rigid high school classroom structure and time constraints, fieldwork can be incorporated into the curriculum (Carrick et al., 2016). After their program, 68% of participants said they would consider becoming a scientist, and an additional 24% said that they were now interested in becoming geoscientists. Carrick et al. emphasized the importance of a summer program in attracting underrepresented minority students. Ayotte-Beaudet et al. suggest that outdoor learning could help some students deepen their learning, which would be particularly applicable if a school has easy access to outdoor space that displays key geologic concepts (e.g. a rock outcrop to talk about deposition, a particular land feature, etc.). While reforming curriculum is a lengthy and difficult task, integrating concepts of social justice into science disciplines synthesizes the two in such a way that students can understand the implications science has for their communities (Bradford et al. 2023). Working towards designing new curricula that integrate prior standards and relevant community needs creates a bridge between science and the students.

Conclusions

If the geosciences remain as homogenous as they currently are, the field is at risk of stagnation. The Earth is a concern for every human on it, so why do the people studying it reflect only a small part of all people? A small, homogenous group of scientists focused on a field that affects the entire planet could limit the full scope of benefits of their studies. Teachers are already stretched thin trying to teach the minimum required content, so how is it reasonable to ask them to include additional information and work on new projects on top of their workload?

Flexibility in curriculum and deemphasizing the standards teachers must follow allows for teachers to adjust their curriculum to accommodate new concepts into their practice.

Future Work

When continuing this type of work, the use of better surveying practices to collect more thorough data would be the top priority. Case studies proved to be the most helpful when studying the implementations of certain curricula or practices to keep students engaged with Earth Science. Since there is such a large gap between the standards and their in-classroom applications, understanding the student and teacher perspective is essential in understanding the realities of Earth Science in the classroom.

Special Thanks to the Hudson Valley science teachers for their feedback and comments on their survey; Dr. Laura Haynes and Rev. Dr. Leonisa Ardizzone for their contributions and support; and Celeste Brinkhuis for her editing and support.

Appendices

1. NYS Learning Standards for Mathematics, Science, and Technology

    Standard 1: Students will use mathematics analysis, scientific inquiry, and engineering design, as appropriate, to post questions, seek answers, and development solutions.

    Standard 2: Students will access, generate, process, and transfer information using appropriate technologies.

    Standard 3: Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.

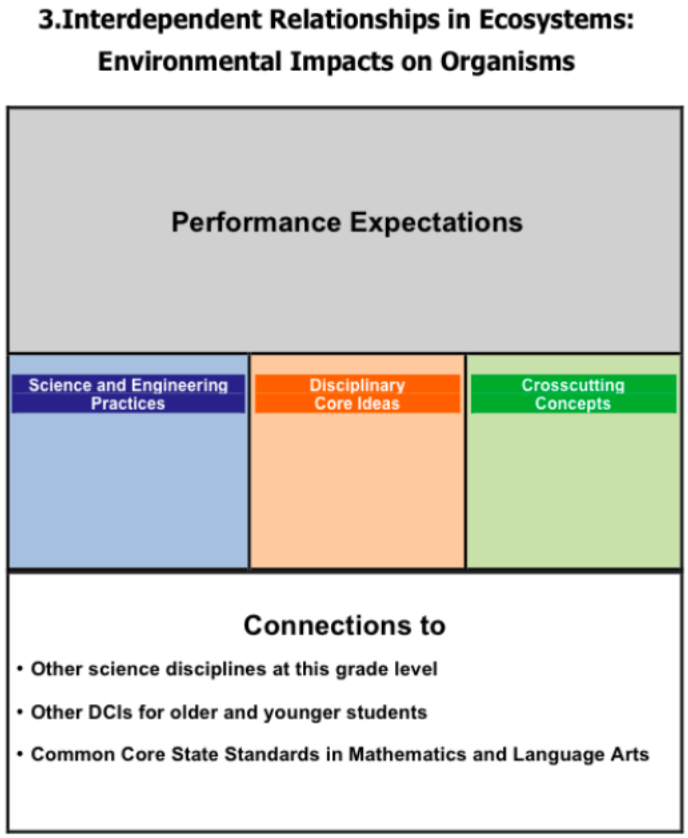
    Standard 4: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

