TRACKING DISPARITIES: HOW SCHOOLS MAKE UP SCIENTIFIC AMERICANS AND PATHOLOGIZED OTHERS

By

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To Mom and Dad, for your limitless love, faith, and wisdom

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ABSTRACT

This dissertation examines current science education reforms by asking how it became historically possible to classify students, diagnose their differences, and prescribe distinct pedagogies in the name of inclusion. Through historicizing present pedagogical practices, the study explores how science education carries assumptions of human difference that undermine commitments to equality and justice.

The study makes visible a paradox in pedagogies offered to empower marginalized groups by analyzing the ordering strategies that divide students as requiring distinct tiers of instruction. Juxtaposing historical analyses of research and policy with a two-year ethnographic study of high school teachers confronting racial disparities in tracked science courses, the dissertation traces shifting grids of classificatory practices in the 1920s and 2010s that direct teachers to see and sort difference in particular ways. Despite key shifts, tools to classify learners today retain norms that pathologize some people as less “scientific” than others. These tools make tracking appear like a natural response to pre-existing conditions (e.g., achievement gaps, differing interests, health disparities), obscuring how those distinctions were produced. The analysis underscores the danger in seeking to include underrepresented groups today without considering the ways in which these methods resemble strategies to improve the minds, attitudes, and hygiene of immigrant and colonized groups a century ago.

The study rethinks the traditional conception that U.S. science education has only recently discovered diversity and has become progressively more inclusive since. An attention to the historicity of science pedagogy suggests that core debates within the field today—such as perceived tensions between scientific rigor and cultural relevance, or competing visions of preparing novice scientists versus future citizens—emerged in opposition to hopes and fears of

Americanizing a racialized Other. Finally, the study raises implications for educational research, policy, and teacher education, particularly the importance of understanding how difference is ordered through the very techniques by which teachers are recognized as having professional knowledge of students and their “diverse needs.”

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Chapter 1. A Paradox of Diversity and Exclusion

> Widespread science and technological literacy will be critical to the economic well-being of the nation and the personal well-being of its citizens in the 21st century. Persistent science achievement gaps, however, imply that non-mainstream students will be increasingly disadvantaged in both job markets and civic decision-making.
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> —*Diversity and Equity in Science Education* (O. Lee & Buxton, 2010, p. 10)

> [W]ithout the right skills, people will languish on the margins of society, technological progress will not translate into economic growth, and countries will not be able to compete in the global economy. It is simply not possible to develop inclusive policies and engage with all citizens if a lack of proficiency in basic skills prevents people from fully participating in society.
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> —*PISA 2015 Results: Excellence and Equity in Education* (Organization for Economic Cooperation and Development [OECD], 2016, p. 6)

> But could we not invert the terms of the problem by asking if it is not precisely the desire to abolish the distance that creates it?
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> —Jacques Rancière (2009, p. 12)

This study explores questions of educational equity, diversity, and inclusion by examining a paradox. The paradox is that the tools we use to talk about who needs to be included—and how—inadvertently produce new exclusions. Educational research and policy have long classified people as different types of learners, diagnosed what makes each category different, and prescribed how those in certain categories must change. In science education, those marked as “non-mainstream” or “on the margins” have been asked to change themselves in particular ways to be recognized as having the knowledge and skills to qualify them for inclusion in science or in society. This begs the question: How has science education contributed to the making and unmaking of citizenship—in ways that have rendered the category self-evident for some, but conditional, precarious, or unattainable for others?

Citizen is an ambivalent term in science education. On the one hand, it is treated as a universal—a synonym for person. This universalized sense of citizen appears in arguments that science literacy is necessary for "all young people" to become "better citizens" (OECD, 2016, p. 263). On the other hand, science education research also contrasts citizen with the category of scientist. That is, "the term 'citizenship' is used to capture the scope of activities of the non scientific public (that part of the populace not possessing professional expertise in the sciences)" (Rudolph & Horibe, 2016, p. 807). In this sense, a citizen is a layperson, defined by what one is not—an expert whose claims wield the cultural authority of science (see Gieryn, 1999).

Science education research and policy tend to emphasize practical teaching strategies. Studies and frameworks propose specific visions for how teachers can foster:

- scientifically literate citizens,
- informed citizens,
- responsible citizens,
- healthy citizens,
- STEM-engaged citizens, and
- empowered citizens.

These are not synonyms, and the meaning of each is a matter of dispute.[1] Yet the crucial thing to note is that we are not just talking about science anymore. There is no natural science theory or

[1] For recent debates over the meaning of science literacy, see Roth and Calabrese Barton (2004), Feinstein (2011), Linder et al. (2011), and National Academies of Sciences, Engineering, and Medicine [NASEM] (2016). The term "informed citizen" appears in literature on teaching socioscientific issues (e.g., Kolstø, 2001) and in recent PISA Science reports (e.g., OECD, 2016). A focus on responsible citizens appears in literature on environmental

law that dictates what counts as a worthy citizen. Citizen is a political category, and not just in the sense of legal status as in the Deferred Action for Childhood Arrivals (DACA) program. Scholars and activists have documented the gradations of social and cultural citizenship that buffet people's daily lives (see e.g., Davis, 2012). Thinking of Claudia Rankine's (2014) book *Citizen*, hurricane Katrina—and more recently, hurricane Maria—exposed the degree of second-class citizenship experienced by racialized and colonized peoples, where some bodies are treated as less entitled to rights of state protection, freedom, and life. Citizenship can be made and unmade through divides between deserving and undeserving refugees (e.g., Sanya, Desai, Callier, & McCarthy, 2017), or between those seen as real Americans versus as perpetual foreigners in their own country (e.g., S. Lee, Wong, & Alvarez, 2008). Citizen, then, is not a universal or fully inclusive category.

Certainly, U.S. schools operate within this broader set of political conditions, but what does this mean for science education in particular? If I return to the bulleted aims of science education listed above, three things can be observed. The first is that these classifications are moral criteria and social judgments. The qualifying terms (e.g., informed, responsible, STEM-engaged) establish proper modes of how to think and feel, how to manage one's daily life, how to engage with others, and how to be recognized as a good and reasonable person. These are questions that cannot be settled by consulting a geophysicist or a molecular biologist.

The second thing to notice is that types of citizens are not born, but made (Popkewitz, 2008). The bulleted terms are stated educational objectives precisely because it is assumed that: a) not all students already possess these qualities, and b) left strictly in the hands of their

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education (e.g., Rickinson, 2001) and social justice science education (e.g., Dimick, 2012). The U.S. Next Generation Science Standards (NGSS) emphasize the need to foster STEM-engaged citizens (NGSS Lead States, 2013a). Emphasis on fostering empowered citizens appears in movements promoting ecojustice and citizen science toward a more sustainable and democratic society (e.g., Gray, Colucci-Gray, & Camino, 2009; Mueller & Tippins, 2015; Tan & Calabrese Barton, 2012).

caregivers, not all children will develop these qualities on their own. Hence, the school, the science teacher, and the educational researcher have been charged with intervening to make sure that the personal qualities designated as "science" get developed in "all Americans" (e.g., AAAS, 1990).[2]

The third thing to notice is that those qualifiers are comparative. Recognizing who is scientifically literate relies on imagining others as scientifically illiterate (e.g., Prewitt, 1983)—even if the latter phrase is rarely used today. The effect of these qualifiers, regardless of intention, is to erect borders. The borders divide those presumed to already have these qualities (e.g., from their upbringing), from those cast as not (or at least, not yet) informed, responsible, engaged, or empowered.

In one sense, these observations seem too obvious to be stated. Of course, schools are preparing future members of society—a task that requires setting goals for what citizens should know and be able to do. Yet, in another sense, they introduce questions of moral judgment and power relations that do not sit well in the field of science education. The idea that science education carries societal norms and values runs counter to traditional notions of science as universal and value-free. The idea that science pedagogy imposes cultural norms onto students and their families runs counter to stated commitments to cultural pluralism. And the demarcation of worthy versus unworthy citizens, coupled with the demand that the latter conform to certain standards of thought and behavior, might seem to go against national ideals of egalitarianism and liberty.

[2] The notion that it is the school's responsibility to identify and remediate those not yet prepared for society is a historical phenomenon. Only at the turn of the twentieth century did European and North American schooling become charged as a primary institution for solving societal problems—what Tröhler (2013) has called the educationalization of society.

It can be disconcerting to consider where educational objectives come from, and the sociopolitical work that they do. It is easier to treat an objective like "healthy citizens" as a natural ideal or a humanitarian good.[3] Given recent demands for actionable research insights (e.g., Institute for the Educational Sciences, 2017; see C. Kirchgasler, 2017b), there is a push to skip over what appear to be merely philosophical questions of "what counts as informed or responsible," and move straight to the pragmatism of how to enhance those qualities in students. Yet, one could argue, Pragmatism is itself a philosophy, and the move to dismiss theoretical debates in favor of expert-directed action embodies a particular theory of social change with its own limits and dangers (see Popkewitz, Diaz, & C. Kirchgasler, 2016).

Historically speaking, it should come as no surprise that school science operates as a space for making and unmaking citizens. Why do we have public schools? In the early 1900s, the nation was not a sure thing (B. Anderson, 2016). The roles of university scientists, school professionals, and state officials became intertwined in setting and monitoring norms of proper behavior. The social sciences, especially psychology, sociology, and pedagogy, achieved their professional status in part by demonstrating the utility of applying scientific methods to manage society and prevent what was perceived as the moral disorder of an expanding, urbanizing population (Danziger, 1997; Rose, 1985). The rise of compulsory schooling was to produce and regulate healthy, responsible citizens. This was articulated at the time as saving the masses, Americanizing immigrant groups, and civilizing colonized peoples, while still granting higher training to a select few (e.g., Addams, 1908; Counts, 1925; Dewey, 1916).

Even today, it is clear that schools are in the business of changing people. Students are not expected to leave their K-12 schooling exactly the same as how they entered (Popkewitz,

[3] Ticktin (2017) argues that medical humanitarianism, since at least the 1970s, operates within a moral economy of innocence by invoking the innocent victim who is positioned as ignorant, poor, and marginalized, and the innocent humanitarian who is positioned as affluent, educated, and morally absolved (see chapter 8).

2008). We expect them to learn—whether learning is framed as knowledge, practices, identities, or consciousness. Schooling, in that sense, is about making children into particular “kinds” of people (Hacking, 2007). There is a danger, however, when learning is treated as a science, because the way people are expected to change and develop appears incontestable. This danger is especially acute in science education, where norms and values are often treated as objective standards of science that students must follow for their own health and safety or for the sake of public health and the economic well-being of the nation.

Teaching Science, Making a Difference

A common sense in science education today is the responsibility of the science teacher to make a difference in the lives of students—especially those from marginalized groups. After the passage of the No Child Left Behind legislation in 2001, the emphasis on “closing achievement gaps” became even more ubiquitous, particularly in schools serving demographic groups designated as underperforming. I think about this based on my own experience working in a no-excuses style charter school.

As a first-year teacher in 2007, I saw science teaching as a crucial avenue to make a difference in society. In college, I had been given the chance to sit down with the then Secretary of Education, Rod Paige, who argued that closing the black-white achievement gap was the civil rights issue of our generation. I only applied to teach at schools where this was the driving purpose and ended up at a charter school in East Boston. One of our goals as a school was to make our students’ scores equal to, or even outstrip, those of students in the city’s wealthier, whiter suburbs. When we ended up scoring as one of the highest-performing schools in the state, the school’s CEO described us as a magic factory, taking the scores as evidence that the achievement gap had been closed and equity achieved.

Looking back, my initial pedagogy rested on the premise that my students—by virtue of their classification as low-income, students of color, and English learners—were "at risk" of underperforming (see K. Brown, 2016). Data-driven routines organized my daily work, dictating a clear order of operations: first, fill gaps in "basic skills."[4] Only then could we afford the luxury of investigating scientific questions or socioscientific issues that exceeded the test's mandate. The aim was to promote social equality by producing equity on particular metrics as a proxy for long-term success. The school's mission statement talked about helping our students become problem solvers who could engage productively in their communities; achievement gaps, within the logic of contemporary education reforms, served as indicators that the students (and their families and communities) were not yet equipped with those skills of problem solving and productive civic engagement.[5]

Several years later, I entered graduate school for education, where I had the opportunity to join a research project on a school district undergoing data-driven reforms.[6] My role was to shadow all of the science teachers at Alderwood High School (AHS, a pseudonym) for two years.[7] While this mid-sized public district in the Midwest differed in many ways from the small charter school where I had taught in the Northeast, I was struck by a similar logic—that becoming data-driven could reveal and remediate the needs of distinct kinds of learners. That logic, however, took on different institutional forms.

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[4] To close the gaps, I was to engage in backward planning of the curriculum by itemizing all the vocabulary terms and facts that had appeared on the state science test over the past few years. See Delpit's (2012) discussion on how what constitutes "basic skills" in U.S. schooling embodies certain cultural norms and linguistic conventions. Those children who do not come to kindergarten already displaying these particular norms and conventions tend to be erroneously judged as far behind in knowledge and skills, as intellectually inferior, and as incapable of engaging in what is given as "higher-order thinking" until these so-called basics are mastered.

[5] See R. Gutiérrez (2008) and Ladson-Billings (2006) for critical analyses of the achievement gap discourse and its racializing effects.

[6] *Evidence for the Middle and High School Science Classrooms*; Melissa Braaten, Principal Investigator. Funded by the Spencer Foundation and the University of Wisconsin-Madison Department of Curriculum & Instruction. For findings from the larger study, see Braaten, K. Kirchgasler, Bradford, and Barocas (2015); Braaten, Bradford, K. Kirchgasler, and Barocas (2017); and Braaten, Bradford, Barocas, and K. Kirchgasler (2018).

[7] All proper names of people and places related to "Alderwood High School" are pseudonyms.

Whereas my entire school had targeted the perceived needs of low-income students of color, this district—whose demographics were given as one-third white, one-third African American, and one-third Hispanic—was focused on how to differentiate instructional programming for the distinct needs attributed to various subgroups (see appendix B). AHS was organized in the mold of a comprehensive high school: the 1950s vision of bringing all America under the roof of one high school (e.g., Conant, 1957). In the Sputnik era, this sense of unity (under one roof) was coupled with the insistence that some had more talent than others, and that national security depended on schools responding to differences in students' capabilities, interests, and future destinations by offering distinct curricular tracks.

When I arrived at AHS in 2013, the school continued to offer a labyrinth of science course pathways. Coming from fifth grade, where everyone takes the same science class, I was initially surprised to see the curriculum guide's map of sixteen different science courses, dividing students into Regular versus Honors Biology, then three or four levels of Physics and Chemistry, followed by advanced electives (see appendix C). Those classified as "ESL students" (English as a second language) would usually begin off that map: first taking ESL Science Fundamentals, Biology, and Health, and then entering the science map through a lower-level course like Physical Science or General Chemistry (Interview SF, 2014). Although every student at AHS had to take two science credits to graduate, four (and not just any four) were needed to successfully apply to college (Interview DH, 2015).

Maybe the map should not have come as a surprise. The high school I had attended as a teenager had a similar system of remedial, regular, honors, and advanced placement courses. Yet as a student, I had taken a single pathway through the high school, making it hard to register the range of curricula offered to students in the same school building (see Oakes, 1985/2005). My position as an embedded researcher afforded the chance to observe all sixteen courses, debrief with teachers, and join science teachers for departmental and school-wide meetings. What I found most striking was that those meetings included heated debates over the course map itself.

It turned out that the U.S. Department of Education's Office of Civil Rights was investigating whether the district was discriminating against African American and Hispanic students given their underrepresentation in advanced and honors courses.[8] Racial disparities in tracked coursework had plagued the district for decades—especially in science. At AHS, scrutiny centered on the Physical Science course, described as a "dumping ground" for high-needs students (Meeting fieldnotes, 2013). As one administrator put it, the course predominantly served "the combination of African American special ed males" (Meeting fieldnotes, 2013). Most concerning to teachers was that Physical Science was officially deemed so low that it did not count as a science class if those students tried to apply to college. All agreed that this was a problem, but the solution was unclear. Some teachers proposed an algorithm to determine which students had been misplaced in Physical Science but were in fact ready for General Physics (see chapter 3). Others insisted that the very existence of Physical Science was unjust.

The teachers' shared concern—low-level science courses disproportionately serving students of color—is by no means unique to AHS. By the 1980s, curriculum tracking had become widely identified as a civil rights concern in the United States (e.g., Oakes, 1985/2005; Tate, 2001). Ever since, a large body of scholarship has documented how tracking contributes to *de facto* racial and socioeconomic segregation, fundamentally unequal opportunities, and long-term consequences for students' educational attainment (e.g., Lucas, 1999; Oakes, 1985/2005). Of recent concern is why—despite robust evidence that tracking creates inequities—this practice

[8] Starting in June of 2017, the U.S. Department of Education began scaling back investigations into civil rights violations in the nation's public schools (Green, 2017).

persists in high schools across the nation (A. Lewis & Diamond, 2015; Tyson, 2011). Some studies have focused on the teacher as a site of ideological resistance to detracking (e.g., Oakes, Wells, Jones, & Datnow, 1997), and thus as the target of intervention. Others suggest that, even when a school chooses to detrack math and science classes, teachers may assume that there is an inherent mismatch between certain populations of students and the rigor of quantitative abstractions—what Horn (2007) terms the Mismatch Problem.

The notion of a mismatch was also invoked at AHS. In one department meeting, teachers proposed eliminating Physical Science and sending those students up to General Physics instead. Another teacher (for the moment, I will call him Mr. D) voiced opposition to this proposal. “The whole point of having Physical Science in the first place,” Mr. D explained, “was it would give those kids a chance to mature” (Meeting fieldnotes, 2013). Within one prevailing research paradigm, this statement might be interpreted as Mr. D expressing his own biases, or deficit thinking, since his broader argument posited a mismatch between the mostly African American students in Physical Science and the maturity presumed necessary for Physics. Yet, as I began studying the history of tracking, it became clear that the reasoning I had first attributed to Mr. D had a longer legacy and a wider circulation.

The notion that science teachers must distinguish the relative “maturity” of their students is at least a century old. Consider this quote from one of the earliest U.S. journals of science education research in 1916: “The General Science course, adapted as it is to immature minds, has met with nation-wide approval.”[9] At the time, U.S. high schools were rapidly expanding. Science educators began to articulate a mismatch, describing the existing physics and chemistry courses as “ill-adapted” for the “immature” minds entering high school for the first time (Woodhull,

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[9] The statement appears in an advertisement for a general science textbook (Caldwell & Eikenberry, 1914) in the opening issue of *General Science Quarterly* (1916, p. 63). See Rudolph’s (2005b) analysis of the advertisement in relation to the history of the U.S. general science movement.

1918, pp. 18, 48). The proposed solution was to create a new course called general science, which would move at a slower pace, focus on applied science, and avoid the pure physics that was presumed beyond the capacity of "girls" and so-called "inferior racial stocks," such as Polish, Irish, and Italian immigrants (e.g., Grier, 1920). Certainly, much has changed over the past century. Yet there is a disconcerting similarity in the premise that some groups of students need more time to mature, and therefore require a slower-paced, lower level of science instruction.

Over the course of the study, I became convinced of the need for a longer historical lens to understand what is happening today. For two years, I spent most weekday mornings and afternoons at AHS. There, I heard debates unfold over what should be done to support the "Physical Science kids"—what they were cognitively ready for, whether they had enough interest to take physics, and how to address their immediate needs. In the evenings, I read digitized copies of science education journals, where John Dewey and colleagues were debating what should be done to support the "urban masses"—what they were mentally ready for, whether they had enough innate interest in science, and how to meet their urgent needs for Americanization. The parallels were jarring. Century-old classifications rang a bell with the present, but their tone was off-key. Today, it is in the name of equity and diversity that teachers are taught to notice differences in their students' readiness, interests, and needs, and to differentiate instruction accordingly. What would it mean if similar classifications were designed to bring the country's "unassimilated material into at least as close harmony with the original stock of the nation as it is possible to do" (Hunter, 1922, p. 526)?

My study's original ethnographic design had oriented me to pursue members' meanings (see appendix G). This could mean interpreting Mr. D's intentions, and asking how his reasoning was shaped by the culture of his department and school. What this methodology left unexamined, however, was how it became possible to classify students by relative maturity in the first place. Put another way, prior research has sought to account for the principles and practices of individual people in the present. Rarely has it tried to account for those of past actors embodied in historical artifacts—like the taxonomic techniques that invisibly orchestrate school science today.[10]

Persistent Dilemmas

> The mindset you're really trying to break is that everyone is trying to decode right away: Which [science course] is the hard one? Which one is the easy one? Which one is for the smart kids? Which one is for the special ed kids? . . . And boom, it was over. . . . All the AP kids are over here, and all of the Black kids are over there.
>
> —AHS science educator (Interview TN, 2015)

> A large number of students are ending up in courses that are not at the right level for them. We're trying to find a screening tool to find students that were obviously misplaced. . . . [Removing prerequisites] was a disservice for minority students—that in the name of more access, it's more likely that they're going to fail.
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> —AHS science educator (Interview MS, 2015)

During my two years at Alderwood High School (AHS), science teachers were wrestling with dilemmas of equity and diversity. One perplexity stood out. Why, despite many changes in their daily work (not least the intensifying influx of data-driven reforms), did science course

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[10] Philosopher of science Bruno Latour (1994) gives an example of how the intentions of human actors are delegated into the speed bump, which in French and British English may be called a "sleeping policeman." As explored later in this chapter, this historical process of "blackboxing" makes the "joint production of actors and artifacts entirely opaque" (p. 36).

levels remained so racially segregated?[11] The first epigraph poses a problem. Had prior attempts at detracking failed, because they had failed to disrupt the mindset of ranking students by intelligence and by race? The second epigraph proposes a solution. If unconscious bias was to blame, could they design a colorblind algorithm using test scores to predict which students, regardless of race, could handle the higher-level course? Prior studies of tracking and data use have explained inequity by focusing on the psychology of the individual teacher. The tendency is to attribute quotes like the epigraphs above to teachers' ideological conceptions (e.g., Oakes et al., 1997) or mental models (e.g. Bertrand & Marsh, 2015). But what if instead we asked: How did it become possible to reason about difference in these ways?

While the quotes above were given voice by individual teachers, the categories they invoke, the problems they raise, and the solutions they propose are not peculiar to AHS. The U.S. Next Generation Science Standards (NGSS), released in 2013, also identify student diversity as a pedagogical problem demanding scientific solutions. Citing persistent achievement gaps, the NGSS propose that instructional shifts are needed to "meet the learning needs of the nation's increasingly diverse population" (NGSS Lead States, 2013a, p. 388). The NGSS offers an appendix on equity and diversity, along with seven case studies with effective strategies for making science accessible and relevant to demographic subgroups. Like the desire for an objective screening tool (see second epigraph, above), the NGSS seek a technical solution to inequity through the use of disaggregated data and targeted interventions.

The NGSS' hope of using science to better address student differences is not new. In the first decades of the twentieth century, the issue of different types of students had already been formulated as a problem. The rapid growth of U.S. high schools coincided with industrialization,

[11] A few years prior, the district had forbidden the use of prerequisites and teacher signatures to restrict students' access to higher-level courses (see chapter 3). Other high schools in the district had tried detracking their science courses, offering different kinds of chemistry rather than higher versus lower levels (Interview TN, 2015).

urbanization, and immigration from southern and eastern Europe. Around this time, the social sciences became professionalized and societal problems were increasingly attributed to alleged populational differences (Ross, 1991). Because societal problems were ascribed to defects in the minds and moral habits of racialized groups, schooling became seen as a tool to transform each of these children into a "worthy citizen of the nation" (Whitman, 1920a, p. 31). Science education scholarship began to organize at a national scale, giving rise to a new journal called *General Science Quarterly* (*GSQ*) in 1916 (Rudolph, 2005b). A central preoccupation of *GSQ* was how to adapt science teaching for the "expanding population," described as a "mongrel lot of pupils of all races" (Woodhull, 1917, p. 224).

The aim was to make science teaching more like a science—engineering people in the same way biologists were engineering more productive breeds of corn (Downing, 1925, p. ix). Science education experts drew techniques from psychology and sociology, introducing IQ tests (Hunter, 1920), standardized tests of science ability (Ruch, 1919), interest inventories (Lyon, 1918), and home surveys (Bayer & Clark, 1920). These techniques sought to diagnose and correct the alleged "maladjustment" between the existing science curriculum and the purportedly changing population (Watkins, 1923, p. 238).

Juxtaposing past and present demonstrates that dilemmas of how to classify differences between students did not originate in the minds of science teachers today. As scholars in science studies[12] have explored, scientific ways of seeing and sorting do not belong to the realm of private individuals, but reflect collective and historically contingent norms (Daston & Galison, 2010). Nevertheless, these "rules of perception" (Wynter, 1995) often become so commonsensical that they are nearly impossible to see without some historical perspective.

[12] Science studies, also known as Science & Technology Studies, includes the history, philosophy, sociology, anthropology, and cultural studies of science, technology, and medicine.

Research Questions

As a history of the present (Foucault, 1991), the study uses the past to gain critical distance from today's common sense. During both the 1920s and the 2010s, national anxieties about an allegedly changing population have propelled efforts to adapt the curriculum for perceived demographic differences. The study asks how it became possible to see a mismatch or maladjustment between different levels of science education and different populations of students. The 1920s provide a strategic point of comparison and contrast, throwing current classificatory techniques into sharp relief. The study focuses on what I call *ordering strategies* that classify children and match them with different curricula (see chapter 2). I examine how specific ordering strategies have circulated in varying configurations across three sites of U.S. science education. These sites span classroom practice (the AHS science department from 2013-2015), policy (the 2013 NGSS), and research (*GSQ* from the 1920s). I pursue the following questions:

1. Historically, how did it become possible to think about different "kinds" of students as requiring different forms, or levels, of science education?
2. In the 1920s (*GSQ)* and 2010s (NGSS and AHS), how have different kinds of students been made and matched with different forms of science education?
    a. Along what criteria and on what grounds are categorical distinctions made?
    b. What theories and techniques come together to diagnose these categories as having different needs, and to prescribe distinct forms of instruction?
    c. How are curricula and pedagogies ordered and matched with each category of students?

3. Based on this historical juxtaposition, what are the possibilities and limits in how problems of diversity and equity are currently formulated in U.S. science education?

Ultimately, the study argues that taken-for-granted practices of science education research and pedagogy carry historical assumptions of human difference that undermine commitments to equality and justice. Despite key shifts over the past century, theories and techniques used to classify learners today retain cultural norms that pathologize some people as less "scientific" than others. In so doing, they make a mismatch appear between different kinds of children and the levels of science curricula they can or should access.

Tracking Disparities

> There are those who contend that it does not benefit African-Americans [sic] to get them into the University of Texas where they do not do well, as opposed to having them go to a less-advanced school . . . a slower-track school where they do well. . . . Most of the black scientists in this country . . . come from lesser schools where they do not feel they they're being pushed ahead in classes that are too fast for them.
>
> —Supreme Court Justice Antonin Scalia (*Fisher v. University of Texas*, 2015, p. 67)

In 2015, the U.S. Supreme Court heard oral arguments for the *Fisher v. University of Texas* case concerning affirmative action in college admissions. While AHS teachers were debating how to eliminate racial disparities in tracked science courses, Justice Scalia went on record suggesting that African Americans might in fact benefit from less-advanced schools and slower-track classes—particularly in science. The ensuing public outcry emphasized the politics of left and right, but the argument's citation of mismatch theory also raises questions about the politics of knowledge. How do claims about human difference, such as race or intelligence, manage to acquire the status of scientific theory rather than stereotype—even when those theories remain highly contested?[13] On what grounds should it be decided what type of education a category of students requires or deserves? These are unsettled questions—not only in the Supreme Court, but also in science classrooms across the country.

The study's title, *Tracking Disparities*, brings together two terms related to educational inequality. Tracking has a particular meaning in U.S. educational research, referring to within-school curricular stratification (Oakes, 1985/2005). Disparity usually refers to a difference in the schooling experiences or outcomes of distinct student populations, especially (given the history of segregated schooling in the United States) along lines of race, ethnicity, and social class. So, at first glance, the terms tracking and disparities make sense together.

Yet, on further inspection, "tracking disparities" is full of syntactic ambiguity. Are we talking about how tracking (i.e., curricular stratification) creates disparities? Or are we talking about other disparities, like achievement gaps, that must be tracked (i.e., monitored)? The NGSS, for instance, focus their discussion of inequity on achievement gap data—and the need to make science "accessible" to non-dominant racial and ethnic groups (NGSS Lead States, 2013a, p. 359). This emphasis on *accessibility* could be contrasted with a focus on how curricular tracking (amongst other systemic disparities) restrict *access* to particular forms of science education (e.g., Tate, 2001).

There is also lexical ambiguity within tracking. The term track evokes a racecourse, linking the etymological roots of curriculum (Hamilton, 1989) to debates over schooling and social mobility (e.g., Lucas, 1999): populations getting ahead versus falling behind. In addition,

[13] This question is central to recent scholarship in science studies and the sociology of knowledge. Regarding mismatch theory, an amicus brief for *Fisher v. University of Texas* (Sander & Taylor, 2015) cites Sander's (2004) study of law students' race, GPA, and rates of passing the bar exam, which claimed that affirmative action harms students by admitting them to schools with more rigorous criteria than they are prepared for. Mismatch theory has garnered substantial critique from other legal scholars (Delgado, 2007; Hawkins, 2015), including a reanalysis of the data from Sander's original study (Chingos, 2013).

track can serve as a descriptor, as in the epigraph above where "slower-track" is used synonymously with "less-advanced." Track can also be an action, whether referring to scientists tracking storm data, or the storm itself tracking across the ground. These varied meanings suggest that what has been treated as a stable object of research—i.e., we all know what tracking is—would be better understood as a set of questions. How did U.S. science education become a racecourse with different lanes? How did "slower-track" come to refer not only to a level of course, but also to a type of person?

Many educational studies strive for clarity and consensus: operationalizing terms, revealing findings about those terms, and outlining clear takeaways for practitioners. The problem, however, is that different theoretical and methodological approaches employ the same terms within distinct regimes of truth (Foucault, 1995). Do we assume that research is already *on track* to identify the causes of and solutions to educational disparities? Is it the researcher's role to *track down* perpetrators (whether people, policies, or practices) that can be indicted for racial bias? Should we be *tracking* disparities by treating race as a stable category? Or is racism itself on the move—*tracking* across the educational landscape with unpredictable surges, merging with other modes of projecting and discrediting human difference?

This study belongs to a paradigm of educational research that is not seeking to stabilize one definition of science, equity, or success, but to provoke a fundamental rethinking of how research conceptualizes educational disparities (see chapter 2). This body of research highlights a dangerous tendency to assume a one-to-one relationship between real-world problems and the words we use to describe them; within that logic, problems exist out in the world, separate from but corresponding to the categories we use to study them. The trouble with this view is that it fails to account for the ways that research is already a real-world phenomenon. Research, like teaching, is a social practice, carried out in some institutions and taken up by others, entered into for particular purposes, and under specific historical conditions.

The act of tracking disparities in educational research presupposes notions of what is disparate, between whom, why this is a problem worth studying, and how it can be investigated and addressed. If parity means both sameness and the state of being equal, then the articulation of a dis-parity articulates both a difference and a state of inequality (Diaz, 2017). In other words, studies of disparities are not about just any difference. They imagine, and bring into the public imaginary, a discrepancy that has to be remedied—an inequity that must be redressed.

In this study, I approach dis/parity as a historical and cultural artifact. I investigate how specific practices of research and pedagogy generate distinctions through shifting metrics of social in/equality that operate as qualifications for inclusion/exclusion. The study takes a critical distance from the positivist sense of tracking as monitoring pre-existing disparities between stabilized demographic groups. Instead, it directs scrutiny to the ways those very monitoring processes are also productive of difference. In this sense, the study embraces a different notion of tracking—one that carries a historical sensibility of tracing something meticulously back in time, while keeping an eye on a danger unfolding in the present.[14]

For a sense of that danger, consider two premises that have grounded educational reforms for the past few decades. The first premise—shared across subject areas—is that demographic groups correspond to different types of learners. A prevailing approach, as illustrated by the NGSS case studies, has been to match each subgroup with instructional strategies to address perceived differences in what they know or in how they learn.[15] The second premise—specific to

[14] Here, I am thinking of Foucault's (1977) notion of a history of the present (or, genealogy) as "gray, meticulous, and patiently documentary. It operates on a field of entangled and confused parchments, on documents that have been scratched over and recopied many times" (p. 139).