    Standard 5: Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

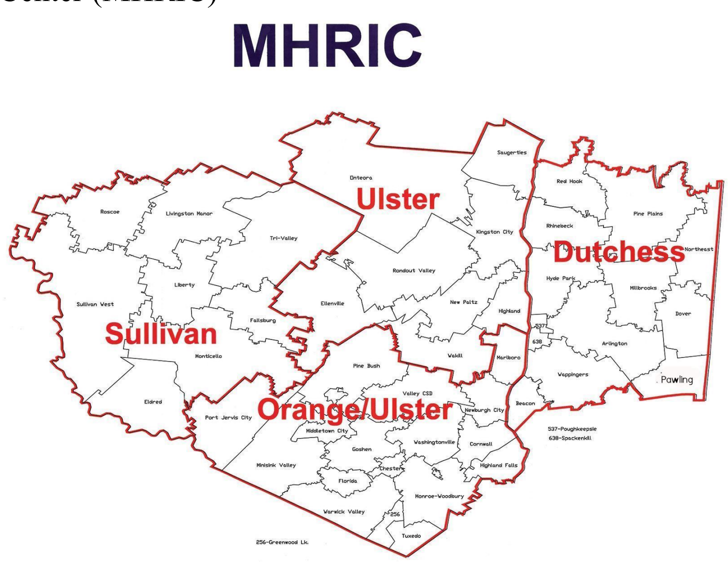
    Standard 6: Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

    Standard 7: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

2. Template of the Next Generation Science Standards formatting (The National Research Council, 2013)



3. Map of School Districts in the Mid-Hudson Region from the Mid-Hudson Regional Information Center (MHRIC)



4. Stokes et al (2017) – "FIGURE 2: The critical incident classification as developed for this study. Subcategories are ranked by number of reported incidents. Bold text represents groups previously identified by Levine et al. (2007); an asterisk represents a previous category that has been modified. Text in italics represents new categories identified by this study."

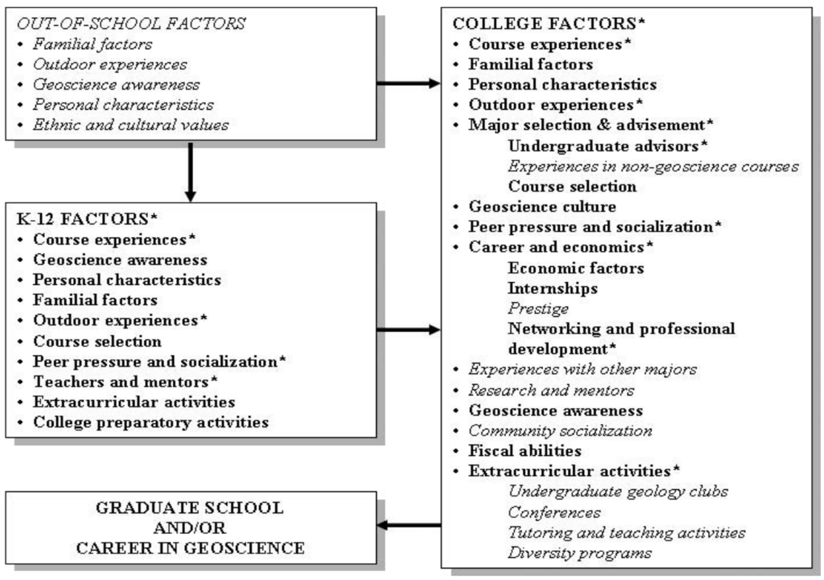


FIGURE 2: The critical incident classification as developed for this study. Subcategories are ranked by number of reported incidents. Bold text represents groups previously identified by Levine et al. (2007); an asterisk represents a previous category that has been modified. Text in italics represents new categories identified by this study.

5. Carrick et al. (2016) - Table 1: List of typical program activities and projects

	Activities and Projects
Day 1: *El Paso geology* (on and off campus)	Observation skills
	Analog modeling
	Hike along Transmountain Road in El Paso
	Analog building of the Franklin Mountains
Day 2: *Search for the pipe* (off campus)	Measuring conductivity
	Measuring resistivity
	Measuring gravity
	Using GPR
Day 3: *Mount Cristo Rey, fossils* (off campus)	Day trip Mount Cristo Rey, NM
	Dinosaur footprints
	Structures, faults, folds, and laccolith contact
	Fossil collecting
Day 4: *Local water treatment* (off campus)	Visit to local waste water treatment plant
	Visit to local desalinization plant
Day 5: *Geophysics* (on campus)	Introduction to geophysics, seismic waves, and earthquakes
	Convection cells and viscosity
	Looking at the ocean floor
	"Journey to the Center of the Earth"
Day 6: *Seismic refraction* (on and off campus)	Field trip for seismic refraction experiment to look for the water table
	Laying the geophones for the experiment
	Collecting data from the geophones
	Data analysis
Day 7: *Volcanoes* (on campus)	Volcanoes discussion
	Mentos eruption experiment
	Viscosity, lava
	Monitoring a volcano experiment
Day 8: *Plate tectonics* (on campus)	Earth's structure
	Mapping earthquakes
	Plate tectonic maps
	Edible plates with Oreos
	Tsunamis
Day 9: *CSI: UTEP* (on campus)	Geology circus
	Density
	Forensics and structure
	Topographic profiles
Day 10: *Wrap up day* (on campus)	Careers for Geoscientists, video and discussion
	UTEP college recruitment, financial aid
	Swimming pool fun

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