[15] See K. Gutiérrez & Rogoff (2003) for a critical analysis of "cultural learning styles."

science education—is an essentialized distinction in the minds of scientists versus laypeople.[16] Science education reforms often assume that not all people are scientists (or scientist-like), but that all can and must become more like scientists.[17]

Together, these premises give rise to a divide referred to in current science education policy as a "two-pronged approach" (NGSS Lead States, 2013a, p. 370). The two-pronged approach distinguishes separate goals for "all students" versus for "scientists of the future" (National Research Council [NRC], 2012, p. 10). In this approach, some students—whether due to their talents or interests—must be recruited for more rigorous scientific training. Meanwhile, others—whether viewed as below benchmark or as outside cultural norms[18]—are said to benefit more from science made relevant to everyday life. At the heart of the study is how the two-pronged approach—this unquestioned divide between potential scientists and prospective citizens—has become entangled with and productive of racializing distinctions (among other differentiations).

What the study attempts to make clear is that premises about different categories of learners are not merely a theoretical concern. They have material effects, because they tell researchers, educators, and Supreme Court Justices what individuals from "diverse" groups will be like in science classrooms. They inform observations of those students' current proficiency

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[16] Science education perpetually invokes a divide between expert scientists and the lay public (Broman, 2012), as well as projecting divides between segments of that public (e.g., who are considered furthest from a baseline of scientific reasoning). Unlike the 1920s, this premise is no longer stated directly, but is evident in policy documents distinguishing subgroups expected to struggle to meet the baseline of the standards versus those that "can and should surpass the NGSS" (NGSS Lead States, 2013a, p. 359).

[17] Consider statements like the following from a report on the 2015 Programme for International Student Assessment (PISA) in Science: "More important, science is not only the domain of scientists. In the context of massive information flows and rapid change, everyone now needs to be able to 'think like a scientist': to be able to weigh evidence and come to a conclusion" (OECD, 2016, p. 3). See also McEneaney (2003) on how international discourses of scientific literacy embody cultural norms of the universal, rational, and action-oriented individual that must be produced through school science.

[18] The premise that some students' lives are outside the norms of school science (or of a "scientific" society) has been discussed as the "perceived disconnect between school science practices and home and community practices of non-dominant student groups" (NGSS Lead States, 2013a, p. 366).

("where they're at") and future destinations ("where they're going"). They preside over the politics of comparison, establishing legal, ethical, and pedagogical precedents for adjudicating claims of human inequality (see chapter 2). Understanding how these distinctions operate, however, will first require rethinking what gets called science in K-12 schooling.

Cutting and Splicing the Science of Science Education

In today's world, we are accustomed to children bringing home test scores that put a number on how well they are doing "in science." We hear on the news that U.S. students are falling behind "in science." These common phrases make it sound like science has one fixed definition, and that at any given point, each person has more or less of that science inside one's mind. Yet if we think instead about the science that scientific communities are working on right now (e.g., genome editing, gravitational waves, the changing Arctic), it is clear that science is, by definition, not fixed in place.

Whether science refers to what is known about the natural world, or how that knowledge has been produced, it has not remained the same over centuries or even decades. As science studies scholars have argued, it makes less sense to talk about the unity of science than the disunity of the sciences (e.g., Galison & Stump, 1996). Scientific disciplines comprise distinct styles of reasoning (e.g., experimentation, taxonomy, statistics) (Hacking, 1992), and boundary work is continually required to distinguish one discipline from another and to keep science separated from non-science (Gieryn, 1999). Yet, much of that dynamic complexity is expunged in the attempt to fix science as a single entity to be taught in school.

Perhaps this is obvious. Given the vast diversity of the sciences, selections must be made about what to include in the curriculum and what to leave out. And given continual change in the sciences, science education may necessarily be a step behind—teaching a fixed screenshot of science rather than an ever-evolving documentary of the scientific disciplines. Less obvious, though, is that the science taught in school is not only composed of elements from the natural sciences. It also contains elements from outside these disciplines.

To extend the analogy, the screenshots of science are cut and edited together in particular ways to produce an entirely different documentary titled Science Education.[19] The tools of the editing room—designed to convert the scientific disciplines into a school subject—do not belong to the natural sciences, but to the social sciences. For at least a century, science education scholars and practitioners have drawn on principles and practices of psychology, sociology, and anthropology to select and sequence particular images of science, narrate certain activities of scientists as learning objectives for students, and splice subject-specific objectives together with broader educational aims. If the editing process works properly, the end result is smooth footage with a recognizable story arc: teachers helping students develop into scientists or science-minded citizens. We watch Science Education and assume we are seeing the natural sciences unfold in the minds of schoolchildren.

Yet, decisions about which screenshots of science to include and which to cut out have not been deduced from the sciences themselves. Built into the editing tools (as well as the screenshots of science) are societal norms and cultural values about the kind of person that schools should be creating, such as "generally desirable human attitudes and values" (American Association for the Advancement of Science [AAAS], 1990, p. 185). "Learning science" or "developing a scientific attitude" is not the same as what scientists are working on (Popkewitz, 2008). At a fundamental level, the goal of classroom activity is not to generate new scientific

[19] This section draws on what Popkewitz (1998/2017) discusses as the alchemy of school subjects, which refers to the translation tools that transfigure the natural sciences into an entirely different substance called school science.

expertise.[20] It is to transform the daily thoughts, beliefs, and habits of large populations of children based on assumptions of what distinguishes an informed citizen or a rational person. When we say that a child, a demographic group, or a nation is behind "in science," what we are also saying is that they are not yet the kind of person that they might (or must) become.

The study will examine how the editing room tools that we inherit from the past shape what seems instructionally possible today. My concern is how these tools cut up the "science" to be learned and splice it seamlessly with social norms and judgments, such that the tools end up dividing people and ordering them along a "hierarchy of value" (Popkewitz, 2008, p. 53) that has little to do with the scientific disciplines. Another way of thinking of this is a shifting grid of discursive practices that make certain objects and ideas intelligible at a particular time and place (Foucault, 1990).

Opening the Black Boxes that Divide Kinds of Learners

To borrow an analogy from Latour (1999), many of the technologies we interact with on a daily basis operate as black boxes. If they are doing their job, we hardly notice they exist. As a result, the whole history of human interaction and the various intentions that went into them are rendered invisible to the end user. Take, for instance, the overhead projector.

As anyone who taught in the age before Smart Boards knows, the overhead projector seemed like one solid entity—until it broke down: "The crisis reminds us of the projector's existence" (Latour, 1994, p. 36). Only then would you open it up and fiddle around with new bulbs and wires. At that moment, you could see the projector not as one fixed object but as a collection of different things coming together. And not just the visible components that Latour mentions like the lens, fan, and mirror, but a whole assembly of scientific theories, business

[20] Even in cases where students are positioned as citizen scientists or as collaborating with scientists (e.g., Roth & Lee, 2004), youth are not generally recognized as full-fledged scientists.

philosophies, and governing techniques. The overhead projector was designed by French inventors in the mid-1800s and used by police to roll mug shots across the screen (Greenslade, 2017). It would come to play an important role in World War II military training before moving into schools in the 1950s (Smithsonian, 2018). In the 1980s, a business school study concluded that the overhead projector leant greater credibility to the presenter, leading to a higher degree of consensus and shorter meetings (Oppenheim, Kydd, & Carroll, 1981). This machine came to embody a pedagogical theory of transmission—the projection of certain knowledge to efficiently train a large room of people.

Similar to the projector, tools of pedagogical classification—like readiness, interest, and needs—can be thought of as black boxes. They simultaneously cut and splice the science to be learned, and also divide people as distinct types of science learners. Readiness, interest, and needs were each invoked at Alderwood High School (AHS) to explain why it was impossible for all students to take the same science courses. They also appear in the NGSS as markers of what distinguishes demographic groups as science learners. As technologies, these classifications do a certain job in the context of the school. Readiness, interest, and needs each appear as a stable, internal attribute that varies in degree; as such, they project onto students a particular profile, as if the inherent attributes of that group demanded a distinct form of instruction. The "Physical Science student," for instance, was assumed to require instruction that was slower pace, more entertaining, and more concretely applied to daily life (Meeting fieldnotes, 2013).

In this study, I explore how each black box contains a network of historical associations. Tracing these varied lineages is more than mere trivia. If we open up the black box, each taxonomic tool was assembled from many parts. In the case of interest, for instance, those parts included biological theories, sociological typologies, psychological constructs, statistical techniques, and pedagogical strategies (see chapter 6). Moreover, it is significant that these parts were assembled at a particular moment in U.S. history, one in which today's concepts of equity and diversity did not exist. In the early twentieth century, explicit goals of social science research, and of the rapidly expanding public high school, included sorting the leaders from the led, separating out the feeble-minded, teaching girls their place in the domestic sphere, and assimilating immigrant groups (e.g., Hunter, 1920). This history matters, because many of the theories and techniques invented in the early 1900s have become blackboxed and continue to circulate in science classrooms today.

Organization of the Study

This introductory chapter has outlined the study's central problematic. In chapter 2, I elaborate on my theoretical and methodological approach, including details of the study design. I make the case for why a particular historiographical method offers a crucial tactic in unsettling expectations of what and who are considered normal, and how science pedagogies produce distinctions by positioning some people as deficient from social norms.

The remainder of the study is organized into three parts that focus on ordering strategies of Readiness, Interest, and Needs (which I capitalize to distinguish the ordering strategy from a particular construct). Each part consists of a pair of chapters. The first of each pair introduces the ordering strategy by exploring a vignette from Alderwood High School (AHS). The second traces the conditions of possibility that allowed this ordering strategy to appear as a taken-for-granted mode of seeing and sorting student diversity in research, policy, and classroom practice.

Part I introduces the ordering strategy of Readiness, or the notion that some students are more mentally, cognitively, or developmentally prepared to learn science than others. Chapter 3 delves into the debate over the Physical Science course at AHS. The worry was that many of these students were unready to access the quantitative abstractions of physics. I examine how developmental stage theories and standardized test data combined to make it possible to "see" readiness for advanced science learning in both individual and demographic terms. A similar logic appears in science curricular standards and teacher evaluation rubrics, where entire categories of people are positioned as requiring strategies to make science more concrete and accessible. Chapter 4 historically traces the practices that make distinct levels of Readiness appear, including the invention of the psychological construct of a "scientific attitude," a standardized test of science ability, and a developmental scale of science learning goals. While acknowledging key shifts, I argue that science education today continues to operate within a comparative style of reason that divides students as possessing or lacking the reasoning needed for daily life. What appear as impartial metrics of science achievement embody cultural norms that project some students as ideal scientific Americans, while racializing Others as not-yet-ready for abstract rigor.

Part II focuses on the ordering strategy of Interest, which draws distinctions in students' motivation, attitudes, or feelings toward science. Chapter 5 introduces the Biology 2 course at AHS that was redesigned to spark an interest in science among students perceived as academically disengaged. Across the high school, Interest oriented the different aims and methods of higher- versus lower-level science courses. Interest also operates in the NGSS as a means of conceptualizing what makes girls and non-dominant racial and ethnic groups different from male or "mainstream" students. Chapter 6 goes on to investigate how interest emerged as a category of social science research. I study the swirling set of historical conditions and practices out of which "interest in science" precipitated as an object of analysis. Tools to conceptualize and measure differences in interest have repeatedly crystallized around shifting demographic distinctions. Today, these tools (along with the data they generate) risk explaining gender and racial disparities in science as simply a product of inadequate desire.

Part III examines the ordering strategy of Needs, which projects differences in students' home lives, cultural backgrounds, and likely future destinations. Chapter 7 considers the Chemistry in the Community course at AHS, designed to prioritize the immediate health-related needs of students seen as less likely to pursue science coursework or careers. A similar hierarchy of needs appears in the NGSS and other recent reforms that aim to leverage public health concerns (e.g. obesity) to make science instruction more inclusive and culturally responsive. Chapter 8 explores how this attempt to foster healthier citizens in science class is not new. I outline how early twentieth-century pedagogies sought to transform daily habits of nutrition and hygiene as a means to improve public health, to "Americanize" immigrants, and to "civilize" pupils in the U.S. colonial Philippines. The analysis illustrates how science and health literacy are not neutral, but embody norms about whose everyday lives require surveillance and intervention. The danger is that efforts to respond to the Needs of "diverse groups" inadvertently reinscribe diversity as pathology through practices that mark exclusionary boundaries of biomedical citizenship.

Chapter 9 concludes by synthesizing the study's implications for teaching and research. The fact that ordering strategies of Readiness, Interest, and Needs each have long histories might generate a sense of pessimism, as if the past somehow predetermined the present. However, by opening up these black boxes, it becomes clear that they are not solid, impenetrable structures. By demonstrating their partiality and historicity, the hope is that these taxonomies will begin to lose their aura of inevitability as devices for ordering children and curricula.

Chapter 2. Deciphering the Making of Difference in Science Education

Two national anxieties have been linked in recent public discourse: 1) the United States falling behind other countries in science and engineering, and 2) the persistence of science achievement gaps between demographic groups. In 2015, for instance, the Obama administration's proposal to improve the nation's STEM (Science, Technology, Engineering, and Mathematics) competitiveness was coupled with attempts to broaden participation in STEM fields by recruiting talented members of underrepresented groups (e.g. White House Office of the Press Secretary, 2015). In this linkage of crises, fears over the loss of national progress risk being ascribed to demographic shifts and to the alleged underachievement of African American and Hispanic students (see Basile & Lopez, 2015).

Following the U.S. presidential election in 2016, STEM appears in the Trump administration's proposal to create a "merit-based" immigration system, whereby individual applicants could gain extra points for a master's or a doctorate in STEM fields, or earn even more points for a Nobel Prize (Kopan, 2017). Although the proposal, in relation with xenophobic discourses (see Sanya et al., 2017), constitutes a significant departure from the policies of the previous administration, it cannot be considered entirely new. Tools to rank individual merit and judge civic potential have long circulated across domains of schooling, immigration, the military, social welfare, and criminal justice. Given ongoing debates over which bodies deserve access to health care, asylum, and civil rights protections, the material stakes are high when minds are evaluated as more or less "scientific," and through this process, adjudicated as more or less meritorious, productive, and American.

Rethinking the Paradigm of Invisibility

A central preoccupation of U.S. science education research today is how to promote equity in the face of increasing student diversity. The field usually traces these concerns back to the *Science for All Americans* report (AAAS, 1990) and the subsequent introduction of multiculturalism into science education research of the 1990s. Literature reviews suggest a particular historical narrative—that up until the 1990s, the field had failed to recognize student diversity and instead offered a one-size-fits-all approach to science education (e.g., Basile & Lopez, 2015; Boutte, Kelly-Jackson, & Johnson, 2010; O. Lee & Luykx, 2007; NRC, 2012). In particular, the 1996 U.S. National Science Education Standards earned critique for promoting a dangerous discourse of invisibility (Rodriguez, 1997); while the standards were peppered with photos of children from underrepresented groups, the text failed to address critical issues of ethnicity, socioeconomic status, and gender.

Directly responding to Rodriguez's (1997) invisibility critique, the 2012 framework for the NGSS proposed a new approach called "making diversity visible" (NRC, 2012, p. 288). As mentioned in chapter 1, this entailed providing case studies for how to teach the economically disadvantaged, major racial and ethnic groups, English learners, and girls, among others (NGSS Lead States, 2013a). The aim of the case studies is to achieve equity through differentiation—matching diverse groups with distinct strategies to achieve the same standards. This logic is not exclusive to science education. Discourses of data-driven decision making and multicultural education converge on a similar common sense: the need to know students' differences to make teaching more responsive to their needs and relevant to their lives. Across educational research and policy, making diversity visible is promoted as a method of achieving social justice.

In *Playing in the Dark,* Toni Morrison (1992) questions the common sense that canonical U.S. literature is "free of, uninformed, and unshaped by the four-hundred-year-old presence of, first, Africans and then African Americans in the United States" (p. 2). She argues that notions of what is uniquely American—e.g., independence, self-reliance, and scientific progress—depended on institutions of slavery and cultural narratives that conjured up an Africanist presence as correspondingly dependent, unreliable, and irrational.[21] Such insights are not confined to literature, but highlight widely circulating theses of Americanness that bear on schools as sites of citizen formation. I want to consider how Morrison's provocation might challenge the paradigm of invisibility in U.S. science education—that up until the 1990s, science education had failed to recognize cultural diversity and instead promoted a one-size-fits-all approach. Even critical scholarship tends to assume that, with Western science as the historical preserve of white male perspectives, heterogeneity has essentially been overlooked, leaving school science uninformed and unshaped by the presence of underrepresented groups.

Yet contrary to the narrative of a one-size-fits-all approach, U.S. science education has long distinguished between the curricula and pedagogies needed by some students versus by others. Consider recurring attempts to adapt instruction for those cast as needing to adapt to mainstream society, whether given as "inferior southern European stocks" (Grier, 1920), "defective delinquents" (Schuyler, 1940), "Puerto Rican pupils" (Sanguinetti, 1961), or "the inner city child" (George & Dietz, 1971). In this sense, difference has been acutely visible in science education for at least a century.

What would it mean to shift the analytical focus from diverse groups to the "dividing practices" (Foucault, 1994a, p. 126) by which differences are seen and sorted in the classroom? Borrowing Morrison's inquiry, it becomes possible to ask how the fabrication of racialized distinctions has impacted not only the segregated margins, but also the normative center. What if

[21] Morrison (1992) uses Africanist to refer to the "denotative and connotative blackness that African peoples have come to signify, as well as the entire range of views, assumptions, readings and misreadings that accompany Eurocentric learning about these people" (p. 3).

racialized categories of difference—typically positioned as peripheral to the core inquiry of the field—have instead been constitutive of mainstream science education?

Prior Formulations of the Problem: Underrepresented Groups, Tracking, and Data Use

This study enters a broader conversation concerned with the "politics of how human beings are known, classified, administered and treated" (Epstein, 2007, p. 207). Its key concerns articulate with those of educational literatures on underrepresented groups, tracking, and data use—issues usually studied in isolation. Before discussing my theoretical and methodological approach, this section will briefly highlight how these existing literatures have conceptualized science, difference, and power.

The problem of "underrepresented groups" in science and engineering has been a site of national concern since the 1970s (e.g., Crowley, 1977). A 1987 National Research Council report outlined a research agenda for studying why "racial minorities" were underrepresented.[22] Major lines of inquiry included whether cognitive differences, motivational variables, and cultural factors might correlate with lower science-related outcomes (Office of Scientific and Engineering Personnel, 1987). Not only did these research paradigms locate the source of disparities within the underrepresented groups themselves, they also reconfigured the notion of race as a set of psychological, sociological, and anthropological risk factors that presented a barrier to "normal" science learning. Rather than take these categories for granted, this study questions how attempts to acquire scientific knowledge about demographic groups produce social and political effects.

Starting in the 1980s, research on tracking shifted the problem from differences inherent within subgroups to differences produced by a stratified system. Emerging from the sociology of

[22] While acknowledging critiques of the term "minority" versus, for instance, "minoritized" groups (e.g., Gillborn, 2006), I strategically cite the exact classifications and terms employed in historical documents in order to draw attention and scrutiny to these shifting taxonomies of difference.

education, this paradigm analyzed the disproportionate representation of minoritized groups in lower-track science courses (e.g. Lucas, 1999; Tate, 2001; Oakes, 1985/2005). While building on this research literature, my study takes a different tack to highlight dynamics that are harder to see within this paradigm. Specifically, treating race as a stable variable obscures important shifts in its historical conceptualization (e.g., from hereditary stocks to sociological risk factors). Moreover, even when detracking occurs, equal educational provision may be impeded by the perceived mismatch between "higher-level" subject matter and "slow kids" (Horn, 2007). My study contributes to this body of scholarship by historicizing and denaturalizing the theories and techniques that make such a mismatch appear.

One explanation for racial disparities in tracked science courses has been educators' implicit biases (Oakes et al., 1997). Recent data use reforms have been promoted as a technical solution to inequity by eliminating subjective prejudice, objectively revealing students' skill levels, and indicating "what works" to close achievement gaps (e.g., Marsh, 2012). However, scholars have also begun to examine how data use reforms inadvertently produce new categories of difference (Booher-Jennings, 2005; Horn, Kane, & Wilson, 2015). These studies point to unanticipated consequences of data use, such as educational triage practices where resources are channeled away from students classified as furthest below benchmark (Gillborn & Youdell, 2000). Yet while offering important insights, the theory of educational triage fails to explain how lower-level courses at Alderwood High School (AHS) or more concrete instruction for non-dominant groups in the NGSS come to be seen as *better* serving those students' needs in the name of equity (see chapter 3). Rather than a simple shift from invisibility to making diversity visible, then, what is required is a more thorough examination of how difference is seen and sorted in research, policy, and classroom practice.

This chapter outlines a theoretical and methodological approach to turn the gaze back onto research itself. The aim is to highlight the epistemic principles and pedagogical practices that produce different "kinds" of students and match them with different levels of science education. The study challenges two prevailing views of research: 1) as an objective realm of knowledge production (i.e., a positivist view of Science), and 2) as a disconnected space of abstract theorizing (i.e., the critique of research as an Ivory Tower). I approach research as a historical and cultural production that embodies premises of what makes someone different from the norm, how that difference can be known, and how it should be administered. These premises do not remain isolated from the world. They come to circulate as common sense in international scholarship, national curricular standards, literature reviews, teacher education syllabi, school policies, assessment metrics, textbooks, lesson plan templates, and daily classroom interactions.

Theoretical Approach: Deciphering the Practices that Make Up Different Kinds of People

The study belongs to an "analytic wave across the disciplines concerned to trace the social construction of difference and the historical production of social categories" (Stoler, 2006, p. 2). Some of this work builds on Michel Foucault's efforts to use history to study the politics, ethics, and science of human difference. Drawing on both Foucault and Franz Fanon, Sylvia Wynter (1992) outlines a critical project called deciphering, which examines historical shifts in the rules that order perception (p. 240). I borrow Wynter's term *deciphering* to refer to scholarship responding to Foucault's provocation to interrogate the politics of scientific knowledge and its dominating effects on those cast as outside the norm. Recent work in science studies,[23] cultural studies,[24] and curriculum studies provide analytical tools for studying the

[23] Within science studies, such projects go by many names: historical ontology (Hacking, 2002), the applied metaphysics of scientific objects (Daston, 2000), the generalization of historicity to natural objects (Latour, 2000), and epistemic history (Daston & Lunbeck, 2011).

making of human kinds (Hacking, 2007), the ordering of knowledge and school subjects (Foucault, 1982; Popkewitz, 2013), and the production of self and Other (Baker, 2002b; Butler, 2011; Morrison, 1992; Wynter, 2006). All have proven essential to the study's efforts to decipher the production of different kinds of students in U.S. science education.

Following Foucault (1994b), politics and science should not be treated as opposites but as intertwined power-knowledge relations. He explains that while existing theories sought to account for how power functions through economic relations, cultural signification, and legal institutions, a new line of inquiry was needed to scrutinize another mechanism of power: the "dividing practices" by which people become objects of study and come to see themselves and others as particular types of subjects (p. 127). This constitutes a shift in focus from *who* has power to *how* power operates. Rather than seeing power as only repressive, Foucault studied power as productive of knowledge, problems, objects, and ways of being a person, which then become available as way of governing one's own thoughts and behavior.

Scholars of feminist, queer, and postcolonial theories have explored a similar set of concerns over how the scientific study of human difference divides an allegedly normal self from a pathological Other (Butler, 2011; Haraway, 1988; Wynter, 2006). In a process called abjection (Butler, 2011), those constructed as different from the norm—e.g., not-yet-scientifically-literate—become subjected to rescue and reform. Their inclusion then becomes dependent on developing the qualities they are seen as lacking. In this process, what it means to be equal is to become the same as an imagined "us." This dynamic is clearly illustrated in a recent PISA report, which claims: "It is simply not possible to develop inclusive policies and engage with all citizens if a lack of proficiency in basic skills prevents people from fully participating in society"

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[24] Cultural studies can be thought of as a fluid set of critical practices, including postcolonial, feminist, literary, and queer theories (Grossberg & Radway, 1995).

(OECD, 2016, p. 6). Abjection demands rethinking how student diversity becomes normalized as an object of scientific study. It also relates to Wynter's (2006) concern of how scientific discourses and tools have operated to overrepresent a particular genre of human thought and activity (e.g., the "basic skills" measured by PISA) as a generic baseline for human existence and equal participation in society.

From seeing stable categories to studying rules of perception. Foucault's approach to history has been characterized as a Copernican-style reversal (Veyne, 1997). The flip from a geocentric to heliocentric universe inverted what was seen as fixed versus as in motion (see Kuhn, 2012). Deciphering performs a similar inversion—from seeing stable objects that demand different practices to inquiring about the specifically dated practices that objectified these objects (Veyne, 1997, p. 150).

Most educational research starts by treating concepts (e.g., motivation) and categories of people (e.g., racial and ethnic groups) as fixed objects. There may be disagreements about how to define those objects, but the objects are assumed to exist in the world, prior to being discovered and formally defined by research. These objects appear to demand practices, such as the "best practices," or "effective practices" seen as necessary for a particular demographic group. But what if instead those very practices contributed to bringing into existence these categories of students?

To borrow two examples from the NGSS case studies, "non-White students" appear to demand teaching strategies that "motivate" them (NGSS Lead States, 2013c, p. 1), whereas "gifted and talented students" demand an "increased level of complexity and abstraction" (NGSS Lead States, 2013h, p. 2). The teacher's job is to recognize these distinct categories and respond to their differing attributes by adapting curricula and differentiating pedagogy (e.g., Stodolsky &

Grossman, 2000). It is here that deciphering urges an inversion: from how teachers should respond to different kinds of students to how those different kinds were produced.

Rather than treating unmotivated students as the *cause* provoking an instructional shift, unmotivated students can be seen as an *effect of power* (Foucault, 1991). To be clear, the argument is *not* that the dry lectures of traditional science classes caused some groups of students to lose motivation (i.e., dry for whom?). Instead, I want to suspend the very notion of unmotivated students—to ask how a whole grid of scientific and schooling practices came together to make such a category possible to think and talk about. Classifying students along a linear spectrum of motivation is so commonplace today that it is helpful to remember that the concept was inconceivable earlier in the history of U.S. schooling. In the mid-1800s, for instance, teachers were instead instructed to keep track of whether the child was becoming more "angel-like or fiend-like" (Mann, 1867a, p. 346; see chapter 6).

To consider how categories like motivation came into being at a particular time and place requires shifting from a philosophy of objects to a philosophy of relation (Veyne, 1997, p. 162). A relational philosophy gets us out of the tired debate of realism (i.e., objects really exist and are then given names) versus nominalism (i.e., the only real things are the names we give). As an alternative, philosopher of science Ian Hacking (2002) offers dynamic nominalism, which holds that, when it comes to classifying people, our practices of naming interact with the people that we name (p. 2). Different ways of seeing and knowing the world, such as taxonomic systems and statistical analyses, shape what is seen and known in multiple, indeterminate ways (Bowker & Star, 1998; Latour, 1999). With the historical emergence of distinct styles of scientific reasoning, new objects appear, along with novel forms of evidence, criteria for judging truth claims, and possibilities for thought and action (Hacking, 1992, p. 11). Dynamic nominalism dismantles the false separation between ideas and material reality by recognizing that scientific theories and techniques become powerful actors in the social world.

Instead of research *discovering* a reality—a knower revealing what is out there to be known—we can think about research as *displaying* phenomena (Danziger, 1997, p. 188). What is displayed as real cannot be accounted for in the objects that emerge, but in the dynamic "intra-actions" among observer, observed, and a whole apparatus of conceptual and material tools that demarcate what is being observed (Barad, 1998, p 99). The objects that are seen are produced through practices and rules that govern both the observer and the techniques of observation (Daston & Lunbeck, 2011). In this sense, psychological categories are neither natural kinds nor illusions. They do refer to features that are real, but it is a historical and cultural reality "in which they are themselves heavily implicated, a reality of which they are a part" (Danziger, 1997, p. 192).

There are any number of ways by which students can be seen and sorted as different from one another. The eye of the physicist or the physics teacher must be trained in disciplinary ways of seeing in order to produce observations recognizable to their respective communities (Daston & Lunbeck, 2011). To observe, as its etymology suggests, is not simply to see, but "'to conform one's action, to comply with,' as in observing rules, codes, regulations, and practices" (Crary, 1990, p. 6). This means that an observer is one who sees "within a prescribed set of possibilities" (p. 6). These possibilities change over time, as the "angel-like versus fiend-like" distinction reminds us. Becoming an observer of students is also to become an observer of established rules of perception and classification. As feminist and postcolonial science studies scholars contend, scientific observation should no longer be mistaken for innocent sight (Haraway, 1988; W. Anderson, 2006).

At the same time, rules of perception should not be read as merely repressive (Wynter, 1995). Their disciplining constraints are *productive* in the sense that they make new objects—whether electrons or AP kids—available to sight, thought, and action (Daston, 2000). And while electrons may be indifferent to how they are classified, there is more at stake politically and ethically when people become objects of scientific inquiry (Hacking, 2007).

Central to my study is Hacking's (2007) contention that "kinds of people"—e.g., the genius, the juvenile delinquent, gifted and talented students, non-White students—are not merely rhetorical labels. Just as we can talk about the historicity of objects and ways of knowing, we can also discuss the historical coming into being of the very possibility of different kinds of people (Hacking, 2002). When new categories of human beings emerge, this changes the space of possible ways to be a person: the category and the people in it emerge hand in hand (Hacking, 1986, p. 165). This process can be thought of as a *fabrication* in both senses of the word (Popkewitz, 2004): *made up*, or not originally in the world, categories like "unmotivated students" end up being *made into* reality as people are provided with new ways to understand themselves and Others.

The power of classification is not reducible to words creating a self-fulfilling prophecy (Popkewitz, 1998/2017). The categories are materialized through practices of knowledge production and social administration. In Hacking's (2007) terms, the engines of scientific discovery become the engines of making up people: counting, quantifying, creating norms, correlating, medicalizing, biologizing, geneticizing, normalizing, bureaucratizing, and reclaiming identities (p. 10). These categories are non-deterministic, because those classified can respond by rejecting the category, conforming to it, or changing in unpredictable ways—what Hacking calls looping effects. As a result, kinds of people are always moving targets (p. 12). Put another way, ontologies of human kinds are “both productive and responsive, expectant and late” (Stoler, 2009, p. 4), full of the uncertainty of trying to classify people for particular ends within a changing set of power relations.

Mutating assignments of essence: Different kinds of students and school science. A deciphering approach takes seriously the concern that knowledge is not only about understanding, but cutting (Foucault, 1977). This entails a shift from studies of race as a group identifier or timeless structure, to studies of racialization as a historical and sociopolitical process. Instead of trying to further our understanding of Black students, the target of analysis shifts to the comparative theories and techniques by which blackness, together with other forms of Otherness, is seen, sorted, and scientifically known—often in opposition to implicit norms (e.g., whiteness, Americanness).

Rather than prematurely restrict the analysis to a focus on racialization, I treat the making of difference as an empirical question, asking: What various cuts are made between “kinds” of students? How is the “all” sliced into discrete subpopulations, and how is the science curriculum carved into distinct levels? A deciphering approach asks about the “mutating assignments of essence and its predicates in a specific time and place” (Stoler, 2009, p. 4, emphasis in original). This demands a closer examination of the various categories thought to exist, the specific attributes ascribed to them, and the epistemic habits on which such distinctions are based. I begin from the premise that racial categories are sociopolitical constructs that are both culturally and historically contingent. That is, I do not start with an assumption of what race or racism really “is,” or who qualifies as which category, but rather inquire into what conceptions of “white,” “African American,” “Black,” “Latino,” and so on are asserted in order to examine precisely how a given category is operationalized and deployed. This means that I consider how race, but not only race, emerges in a mutually constitutive relation with the ordering strategies. As I argue in chapter 6, it is not merely that science education research has negatively represented "racial minorities" or "girls" as lacking an interest in science, but that the theories and tools that divide and order students by Interest function in racializing and gendering ways, changing what it means to be understood or to understand oneself as white and male (or as not these things).

To return to the NGSS case studies, we can see that both "non-White students" and "economically disadvantaged students" are said to benefit from strategies that: a) make the standards accessible to their current level of achievement, b) motivate them to take an interest in science, and c) increase their parents' engagement in science (NGSS Lead States, 2013a, p. 388, 395). That is, these categories are presumed to differ in their current *Readiness* to access the existing science curriculum, their *Interest* in learning science, and their *Needs* due to a purported parental disengagement from science. The claim that these students are below proficiency and behind grade level is articulated through disaggregated testing data and case studies of science classrooms serving low-income students and students of color (NGSS Lead States, 2013a, p. 359; NGSS Lead States, 2013b, p. 2). The claim that some students and their parents are "traditionally alienated from science" is asserted by citing studies aimed at designing culturally responsive curricula and attracting African American families to science museums (NGSS Lead States, 2013a, p. 366). In other words, various theories and tools converged to make particular inscriptions available as data points that assign these generalizations the status of research findings rather than biased stereotypes.

Explaining what made such statements possible requires: 1) historicizing the theories and techniques by which objects emerged (e.g., metrics of achievement, interest in science, and parental engagement), and 2) examining how they have become entangled with categories like "race" and "socioeconomic status," such that students classified as "non-White" and "economically disadvantaged" appear to demand particular instructional shifts. To move from a structural analysis of race to a deciphering analysis of difference, then, does not mean ignoring racial distinctions as they emerge on the "surface" of statements. Yet it is also not to restrict the analysis to this category of difference, or to explain its presence as a permanent structure. More pressing is to understand how ontologies of racial kinds and the essences assigned to them have been "protean, not fixed, subject to reformulation again and again" (Stoler, 2009, p. 4). These reformulations occur whenever existing classifications fall short of differentiating the gradations that a specific scientific inquiry or administrative strategy demands (p. 4).

Mutating assignments of essence also provides a way to think about what counts as the science of school science. I avoid stabilizing a definition of what the science of science education really is or should be. There are two reasons for this. First, it makes little historical sense. The science of school science has no fixed identity that transcends time and place, just as the sciences themselves undergo historical transformations (Hacking, 1992), exhibit disunities between disciplines (Hacking, 1996), and vary from one location to the next (Traweek, 1993). Second, a closed prescription of what science should be taught in schools forecloses analysis of the making of different kinds of science education for different kinds of students. By opening up this category for investigation, I can ask: 1) how what counts as science in school has changed historically, 2) how it has become entangled with aims that have little to do with the scientific disciplines, and 3) how it has been constituted differently for different groups, contributing to the making of those groups.

If I return to the image of an editing room (see chapter 1), a deciphering approach challenges the movie-like magic that makes science education seem like a direct transmission of the natural sciences into the minds of schoolchildren. Science and school science have fundamentally different objectives. Unlike grade schools, the primary purpose of scientific disciplines is not to transform the individual scientist into a different kind of person. Nor are the desired outcomes of schooling the same as those of scientific research, such as the production of knowledge, technologies, patents, and so on. Science education is not just about science, or having students do what scientists do. It is also about schools trying to foster the development of particular modes of thinking and social behavior.

In the process of cutting and splicing the scientific disciplines into science for the K-12 classroom—what Popkewitz (2008) calls the alchemy of school subjects—specific tools are needed. In the mid-1800s, the science to be learned in school was both filtered and transfigured by its religious purpose of fostering pupils' moral character. For instance, when Horace Mann (1867b) proposed a physiology course in common schools, the aim was for pupils to become enlightened and obedient to the physical laws of God, as revealed by science (p. 143). In Mann's time, societal problems were often attributed to densely populated cities as a site of moral contagion where virtues dissipated and vices—including ignorance—spread (Boyer, 1978). Within a religious discourse on human difference, Mann's logic contrasted “savages” and their “heathen incantations” with America's civilized communities, who must learn to avoid sinning against their bodies by transgressing the precepts of scientific medicine (Mann, 1867b, p. 150).

By the turn of the twentieth century, the newly professionalizing social sciences would instead provide the tools to convert the scientific disciplines into the contents of school science. As Rudolph (2005b) argues, the general science movement of the early 1900s drew on the expertise of psychology, sociology, and scientific pedagogy to make claims about what science should be learned and how. General science educators advocated for a shift from school science following the *logical* organization of the scientific disciplines to a *psychological* organization: “Looking at the problem from a psychological point of view, it is not so important whether one is teaching biology, physics, or general science to these students, as it is important that the scientific attitude is aroused in these adolescents” (Quickstad, 1917, pp. 156-157). Rather than trying to bring about the redemption of the pupil’s soul (as in Mann’s day), science education would now attempt to foster a “scientific attitude of mind” that could be assessed through standardized tests, interest surveys, and sociological score cards (Ruch, 1919; Lyon, 1918; Bayer & Clark, 1920; see chapter 3). Ignorance had been transfigured from a moral vice to a mental state that could be empirically measured.

In current science education research, debates over what science should be taught in schools tend to appeal to claims about the thinking and social behavior of real scientists. This is an effort to promote what is called authentic disciplinary engagement (e.g., Ford & Wargo, 2006). What tends to go unexamined are the editing techniques and tools—still predominantly from the social sciences—that convert the scientific disciplines into the science to be learned by children in school. These tools generate distinctions by dividing students and cutting up the curriculum into differentiated pathways. Although editing room tools carry specific cultural norms, these normativities escape scrutiny, because they appear to derive from the universal qualities of scientists or of international scientific communities, and thus to transcend culture.

Consider the *Science for All Americans* report (AAAS, 1990). While the report has been held up as an unfulfilled egalitarian promise (e.g., Atwater, 2000), it does not in fact advocate for offering the same science instruction to all. Like the NGSS today, the report calls for a two-pronged approach to science education (see chapter 1). *Science for All Americans* distinguishes between the “common core” of basic scientific literacy needed by “all young people, regardless of their social circumstances" (AAAS, 1990, p. 1), versus the "more sophisticated understanding" needed by those with "special interests and skills" (p. xviii). The science to be learned by the "all," but "especially minority children" (p. 220), has as much to do with "generally desirable human attitudes and values" (p. 185) as anything specific to the natural sciences. The science of school science contains historically and culturally specific notions of who the child is and should be, and who is furthest from these desired norms (Popkewitz, 2008).

This study explores how the science to be learned in school has tended to solidify around national hopes and fears. In the United States, these fears have often centered on designations of racial, ethnic, and cultural difference, as evident in talk of the challenges posed by the "unassimilated" (Hunter, 1922, p. 526), or "the learning needs of the nation's increasingly diverse student population" (NGSS Lead States, 2013a, p. 388). Meanwhile, hopes have been placed in the potential of education to include—and improve—those future citizens. Understanding this process requires suspending assumptions of science and American as static things to understand historically how these normative categories have been configured and reconfigured in relation to one another.

Analytical framework: Ordering strategies. Bringing together these theoretical perspectives, I adopt an analytical framework that I call ordering strategies. Ordering refers to the sequential and hierarchical arrangement of both children and curricula. Strategy refers to the historically provisional set of classificatory principles and epistemic practices that make such ordering appear reasonable and necessary. I am interested in how ordering strategies: 1) classify, or put students in order, 2) diagnose, or identify those who are out of order, and 3) prescribe, or bring them back within the social order. These strategies merge knowledge production (i.e., generating distinctions between types of students) and social administration (i.e., regulating those identified as below the baseline or outside the norm). The analysis will focus on the scientific techniques, schooling practices, and epistemological grounds on which differences are seen and sorted—regardless of the intentions of those designing or employing these tools.

Ordering strategies, as a set of principles and practices, produce new objects of analysis and propositions about those objects. Drawing on broader styles of scientific reasoning (Hacking, 1992), ordering strategies are, like those styles of reason, self-authenticating. What makes them self-authenticating is that they begin with certain ontological presuppositions (Derrida, 1993). These presuppositions are not questions that have already been answered, but answers that seem to have never been questions at all. The presuppositions come *before* (pre) and *order* (suppose) the thought that follows. As explored in chapter 4, one presupposition of different science course levels has been what Rancière (2009) calls the presumed inequality of intellectual capacity (i.e., not all students are capable of learning abstract physics)—even if such claims have progressively become more time bound (i.e., not all students are currently capable of accessing abstract physics).

What makes ordering strategies self-authenticating is their claim to know their own limits and borders (Derrida, 1982). Statistical reasoning, for instance, asserts its capacity to know its own limits by reporting error and degrees of significance (Hacking, 1992). Likewise, the classification of students into tracks claims to know its own limits by identifying students who were "misplaced." For instance, one teacher stated that in contrast to Honors Biology students, General Biology students have no prior scientific knowledge to draw on. When a student in General Biology class asked why carbon monoxide was denser than carbon dioxide, despite having fewer atoms per molecule, the teacher later explained, "He's really an honors student. I don't know why he's in here" (Interview EP, 2013). At issue is not the individual teacher's reasoning, but the mode by which the larger tracking system becomes self-authenticating, as anomalies can always be explained as the mistaken placement of an individual student rather than the mistaken presupposition about General Biology students. The existence of different levels of students offers the “imperial totality of an order” (Derrida, 1982, p. xvi) that claims to know its own limits and to account for its own anomalies.

What are the rules by which the ordering strategy functions? Consider how language acts as a constraint for thought. The rules of grammar call for a choice between a transitive and an intransitive verb; either a subject acts, or a passive construction exists (Derrida, 1982). One way of theorizing the classification of different kinds of students would be to think of teachers as appropriating or resisting a variety of meditational means (e.g., placement tests, racialized discourses of “unmotivated students”) used to see and sort students (see appendix G). This approach tends to differentiate the human agents who act from the meditational means (i.e., reifications) that are taken up or transformed by those agents. Drawing on continental philosophy, postfoundational theories, and science studies scholarship, it is possible to rethink this presumed divide between subjects and objects.

Rather than starting from subjects who produce difference (e.g., teachers appropriating or resisting particular metrics), I want to consider how it is difference from sameness that produces the field of possibilities for what become treated as subjects and objects. This approach draws attention to the principles and practices that make up different kinds of teachers (e.g., the urban teacher, the data-driven teacher) and students (e.g., those alienated from science, underperforming students) as recognizable ways of seeing and being seen. Attending to what Derrida (1982) calls the “play of difference,” the meaning of one kind of teacher or student is only ever produced is in relation to what it is not (p. 5). A teacher’s spoken interactions with a student may be full of ambiguity, complexity, multiplicity or ambivalence, but when it comes to registering for a course or entering scores in the online gradebook, the written classification of a student as either an Honors Biology student or a General Biology student must be discrete, obeying the rules of mutually exclusive course levels. One cannot be both an Honors Biology student and a General Biology student at the same time. Distinct course levels, functioning as the school's grammar, compel the spatial and temporal separation of students by kind.

An advantage of focusing on these rules is that it provokes a new distribution of ethical responsibility. Rather than positioning the teacher as the agent who, together with other human agents (e.g., guidance counselors, parents, and the students themselves), uses the meditational means available to classify students, it brings an additional focus to the techniques (Latour, 1994) that operate as nonhuman agents that have been historically delegated to perform particular functions related to the sorting and ranking of human merit. This is by no means a deterministic process.[25] Nor does it relieve the teacher of ethical responsibility, but instead demands new notions of responsibility *in* scientific practice (Schrader, 2010) that extend beyond the teacher to encompass all those (human and nonhuman) that have been enrolled (past and present) in the production of difference. This demands accountability for the cuts made and the different categories that materialize, but also for what cannot be observed in these practices, and what they prevent from mattering (Barad, 1998; Schrader, 2010).[26]

Interrogating the play of difference brings into view the logic of absences/presences, or doublets (Popkewitz, 1998/2017). To speak of one kind is to evoke its unspoken opposite. In

[25] Consider the teacher who expressed concern about the racially segregated science courses and resolved to teach the same Honors Biology curriculum to both Honors and General Biology classes, and yet wrestled with the fact that only half those students would earn the Honors designation on their transcripts and receive institutional recognition as being prepared for Math Physics (Interview PB, 2015).

[26] Here, I am drawing on Schrader's (2010) discussion of Barad's reformulation of responsibility and accountability: "Responsibility then entails the accounting for the practices that enact a specific cut such that objects-in-phenomena become determined, that is, materialize and matter, and accountability to 'what is excluded from mattering' ([Barad, 2007,] pp. 184, 205)" (p. 285).

preparing students for the course selection process, homeroom teachers are to play a video created to guide students in choosing the best classes for them. In the video, a teacher is asked, "What makes an honors student?"[27] The teacher responds:

> A successful honors-level student is well-organized, and has really good attendance, and is intellectually curious, and is willing to do an hour or so of homework a night. . . . If you're ready for that, then you're welcome—come. (Classroom artifact, 2014)

Each of these characteristics of the honors-level student invokes the opposite qualities of the non-honors, general-level students: that they are disorganized, with poor attendance, a lack of intellectual curiosity, and an unwillingness to do an hour or so of homework. The being of the non-honors student can be thought of as a negative presence, a "hole with determinable borders" (Derrida, 1982, p. 6), where the lack of something that does not lead to nothing but to another something. The absence of these qualities (organization, attendance, intellectual curiosity) in the non-honors student is only visible and intelligible in relation to their presence in the honors student. It is the relation between the two that gives each its being, where it becomes the "gap that governs" (Derrida, 1982, p. 6).The ordering strategies that generate these gaps tend to appear self-evident and resistant to critique. Yet, as Derrida (1982) insists, the membrane surrounding a particular gap must be maintained (p. xxv).

Or, as Latour (1999) contends, scientific objects do not maintain their facticity due to inertia. It takes work to assemble a scientific object, such as Pasteur's microbes or Terman's IQ. Part of this work involves erasing the work itself, so that the object appears natural rather than the product of human action, and thus appears timeless rather than historically contingent (Shapin & Schaffer, 2011). However, the network of associations brought together to give a

[27] This term "makes" has a double meaning; the video appears to refer to internal qualities of students that make them honors material, while "makes" can also be read as a process of fabricating human kinds as described above.

particular scientific object its appearance as fact does not then take on a stable life on its own. Rather, work must continually be put into maintaining that network. This work is not done consciously, but consists of all the practices by which the object continues to be made and the network reinforced. Latour offers the example that every time he drinks pasteurized milk or washes his hands with antibacterial soap, he is participating in the Pasteurization of his world, strengthening the network of microbes as common sense. Likewise, every time that a student fills out a course request card, or that a teacher designs a separate lesson for Math Chemistry versus General Chemistry, the existence of different levels of science courses (and students) is maintained.

Because no ordering strategy is monolithic, totalizing, or deterministic, each has instabilities. As mentioned, Hacking (2007) identifies those instabilities as looping effects produced by contradictory classificatory discourses and by the countless possible responses by those classified. Butler (2011) emphasizes that the production of social reality does not occur once and for all, but entails the ongoing reiteration and reconfiguration of regulatory norms. Given the proliferation of mutating forms, ordering strategies cannot be subsumed within a binary analysis of hegemony versus counter-hegemony. Rather, they generate a multiplicity of non-neutral effects that makes possible a "plurality of resistances," which emerge from within the strategic field of power relations (Foucault, 1990, p. 96).

While there can be no comprehensive accounting of this plurality of resistances and looping effects (see appendix G), my task is to analyze the rules, principles, and practices that make "these diverse responses simultaneously possible" (Rabinow, 2003, p. 46). One of the easiest ways to see these mutations and reformulations is through historical analysis. However, not just any historiographical approach will do. Next, I explore how the study's theoretical approach demands a rethinking of traditional methodologies for historically tracing issues of equity and diversity in the field.

Methodological Approach: Historicizing the Making of Difference

> What are the rules that govern the shared and integrating conception of the past… of the reality in which we participate as actors at the same time as we attempt to observe it?
>
> —Sylvia Wynter (1995, p. 12)

History has long promised to reveal where we came from so as to better understand where we are and move with greater confidence into planning the future. At the same time, history occupies an ambivalent status in the natural and social sciences. Commonly segregated to separate subfields, historical studies are often seen as having little relevance for the rest of the discipline. As Danziger (1997) notes, "if the historical course of science represents the cumulative improvement of knowledge, then the past simply consists of that which has been superseded" (p. 9). Likewise, most educational research relegates history either to a separate subfield or to the task of a literature review. The conventions that organize the literature review tend to generate a narrative of progressive improvement: that the field's studies of learning and teaching have been getting "better" over time (e.g., more accurate, more sophisticated, more equitable) and that the current study will further shrink the gaps left by prior studies. In this narrative, the field's distant past would offer little more than trivia as false starts in the disciplinary forefathers' attempts to measure and improve teaching and learning.

Yet as Wynter (1995) suggests, how histories are told—or what rules of perception are in effect—is of great consequence for understanding the social reality that educational research attempts to observe and intervene upon. Take, for instance, the IQ test. With hindsight, the original IQ tests appear arbitrary and unfair—quizzing army recruits, schoolchildren, and immigrants on popular U.S. card games (pinochle) and comic artists (Bud Fisher) as signs of their natural intelligence (e.g., Yoakum & Yerkes, 1920). However, the teleology of a literature review assumes that those earlier missteps have been corrected and blatant cultural biases removed, as educational research has developed more sophisticated theories of how children learn and more valid techniques to measure that learning. Albeit challenged by post-Kuhnian and postcolonial science studies (Harding, 1998), the premise that science yields an inevitable arc of progress still operates as one of the rules governing our "shared and integrating conception of the past" (see epigraph, above). When this arc of progress is presupposed, a close inspection of the field's less mature stages hardly seems worthwhile, and history appears irrelevant except as a celebration of how far the field has come and an affirmation to keep moving forward.

Deciphering historiographical rules of perception. Consider a recent science education volume titled *Moving the Equity Agenda Forward* (Bianchini, Akerson, Calabrese Barton, O. Lee, & Rodriguez, 2013), which opens with a look back at the past. The introductory chapter offers a historical account tracing the concept of "science for all" in U.S. policy from the late 1800s to today (DeBoer, 2013). This account illustrates two historiographical rules that impede a closer examination of the making of difference in U.S. schools.[28] The first rule is the assumption of a universal student experience. In the history of "science for all," the period from the late 1800s to today is described as "a period of massively expanding scientific discovery and technological development, during which time social institutions made a commitment to extend opportunity to all citizens" (DeBoer, 2013, p. 5). What appears timeless in this account is the United States' commitment to provide "all citizens" with the scientific knowledge needed to participate fully in society and to pursue science-related careers (p. 5). In other words, the

[28] At issue here are not the intentions of individual authors, but collective and historically contingent disciplinary norms for producing valid accounts of the past.

narrative assumes a perennial aspiration to include all citizens in science, coupled with ever-improving efforts by research and policy to fulfill this promise. Yet this claim can only be upheld with a key caveat: that not all those who reside in the United States counted as citizens, or even as people (Coates, 2015, p. 6). However, such exclusions remain absent from most historical accounts of science education.[29]

What renders these exclusions invisible is the tendency to adopt historical actors' terms (e.g., students) as timeless, universal categories. In this case, the history of "science for all" does acknowledge that only a small percentage of school-aged children attended school (p. 6), but neglects to mention the existence of separate institutions for those classified as "Negroes," "Indians," and the "feeble-minded" (Jones, 1917; Miller, 1903; Board of Directors of the New Jersey Training School for Feeble-Minded Girls and Boys, 1903).[30] Historiographical assumptions of universality are rooted in long-standing narratives of American history as one of freedom and equal opportunity (see Morrison, 1992), and of U.S. public education as an all-inclusive endeavor promoting democracy and the common good (see Labaree, 2010). The effect is to obscure the modes of reasoning used to divide subpopulations, making it hard for readers of such histories to assess whether similar modes of reasoning persist in some form today.

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[29] In reviewing the landscape of historical writing on science education, Rudolph (2008) concludes that very few studies have considered questions of differential access or experiences, arguing that the "cluster of valuable studies on women in science should point the way to much needed work on other under-represented groups" (p. 74).

[30] The traditional periodization of historical studies of education tends to respect and reiterate the boundaries that past educational scholars placed around their objects of study and the jurisdiction of their own expertise. *General Science Quarterly*, for instance, focused on "average students," or the masses attending so-called comprehensive high schools (Loevenguth, 1918, p. 369). Passing references also appear to those cast as not of the average, such as "machinery established for the segregation of low grade mental types and also the segregation of eye and ear defects" (Hunter, 1920, p. 382). *GSQ* targeted the masses regarded as unassimilated, but separate professional societies, state agencies, and scholars targeted those abjected as unassimilable. These included the American Association for the Study of the Feeble Minded (e.g., Goddard, 1910), the Office of Indian Affairs (e.g., Miller, 1903), and *Negro Education* reports (e.g., Jones, 1917). Further inquiry is needed to bring these spaces into relation, to examine the theories and techniques that made such differentiations appear reasonable, and to trace whether similar logics persist today.

Second is the tendency to adopt historical actors' distinctions as part of the historian's explanation for why a particular change occurred. That is, when historical actors do make explicit distinctions between kinds of people, those categories are sometimes taken up as "real Kinds" (Hacking, 2005, p. 104) that naturally require different types of science education. For instance, the history of "science for all" describes the 1920s as a moment when an "increasingly diverse population" enters U.S. schools (DeBoer, 2013, p. 7), such that science educators had to differentiate the curriculum "to meet the demands of the great masses of people" (p. 7). Likewise, in discussing the 1950s, the historical account reiterates the distinction of historical actors between the "academically able student" and the "typical high school student" (p. 11), and uses this to provide a lesson for today: that inclusion requires attending to varied levels of ability and motivation in order to make instruction "suitable for all" (p. 11). Like the premise of a universal student experience, the tendency to take up historical actors' categories does not originate with an individual historian but reflects a disciplinary norm—that of attempting an objective reconstruction of the past according to the actors' terms (Munslow, 1997). An unfortunate effect is that readers are left with the impression that U.S. schools always intended to be fully inclusive, but that these efforts were stymied by the differences that U.S. educators and their scientific instruments (e.g., IQ tests) discovered in their "changing population" of pupils.

This is why historiography, or how history is told, matters. The premise of a universal student experience, coupled with the assumed objectivity of historical actors' classifications, reflect and reinstantiate an arc of scientific progress. If the history of science education assumes this shape, then the current equity-oriented research agenda—operating under similar rules of perception—is reassured of being on the right track. Further investigation will reveal even more effective interventions for more precisely targeted subgroups. Gaps will be closed incrementally, and this expanding knowledge base will eventually ensure "science for all Americans." The danger is that these historiographical rules serve to efface the shifting modes by which differences have been produced and ordered in U.S. science education. Next, I outline a historiographical approach that attends to this making of different "kinds" of students by matching them with different levels of science education.

An entangled history of the present. For at least four decades, history as an academic discipline has grappled with challenges to its previous orthodoxy—that one accurate account of the past could be discovered through the methods of an objective historian (Scott, 1992). In the history of science, engagement with science studies and cultural studies has called into question the historiographical rules that made modern science appear both universal and uniquely Western (e.g., Santos, 2010). New areas of study (e.g., historical epistemology) have challenged the timeless nature of scientific norms and practices, demonstrating that things like objectivity, observation, and classification have their own histories, and that epistemic issues cannot be neatly separated from social and ethical ones (Bowker & Star, 2000; Daston & Galison, 2007; Daston & Lunbeck, 2011). Within education, curriculum history has also seen the rise of cross-disciplinary approaches that examine relations of knowledge, power, and social change (e.g., Popkewitz, Franklin, & Pereyra, 2001). In taking stock of these historiographical shifts, a key takeaway is that the historian's methods, tools, and categories can no longer afford to be sheltered from historical analysis (Sobe, 2013; Veyne, 1997). It makes little sense to treat historical actors as embedded in complex social and political settings, and yet assume that the way we conduct research in the present is objective, timeless, and isolated from our own historical situation.

An alternative historiographical approach is called a history of the present (Foucault, 1977). It asks about the confluence of conditions and practices that allowed some aspect of today's common sense to appear (Popkewitz, 2013). As Sobe (2013) argues, this historicizing approach can be thought of as entangled in two ways:

> Entangled history can refer to analyses of the tangling together of disparate actors, devices, discourses, and practices, with the recognition that this tangling is partly accomplished by said actors, devices, discourses, and practices and partly accomplished by the historian her/himself. The critical leverage of such an approach inheres in the attempt to develop situationally specific understandings of why-this-and-not-that. (p. 100)

In other words, this is first a call to trace what is already entangled, rather than imposing artificial boundaries around the objects and domains of analysis. Second, it is to acknowledge the political work of the historical analyst in choosing a problematic to disentangle and in actively entangling past and present for a particular purpose.

This study seeks to trace what is already entangled in U.S. science education that has produced different categories of people. To understand the construction of objects and their historical relations, it is important to consider how reasoning circulates across domains that are often studied separately (Foucault, 1977). The study asks what came together from "outside" the field of science education to make certain problems and categories thinkable. Chapter 4, for instance, explores how early standardized tests of science ability drew on sociological taxonomies that contrasted scientific reasoning with the "foreign dogma" of Catholic immigrants and the "folk beliefs" ascribed to racialized groups. I argue that notions of science ability and achievement—as individualized attributes that vary in degree—cannot be fully understood through an internalist history or literature review of standardized science assessments. To understand current paradoxes of diversity and exclusion, it is necessary to trace how external practices of differentiating human kinds in sociological, religious, and cultural terms moved into the field, where they took on new forms and generated a number of material effects.

Besides tracing what is already entangled in U.S. science education, I strategically entangle the 1920s with the 2010s, because the former provides critical leverage to rethink current formulations of equity and diversity. This was a moment of compulsory education, immigration quotas and settlement houses, Jim Crow segregation and widespread lynching, organizing by women's suffrage movements and the National Association for the Advancement of Colored People (NAACP), as well as eugenics, imperial acquisitions, and debates linking racial hygiene to American citizenship. The early twentieth century is a moment when aspirations to convert education into a science brought psychologists, sociologists, child study experts, and public health officials into conversation with pedagogues. I am especially interested in the demand to redefine the expertise of the science teacher as grounded in "knowledge of the pupil" (Quickstad, 1917, p. 159) in terms of individual and demographic differences:

> For in any scheme of modern education we must take individual differences into consideration. We no longer educate in the mass. Sex, age, environment, capability, heredity, all are important factors which must be recognized by the modern teacher in educational practice. . . . Recent developments in educational psychology show . . . one method of attack. (Hunter, 1920, pp. 384-385).

Tactically, I bring this early twentieth-century method of attack into conversation with early 21st-century science education reforms aiming to address equity and diversity concerns through better knowledge of students' individual and demographic differences in order to ask what exactly has changed. How do the tools designed to equip the "modern teacher" back then relate to those used to prepare the "data literate teacher" today, and what does this mean for questions of disparity and exclusion?

Study Design: Historicizing the Making of Difference Across Multiple Sites

Methodologically, the study is a history of the present (Foucault, 1977) focused on how different kinds of students came into being at a particular time and place (Hacking, 2007). I trace ordering strategies across three sites of U.S. science education: *General Science Quarterly* (*GSQ)* (1916-1929), the Next Generation Science Standards (NGSS) (2013), and the science department at Alderwood High School (AHS) (2013-2015). The study does not attempt to provide a totalizing account of these three sites. Many other stories and histories could be told. As outlined in chapter 1, I strategically focus on the ordering strategies by which students are classified, diagnosed as having different learning needs, and prescribed different forms of science instruction.

I purposefully selected each site, not as random or representative cases, but for their theoretical richness in allowing for a deeper understanding of the ordering of students and curricula in U.S. high school science. *GSQ* was one of the first major journals of the emerging U.S. science education research community in the early 1900s, eventually being renamed *Science Education* in 1929. Having arisen from the general science movement, its central preoccupation was responding to perceived differences in the populations entering high schools at the time. *GSQ* (1916 to 1929) offers an effective site to explore how the alchemy of school science fabricates racialized Others, since attempts to adapt science instruction coincided with efforts to rescue and reform the "urban masses," "foreign-born immigrants," and "Filipino natives" (see chapter 8). Similar to *GSQ*, the NGSS aim to provide a national vision for reforming pre-collegiate science education. More than any previous set of standards, the NGSS strive to provide a synthesis of current research on equity and diversity in order to help science educators respond to perceived differences in the demographics of students entering U.S. schools. Finally, AHS is a U.S. high school where a central discussion in the science department has centered on concerns about equity and diversity in facing what is regarded as a “changing population” of students. During the two years of my study, AHS’s district began implementing data use reforms in the hopes of closing racial achievement gaps, as well as addressing a civil rights investigation for the underrepresentation of students of color in upper-level coursework.

All three sites offer ample opportunities to collect statements concerning dilemmas of which students require which forms of science education, and how such differences can be seen and verified. I tailored data collection to each site, employing journal articles (*GSQ*) and policy documents (NGSS), as well as educator interviews, classroom and meeting fieldnotes, and artifacts (AHS) (see appendix A). I drew from all of these sources to generate comparable sets of statements and to analyze classificatory practices at work in each site. I treat each of my sites as a sort of historical “archive” that required certain ways of reasoning to make the things of school science appear (Popkewitz, 2008). While *archive* usually refers to a place where official historical records are kept, a historicizing approach uses this term to describe a set of statements that can be read together as displaying the products of historical practices and modes of reasoning (Stoler, 2009). Understanding my sites as archives means that I treat the “data” collected from each site as statements indicating what it was historically possible to see and say concerning different kinds of students. The classificatory logics sedimented in these statements did not originate in any one site, and therefore cannot be understood within the bounds of science education or even schooling.

When I first began reading primary sources from the early twentieth century, I noticed resonances with current calls to adapt science instruction for a "changing population." While some of the language of *GSQ* reads as bizarre and of the past (e.g., hopes of "race betterment"), other modes of seeing and sorting difference are reminiscent of the present (e.g., standardized tests). As such, I treat statements at AHS and in the NGSS as equally strange as *GSQ*, and use similarities and differences between these events as a tactic to denaturalize the present. As Foucault (1977) contends, it is neither the case that the past anticipates the present, nor that the past imposes its predetermined forms on the present. It would be reductive and misleading to assume that the 1920s constitute a singular origin for phenomena occurring today.[31] Instead, I use apparent resemblances and contrasts between past and present as provocation for deeper investigation. For instance, I noticed that in early 1900s science education research, pupils' interests in science were distinguished by sex and by racial stock. However, scholars at the time lamented the fact that there was no instrument analogous to the IQ test to measure interest and other broader aims of science teaching (see chapter 6). Since more recent research makes quantitative claims about the relative levels of interest of students by gender and race/ethnicity, this apparent rupture demanded further research on when and how interest or motivation became operationalized as measurable attributes and correlated with demographic categories.

A deciphering approach to data collection. My study of AHS emerged from a larger research project focused on how science teachers make sense of data use messages and practices in a district undergoing data-driven reforms.[32] Initial data analysis for the larger project prompted questions about the intersection of data use practices with talk of different "levels" of students in

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[31] That would be to commit the historicist fallacy of false precedent—to assume that because we see similarities between the present and a moment in the past, that the words or ideas meant the same thing back then, or that they originated there, and that they have been sustained continuously since.

[32] See footnote 6 in chapter 1.

tiered courses and assessment categories, providing one impetus for this study. AHS has eleven science teachers, sixteen tiered science courses, and a student body classified as racially, linguistically and socioeconomically diverse (see appendix B). My study includes the same participants and setting as the larger project, but I adopted additional data collection procedures and a distinct analytical framework.

During two years as an embedded observer in the AHS science department (2013-2015), I engaged in 240 hours of classroom observations, 160 hours of meeting observations, and 90 hours of interviews. Data collection for the larger study included writing ethnographic fieldnotes in science classroom observations, conducting a debrief interview with the teacher following each classroom visit, writing ethnographic fieldnotes at weekly department meetings and occasional school-wide meetings, collecting artifacts from classroom visits and meetings, and conducting semi-structured interviews with science teachers at the end of each year on themes of data use and responsive teaching.

At the start of the second year, I spoke with the science department at AHS about my research and how it both built on and diverged from the larger study. I invited all science teachers from the larger study to participate in the study, and all decided to participate (see appendix B). I explained the specific concerns that my study sought to explore: which students appear to require which types of science education and for what purpose. In introducing my study and in subsequent interviews, I emphasized that my aim was not to characterize teachers' individual conceptions of equity, diversity, or race. Rather, I was interested in how these issues were formulated as problems in U.S. science education across research, policy, and practice and how they changed over time.

To this end, I extended artifact collection beyond the school to contextualize emerging patterns in district, city, and national discourses. I also revised my classroom observation schedule in the second year. In year one, I observed one class with each teacher on a rotating basis, visiting each eight times and debriefing after each visit (see appendix D). In year two, I spent three consecutive days with each teacher across multiple courses, which allowed me to conduct extended debriefs with teachers concerning variations that emerged in the aims and instructional practices of each course level. I continued to take fieldnotes at weekly department- and occasional school-wide meetings and conduct formal interviews with each science teacher focused on data use.

Additionally, I concluded data collection at AHS by using a second formal interview to discuss emerging themes with participating science teachers, as well as another set of AHS educators. Selection of the additional set of educators was based on one of two criteria: 1) having a role in supporting subgroups of students in science courses; or 2) having participated in meetings concerning equity and diversity in science courses at AHS. This final interview aimed to engage each interviewee as a fellow analyst of complex phenomena operating across domains of pedagogy and research. I presented artifacts from school-wide meetings (e.g., data displays concerning racial disparities) and from the NGSS (e.g., case studies for "diverse" subgroups) in order to pose questions about preliminary themes (see appendix E). The artifacts served to elicit more discussion about data use, diversity, and equity, especially the various messages teachers received and the questions and critiques they raised about these modes of reasoning. By laying out tentative ideas, questions, and tensions from my initial cross-site analyses, my aim was also to make my theoretical commitments more visible to participating teachers. The purpose was to examine the classificatory practices and historical rules of perception that govern researchers and teachers alike, although never in totalizing or deterministic ways.

Data analysis: Historicizing ordering strategies across sites. Throughout the data collection process, I engaged in iterative rounds of data analysis, including open, systematic and focused coding, and writing analytical memos (Emerson, Fretz, & Shaw, 1995). At weekly research meetings, I discussed the data use practices I observed with researchers at two other schools, which offered insights into district-wide practices (e.g., disaggregating school improvement metrics by race). In the summer between years of data collection, I engaged in preliminary analysis of the roles of data in classifying students for the lowest-level Physical Science course. Using qualitative data analysis software, I conducted an initial round of open coding, creating codes for categories used to describe students, qualities assigned to those categories, and evidence used to verify or contest those qualities. This allowed me to generate second-order codes, write memos about emerging dilemmas, and look for disconfirming evidence (e.g., data used to contest claims of different levels of students).

Next, I expanded my open coding to read data sets from all three sites alongside one another. In keeping with my research questions (see chapter 1), I conducted a round of focused coding using the following questions: 1) *What categorical distinctions are made?* (e.g., “Physical Science kids aren’t math-ready for physics.”), 2) *How are these distinctions seen and known?* (e.g., “We designed an algorithm using weighted math and science test scores to predict who could pass General Physics.”), and 3) *How are curricula ordered based on these distinctions?* (e.g., “In Physical Science, we focus more on concepts than on quantitative calculations.”)

The focused coding allowed me to further specify my analytical framework and center further analysis on three ordering strategies: Readiness, Interests, and Needs. Each term has appeared in the field of science education for at least a century, but it was not the appearance of the word itself that mattered. Instead, I adopted these terms as metonyms for ordering strategies that comprise a fluid set of theories and practices that distinguish "kinds" of students and the sorts of science education they seem to require.[33] While I separate the three strategies for analytical clarity, their notions of difference were deeply entangled, as I discuss in the chapters that follow.

Readiness, Interests, and Needs were certainly not the only modes of distinction deployed within the three sites of U.S. science education that I analyzed. However, I selected these three purposefully for their ubiquity, their repeated association with notions of racial, ethnic, and cultural difference, and the weight they were given in determining one's opportunities and entitlements within school science. I do not attempt to produce a comprehensive representation of these modes of reasoning, but to examine a sufficient corpus of statements to analyze how the ordering strategies operate, as well as tensions and instabilities in their rules for truth.

The final phase of analysis entailed identifying continuities and discontinuities in each ordering strategy across the three sites of analysis. I used cross-site comparisons to refine my set of codes, conduct additional research into primary and secondary literatures to trace the history

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[33] What I gathered under my analytical category of Readiness, for instance, was not simply uses of the word "ready," but a wide range of mental, cognitive, and developmental classifications. The criteria for counting a statement as an instance of Readiness emerged from continual comparison of the statements from the three sites and in relation with my other analytical categories of Interest and Needs. For instance, because U.S. psychology has long made a distinction between thinking and feeling, or between cognition and affect, I examine the former under Readiness and the latter under Interest. What I came to distinguish as part of Readiness were any classifications of students on the basis of a difference located in students' mind that related to their current or future capability to think or reason in a particular way, or to learn or access a certain "level" of science instruction in terms of its degree of difficulty, abstraction, or pacing (see part I).

of specific theories and tools, and ultimately generate arguments about the historically contingent reasoning that divides science students into hierarchical categories.

Beyond Context: The Spatial and Temporal Politics of Comparison

A research study's context and participants can be narrated in different ways. For instance, the setting for the ethnographic portion of my study could be described as Alderwood High School (AHS), one of several high schools in Glacier City School District (GCSD), located in a midsized city in a Midwestern U.S. state. And technically speaking, data collection at AHS occurred from 2013 to 2015. However, part of what a deciphering approach seeks to question is how temporal, spatial, and corporeal boundaries are placed around the case or phenomenon under investigation. This brings into focus the politics of comparison that make up places, time periods, and people as alike or distinct.

Some classifications appearing at AHS exhibited particularities to the school, district, and state, while others circulated in national or international reforms. The school's tiered science courses and intervention programs provided common ways of discussing differences, such as "honors kids" versus "non-honors kids," "Phy-Sci kids" (in the Physical Science course, see chapter 3), and "AVID kids" (in the program called Advancement via Individual Determination, see chapter 5).[34] Teachers also invoked categories from broader research and policy. These included differentiations of socioeconomic status ("free-and-reduced-price lunch"), race and ethnicity ("African American," "Latino," "Hmong," and "White"), disability ("kids with IEPs," or Individualized Educational Plans), language proficiency ("ELLs," or English language

[34] Additional school programs that were discussed as types of students included: "band kids," "BAS kids" (students recruited for a new club for Black students in advanced science courses), and "Science Olympiad kids" (an extracurricular science team competition). Other salient categories included: "hall wanderers," "disenfranchised kids," "non-attenders," "at-risk kids," "tough kids," "behavior problems," and "kids from [Urban Center]," a city that shared a long history of racial segregation and migration with Glacier City.

learners), gender ("girls," primarily of concern in physics), and giftedness ("high flyers").[35] The NGSS Appendix on equity highlights similar categories of students as having unique "learning needs" that demand "instructional shifts" (NGSS Lead States, 2013a, p. 359).

Besides comparisons between subgroups of students, AHS itself was frequently compared with other schools in the district. Lauded as a "school to watch," administrators emphasized that AHS was outperforming Balsam High School (BHS), the one other high school in GCSD discussed as having "similar demographics" in percentage of low-income students and students of color (Meeting fieldnotes, 2014). Similarly, a data display in the front hallway depicted AHS 10th graders in positive terms—not as scoring the highest in the district, but as having made the biggest test score gains since 8th grade relative to those at the other three high schools (School artifact, 2014). The graph's title—"Taking who you get and making them better"—indicates implicit rules governing what constitutes a fair and favorable comparison. The lower average scores of incoming AHS students may have projected them as less desirable overall ("who you get"),[36] but the abjection of AHS students' underperformance offered a new brand of exceptionality for the data-driven teacher through appeals to "get creative to not drop the integrity of what you do by servicing the changing population" (Meeting fieldnotes, 2013).

While talk of a "changing population" is ubiquitous today, it is useful to recall that there were many ways in which the people living in Glacier City were not exactly the same as those residing there a decade prior. From 2005 to 2015, for instance, there were more boys named Austin and more girls named Taylor.[37] Yet of the myriad ways that people can vary, only certain

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[35] While there was no Talented and Gifted program at the high school, some students were referred to as "gifted" or "talented" to denote their prior participation in those programs.

[36] This discourse was also evident in a school-wide meeting, where a data display of racial disparities in the school improvement plan was accompanied by the statement: "We don't get to decide who comes here" (Meeting fieldnotes, 2013).

[37] According to state baby name statistics, the years 2005 to 2015 saw a sharp increase in the number of boys named Austin and girls named Taylor of high school age.

markers of change draw concern as pedagogically significant or administratively problematic.

At AHS like many other schools in the U.S., population change was described in socioeconomic, racial, and linguistic terms. This was expressed as the school "crossing a threshold of 50% free-and-reduced-price lunch," and undergoing an "ethnic shift" due to a "quickly growing ESL population" and African Americans moving in from nearby urban centers (Meeting fieldnotes, 2013). Disaggregated data on achievement gaps and graduation rates, coupled with lower average test scores, made up the student body as a "different clientele" (Meeting fieldnotes, 2013). With the majority cast as "at-risk" (see K. Brown, 2016), a new protected class emerged: the "high-flyers" (Meeting fieldnotes, 2014). The worry was that these students had now been placed at risk of being held back from their "potential," unless they could be "insulated" from the slower-paced pedagogies and increased behavior problems associated with "general-level" kids (Meeting fieldnotes, 2014). Assembled in this distinction between the "at-risk kid" and the "high flier" are statistical correlations, psychological and sociological theories, and moral and legal discourses that divide and order people along a hierarchy of space and time.

In the United States, the discourse of a "changing population" also calls upon a mythologized past. This is evident in the 2016 presidential campaign slogan, "Make America Great Again," as well as in implicit references in educational research, policy, and practice to "Public School Way Back When," or a time before desegregation when the children were allegedly homogeneous and easier to teach (Ladson-Billings, 1999, p. 219). In fact, the discourse of a changing population dates back even farther than *Brown v. Board of Education*. As one science education scholar wrote in 1918:

Think what the situation was like 36 years ago. I recall it very distinctly. One was apt to

> have about 6 pupils in the chemistry class. We had laboratories then as we have now, and with 6 pupils—all American born—homogeneous—there was no reason why one should not do good teaching, at least the best he was capable of. (Woodhull, 1918, p. 223)

This statement shares a striking resemblance to the comparative reasoning in today's discussions of a lost homogeneity of America and the perpetual crisis of urban/rural schooling (Popkewitz, 1998/2017). These national and historical resonances should place in question any portrayal of my study's setting as delimited to 2013-2015 or to AHS and its faculty.

In contrast to a statistical discourse of generalizability, this study's approach demands an attention to the particulars of time and space, but also an expansion of the inquiry past the temporal and spatial brackets placed around a case study or an activity system. This has implications for how I attribute, localize, and interpret quotes. First, in a move to decenter the individual subject as the origin of a statement, I cite statements of my research participants by pseudonym initials (see appendix B) and refrain from adding biographical details (e.g., gender, demographic categories, experience) to "flesh out" the speaker (see appendix G). In this, my goal is to make it analytically clear when I am citing different individuals, while keeping the focus on the statement itself and what made its logic and practices historically possible.

Second, the chapters purposefully employ a recursive style, moving back and forth across sites of research, policy, and practice. I pair teachers' statements with statements that might seem oddly distant in space, time, and professional status, such as pairing an AHS teacher's quote with a statement from John Dewey. The strangeness of this approach underscores the traditional conventions of educational research that treat teachers (and not scholars) as objects of study. Educational research conventionally positions teachers as practitioners that either successfully adopt or misinterpret and misapply research findings and tools. Contrary to this approach, I strategically juxtapose statements of teachers, researchers, and policymakers of past and present in order to highlight the historical and social nature of epistemology. The aim is to illustrate how the rules for seeing and sorting difference precede the entrance of individual actors—and in fact, provide the means for making oneself into a certain kind of person—and yet do not remain stable or incontestable (see chapter 9).

Third, I use statements not to infer a unified ideology, but to analyze the various rules of perception that make classifications and their assigned attributes visible. Studies treating race as a stable analytical category might search for direct and indirect references to African Americans, and interpret surrounding text as coded language for race (e.g., Pollock, 2004). To study mutating assignments of essence necessitates a different analytical approach. Instead of trying to extract hidden meanings from coded language, a deciphering analysis remains at the surface of the statements, observing exactly what is said and done. There is no need to psychologize the teacher by inferring their conscious or subconscious intentions. Instead, I will look at the practical conduct of teaching and ask how it became practical, mapping what are taken as natural ways to be a teacher at this time and place. "*What is made*, the object, is explained by what went into its making at each moment of history" (Veyne, 1997, pp. 160-161, emphasis in original). These historically provisional rules of perception are invisible, not because they are buried in a person's false consciousness, but because they are so much at the surface of daily life that we cease to notice let alone to question them.

Consider the following statement from an interview with an AHS science teacher:

> I can't change anybody's socioeconomic class or race, but what I can do is make things in a more sequential manner and break things down more in a step-by-step method, so that people from all different achievement levels can achieve to whatever their

> background or intelligence . . . or whatever they're allowed to innately . . . and going into school with hundreds of less vocabulary words that a poor kid has. . . . When you have kids immigrating from Africa, you don't see those same disparities. So there's some cultural context that is not just race at all. Otherwise, African American kids would be in the same boat. . . . And intact families—it has a lot to do with that, in my opinion. (Interview EP, 2015)

In approaching the above quote, I do not seek to explain the classifications and ascriptions as located within the biography of the teacher, the culture of the teacher workgroup, or the immediate contextual factors of the activity system. Instead, deciphering what made such statements possible requires: 1) historicizing the theories and techniques by which objects like "achievement levels," "intelligence," "vocabulary words," "cultural context," and "intact families" emerged, and 2) examining how they became entangled with categories like "class" or "race" such that students classified as "poor" and "African American" have come to appear as if they (as a "kind" of learner) require more "sequential," "step-by-step" methods of teaching.

Some of these classificatory logics can be seen more clearly through historical juxtaposition. Consider this statement from a science teacher in *GSQ* almost a century prior:

> The population . . . consists largely of various types of foreigners: Italian, Polish, German, Hungarians and few English. . . . The children . . . show all the potentialities one might expect knowing their environment. A few are unusually bright and alert, some give evidences only of a passing interest in things educative, while a majority perhaps are rich with family tradition and superstition. . . . Care is taken not to introduce any subject matter that is beyond the mental grasp of the pupil. . . . The pupil's work is definitely mapped out for him. (Carpenter, 1916, pp. 47, 49, 52)

Compared to the 2015 quote, this 1916 statement exhibits distinct categories with differing attributes, along with different rules for making truth claims about them. For the 1916 science teacher, it would be literally unthinkable to discuss the number of vocabulary words possessed by students in a particular socioeconomic bracket. For one, the research studies on which this contemporary commonsense depends had not yet occurred (see Adair, Sánchez-Suzuki, & McManus, 2017 for a review of this research, its limits, and dangers). Moreover, policies and administrative structures were not yet in place to conceptualize or collect data on "free-and-reduced lunch" students. On the other hand, this science teacher in 1916 could assume something else of his readers: 1) that referencing his pupils as "Italian, Polish, German, Hungarians" would indicate something about their potentialities, environment, interest, family tradition, and superstition, and 2) that these attributes would be understood as dictating the need to carefully map out science instruction to be within their "mental grasp."

Despite stark differences, the two statements share a common premise: that it is the science teacher's professional responsibility to know the differences between the types of students in their classroom, and to respond by adapting science instruction to be within the grasp of what each group can access or achieve. My study is not concerned with the identity of these individual teachers, but with the historical fabrication of the teacher as a kind of person: whether the "good," "modern" science teacher of the 1920s, or the "equitable," "data-driven" science teacher today.

If I put into question the notion of an absolute origin or linear development (Derrida, 1982), it makes little sense to organize the study chronologically, and there is not one obvious place to begin. I have chosen to organize Parts I, II, and III around ordering strategies of Readiness, Interest, and Needs, respectively, and these parts may be read in any order. The first chapter of each part opens with a pair of epigraphs to signal a strange resonance of past and present. Next, I present a vignette exploring how a certain mode of ordering students and curricula operated in the daily details of science teaching at AHS. In narrating these dividing practices at AHS, I purposefully interweave examples from recent scholarship and policy. This is to continually cut against the conventional reading of educational research that what happens “at” the school is “of” the school or “of” the study’s participants (see appendix G).

The second chapter of each part returns to the early twentieth century, which serves as a vantage point from which to question the self-authenticating nature of today’s ordering strategies and to ask what has changed from a century prior. By destabilizing notions of linearity from past to present, the study aims to upset the prevalent chronology of continual progress, which assumes that research yields an expanding knowledge base about student diversity, thereby ensuring greater equity.

PART I. Readiness as an Ordering Strategy

The first part of the study explores how science education orders people based on differences presumed in how they think. Historically, metrics of science ability and achievement have been entangled with theories of developmental psychology, which generate hierarchies of mind in temporal terms. Critical analyses of developmentalism are not new (e.g., Baker, 1999; Burman, 1994; Martins, 2017; Walkerdine, 1988). Nor are critiques of discourses of kindergarten readiness (e.g., Graue, 1993) or college readiness (e.g., Kee, 2013). What the study contributes is a closer look at how developmental theories and mental testing were assembled in science education research and pedagogy, and how discourses of the past and their racializing effects relate to current efforts to confront racial disparities in science coursework.

Part I focuses on the ordering strategy of Readiness, or the principles and practices that permit claims about a student's present capability and future potential to learn a certain "level" of science. Analytically, I use Readiness (with a capital R) to discuss two intertwined trajectories: a readiness scale of the student's mind, matched with a progression of curricular rigor. Together, these trajectories divide students as closer or further from the norm of "thinking like a scientist." Readiness assumes that research has achieved a definitive consensus about how scientists think, which can and should serve as a model for the ideal citizen to be fostered in public schooling.

Chapter 3 presents a vignette of a meeting where Alderwood High School (AHS) teachers and administrators were debating how to redress the overrepresentation of African American and Hispanic students in the lowest-track Physical Science course. But why not have all students take Physics? I explore how the perceived need for distinct course levels was grounded in the premise that students exist at different stages of cognitive development or skills, and that achievement data could reveal their readiness for quantitative abstractions. Drawing on classroom observations and teacher interviews, I illustrate how these principles operated in high-stakes moments of testing and course placement decisions, as well as in the daily details of science teaching. Readiness distinguished some minds as already primed for the fast-paced transmission of abstract science content, and others as requiring more applied content, concrete pedagogies, and a slower pace. Since principles of Readiness circulate as common sense across educational research and policy, historical analysis is needed to restore the tethers linking developmental stages and science achievement data to particular cultural norms and sociopolitical imperatives.

Chapter 4 traces how Readiness emerged in the United States as a means of classifying different kinds of science learners. In the early twentieth century, science was inscribed in the curriculum as a universal form of reason and a metric of civic potential that embodied national hopes and fears. New techniques like the developmental scale and the standardized test promised to reveal differences in the degree to which a child's thinking imitated that of a scientist—referred to as straight-line American reasoning. I argue that what came to count as scientific thinking in schools did not derive strictly from scientific disciplines. It emerged, at least in part, through opposition to ideas and peoples cast as unscientific—whether labeled primitive superstitions and foreign traditions in the 1920s, or naïve conceptions and cultural knowledge in the 2010s. A key difference is that Readiness today is linked to discourses of equity, accessibility, and relevance. Together, the chapters draw attention to a comparative reasoning that orders racialized groups along a developmental scale of readiness and matches them with a curricular progression of rigor from local to universal, and from concrete to abstract.

Chapter 3. "Give Those Kids a Chance to Mature": Sorting by Alleged Readiness for Scientific Thinking

> The whole point of having Physical Science in the first place was it would give those kids a chance to mature. So that they can mature and take more advanced science classes later. . . . And obviously what's most important is making sure that all kids are getting college and career ready.
>
> —AHS science educator (Meeting fieldnotes, 2013)

> There is nothing comparable to a good science course to teach your students *how* to think consistently, clearly, logically. This is one prime reason why the general science course, adapted as it is to immature minds, has met with nation-wide approval. . . . The pupil is led to think for himself, to make observations, and in short, to lay the foundation of future intelligent work.
>
> —Textbook ad in *General Science Quarterly* (1916, p. 63, emphasis in original)

U.S. schools have long classified people by making distinctions in how they think. Sometimes that judgment has been made in absolute terms—casting individuals or categories of people as wholly incapable of reason. But more often, distinctions in thinking have been made in relative terms—positioning people on a sliding scale of mental or cognitive development. That scale registers some minds as already mature: quick, logical thinkers, fully capable of advanced science and mathematics. In comparison, other minds are marked as immature or unready. Of course, identifying students as not ready *yet* is not the same as judging them incapable. Recent data-driven reforms argue that for those students who are behind, catching them early is the key to catching them up. This "power of yet" has been endorsed across TED Talks, educational blogs, and Sesame Street songs.[38] Yet, even so, schooling has a way of converting distinctions in time into differences in space. Marking students as behind the expected timeline tends to position them—not in intent, but in effect—as academically or intellectually below.

The epigraphs above describe two science courses, a century apart, which sought to adapt science instruction for students perceived as stuck at an earlier stage of thinking. In the first epigraph, teachers at Alderwood High School (AHS) were debating the fate of the Physical Science course (Meeting fieldnotes, 2013). Physical Science, originally adopted in response to demographic shifts in the district, had recently come under scrutiny (Interview TN, 2015). In a civil rights investigation, Physical Science was the most egregious example of racial disparities in science coursework. Serving mostly students classified as African American and Hispanic, it was considered so "low" that it did not count as a high school science course when those students tried to apply to college (Meeting fieldnotes, 2013). AHS teachers increasingly denounced the course as a "dumping ground" and academic "dead end." Yet for many, eliminating the course altogether seemed pedagogically reckless. Where would the "Phy-Sci kids" go? The case for keeping the course rested on notions that some students were not "math-ready" for physics, that they did better with "concrete" facts rather than abstract concepts, and that Phy-Sci would give them "a chance to mature" (see first epigraph, above) (Meeting fieldnotes, 2013).

Nearly one hundred years earlier, general science was advertised across the United States as a course adapted for "immature minds" (see second epigraph, above). It too had been promoted as a necessary response to what was perceived as a changing population (Caldwell, 1917). The fear was that U.S. high schools were filling with "a mongrel lot of pupils of all races"

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[38] The "power of yet" is a phrase currently associated with psychologist Carol Dweck's (2006) work on growth mindset and a 2014 TED Talk of this title.

(Woodhull, 1917, p. 138). Those pupils, according to evolutionary theories of the time, were ill adapted for the quantitative abstractions of physics and chemistry, but would benefit from science "presented in a concrete form" (p. 157). General science promised to lay a missing foundation that would allow those populations to mature and "learn *how* to think" (second epigraph). Yet, amidst great optimism about the course (e.g., Dewey, 1916), several educators argued that it was not working as planned. In the opening issue of *General Science Quarterly* (*GSQ*), an article warned that the course could easily become a "receptacle into which all pupils might be gathered who were not fitted for the 'higher things' of the traditional routine" (Greenlaw, 1916, p. 36). Five years later, another educator wrote that general science was indeed turning into "a dumping ground for the poorer classes of pupils," with standards so low that it often did not even count as a science course (Collister, 1921, p. 224).[39]

Strange resonances appear between general science and Physical Science. Both cordoned off a new curricular space, demarcating some as unready for higher levels of reasoning. This reasoning differentiated some kinds of thinking and thinkers as "abstract" in opposition to what was given as the "concrete." Both courses sought to adapt science instruction for this lower stage of "concrete" thinking through pedagogies also labeled concrete: applied, local, immediate, practical, and hands-on.[40] Such distinctions are not unique to science education. Widely accepted standards of good pedagogy have long dictated the need to differentiate instruction by matching individuals (and demographic subgroups) with a "developmentally appropriate" level of challenge.

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[39] See Rudolph (2002, 2005a, 2005b) for discussions of the historical conditions, especially following World War II, which contributed to a growing discontent with General Science and its focus on the science of everyday life.

[40] The analysis later in the chapter will call into question the self-evidence of this abstract/concrete distinction.

Even stranger, perhaps, is that the critics of general science (1920s) and of Physical Science (2010s) echo the same refrain, alleging that the courses had become a *dumping ground*. The imagery here is of a place of no return, filling with those regarded as too difficult to teach. What made this critique equally intelligible, although not identical, within the distinct moments of the 1920s and 2010s? A century ago, the notion of restricting poorer classes to a lower scholastic tier raised the specter of Old World aristocracy that was anathema to American self-understanding (e.g., Downing, 1925). Today, course placement disparities are taken as evidence of broader systems of oppression by race and class (e.g., Oakes, 1985/2005). At AHS, for instance, the racial disparities in upper- versus lower-level science courses fueled worry that bias had infiltrated what should otherwise be an objective system. At both moments, *dumping ground* was a critique that called into question the scientific aspirations and egalitarian aims of American education. After all, psychological tools—whether tests of intelligence, ability, or achievement—have long promised democratic transparency by using quantitative data to measure merit in order to meet the needs of each individual (see Carson, 2007; Danziger, 1997; Porter, 1995).

Reverberating between past and present is a key epistemic anxiety. In efforts to know and respond to different stages of mental or cognitive development, how had good pedagogy gone badly? How had differentiated instruction turned into a dumping ground?

Ordering Minds in Time

This chapter introduces the first of three ordering strategies. I originally considered using the term "Capacity" to discuss the dividing practices related to mental testing, developmental psychology, and cognitive learning theories. However, the language of mental capacity, in frequent use in the first half of the twentieth century, has since declined in policy and research—dismissed by many as inaccurate and inequitable (e.g., Dweck, 2006; Valencia, 1997).

I settled on Readiness to name this first ordering strategy. Like "mental capacity," readiness was also a key construct of early twentieth-century psychology (e.g., Thorndike's law of readiness), but, in contrast with IQ, it persists in national policy documents and teacher conversations today. Readiness also offers a useful etymology. Its roots—to prepare or to arrange—emphasize how psychological assessments rely on social criteria and values to determine what someone is being prepared or arranged for. Who has to develop which attributes, and to what ends? Ready can be both verb (to *ready* someone) and adjective (a person assessed as *ready*). This slippage highlights a danger in how schools are charged both with the act of preparing students, and also with adjudicating their differential degrees of preparation.

That danger is evident in the Coleman Report (Coleman et al., 1966). Commissioned by the Civil Rights Act of 1964 as a study of the educational opportunities available to white versus "Negro" students, the report generated data on racial disparities in achievement as one of several forms of evidence of unequal treatment. The report's findings testified to discriminatory schooling conditions (e.g., the relative absence of college preparatory curricula in "Negro schools"), but in its citation of achievement differences, also fueled a narrative of the "Negro student" as "least prepared" (p. 297). As the achievement gap narrative proliferated in the decades that followed (Gutiérrez, 2008; Ladson-Billings, 2006), one effect was to project the problem of unequal treatment onto the interior of the child's mind—a child and a population made up as "cognitively different" and as "unready" to access the college preparatory curriculum rarely extended to them in the first place (see Tate, 2001).[41]

[41] Of course, the achievement gap discourse was not the first instance of the racialization of the mind in the United States (see Darby & Rury, 2018). Moreover, although the Coleman Report rejected the use of achievement tests as measures of stable mental abilities, the achievement gap discourse did not make earlier theories of racial differences in mental capacity disappear. Prior research on "Negro intelligence" would become reconfigured as studies of "Negro intelligence and achievement," which by the late 1960s had begun citing civil rights legislation to authorize their investigations (e.g., Kennedy, 1969; for critical analysis, see Bond, 1959; Valencia & Suzuki, 2000).

Intertwined with Readiness are a number constructs claiming to differentiate human minds. These include domain-general categories like mental capacity and intelligence, as well as domain-specific attributes like scientific talent, scientific potential, and science achievement. Each was invented or reinvented over the course of the twentieth century, undergoing shifts in conceptualization and measurement. Some, more than others, have provoked debate over their historical formation and sociopolitical ramifications. Intelligence in particular has incited perennial controversy.

In the earliest years of intelligence testing in the United States, some claimed that IQ tests revealed fixed mental types that must be permanently segregated. Lewis Terman (1916) infamously wrote that amongst “Indians, Mexicans, and negroes,” many were:

> uneducable beyond the nearest rudiments of training. No amount of school instruction will ever make them intelligent voters or capable citizens. . . . Children of this group should be segregated in special classes and be given instruction which is concrete and practical. They cannot master abstractions, but they can be made efficient workers. (p. 92)

Meanwhile, some of Terman’s contemporaries regarded intelligence testing as a dangerous and insufficient measure of the human mind. John Dewey (1924), for instance, rejected the notion that “when you have a student’s intelligence quotient—his I.Q.—you have a certain insight and measurement of him as an individual” (p. 465). Yet, Dewey continued:

> This finding is valuable for the purposes of classification, which places the individual where he will work most effectively with others, and prevents useless retardation. . . . It guards against the mistake of trying to make an individual go at a faster pace than he is capable of moving. (p. 465)

Previously, Dewey (1916) had argued that the general science course must meet the "great mass of the pupils" where they were at developmentally by focusing on "concrete experience," rather than offering "a premature diet of abstract scientific propositions" (p. 8).

What this suggests is that both sides of a contentious debate over IQ could meet on the common ground of Readiness. Both took as self-evident the imperative to minimize inefficiency by aligning the scale of mental readiness with the spectrum of curricular rigor. Disagreement would focus on how far and how easily students could be moved up that scale. What emerged as foundational to U.S. educational psychology was a cluster of classifications linking scales of low/high intelligence, immature/mature minds, practical/theoretical knowledge, slow/fast-paced learning, and concrete/abstract instruction. I will discuss this entangled set of scales for ordering minds and curricula as the ordering strategy of Readiness.

Readiness, in contrast with scrutiny around the racialized history of IQ (e.g., Gould, 1996), appears today as an equity strategy. Studies of tracking have distinguished between teachers who hold fast to an ideology of fixed intelligence, versus those who embrace newer conceptions of intelligence as malleable and developing over time—where the latter position is positioned as counterhegemonic (Oakes et al., 1997). Current science education policy promotes using measures of college and career readiness to differentiate instruction and to monitor progress in addressing racial disparities (e.g., NGSS Lead States, 2013a). An emphasis on readiness, achievement monitoring, and malleable capabilities is heralded as a progressive turn away from fixed notions of ability and a deficit model of intelligence.

Yet, what often goes unremarked is that time has long provided a technical register for ranking human intellect. This is evident in a succession of terms like "mental age," "retardation," "developmental delay," "slow versus fast learners," and "behind versus ahead of grade-level."[42] A linear ordering of time has also contributed to historical processes of racialization—classifying peoples from backwards to advanced, pre-modern to modern, underdeveloped to developed. As early as the seventeenth century, for instance, European imperial visits to colonized spaces were equated to traveling back in time (Pratt, 2007; Sobe, 2013).

By the early twentieth century, U.S. social sciences began to conceptualize those racialized as "Negro," "Indian," and "Oriental" as a window into earlier stages of Europe's past, as well as younger stages of human development (Lesko, 2012). Psychological instruments began translating evolutionary theories and developmental stages into numerical calculations and cutoff scores. As truth-telling devices, mental testing permitted new claims of equivalence between the minds of African adults and those of Caucasian children (e.g., Hall, 1904), or more recently, between the mathematical abilities of African American 12th graders and those of white 8th graders (e.g., Education Trust, 2003 as cited in Martin, 2009).[43] These comparisons are one manifestation of how developmentalism imposed a linear and irreversible notion of time, from which differences were produced (Popkewitz, 2008).[44] Because learning is assumed to progress at a steady rate over time—a principle that also makes possible learning curves and value-added metrics[45]—identifying a demographic category with a younger age group or an earlier grade level functions to position their minds as behind and below.

The rest of the chapter is organized as follows. First, I offer a vignette of the debate over Physical Science that took place at Alderwood High School (AHS) in December of 2013. I

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[42] Importantly, this linkage between time and metrics of human intellect (e.g., mental age) is historically provisional. Prior notions of deviance were formulated not as temporal stages of backwardness, but in terms of sin, sickness, and criminality (Franklin, 1994).

[43] See Martin (2009) for a discussion of this racialized hierarchy in mathematics education.

[44] For discussions of alternative conceptions of temporality, see Popkewitz (2008) and Wynter (1995).

[45] Value-added metrics, for instance, rely on inferring months of schooling gained or lost (Kane & Staiger, 2012).

highlight how Readiness was perceived as a barrier to detracking, but also as indicating a potential solution to racial disparities. What if an algorithm could predict which Physical Science students from underrepresented groups were in fact ready to learn Physics? Next, I analyze how techniques to measure Readiness helped to organize science coursework across the high school, especially the developmental scale and standardized test data. Finally, I make the case for situating Readiness historically—a task I undertake in the chapter that follows.

Vignette: An Algorithm to Sort Out the "Dumping Ground" of Physical Science

All of the Alderwood High School (AHS) science teachers, plus a few administrators and support staff, gathered for a lunch meeting in December of 2013. The only item on the agenda was Physical Science (Meeting fieldnotes, 2013).[46]

"I found some of this data interesting," said an administrator, handing out a spreadsheet of student demographics and grades in the Physical Science course. "So you do have a combination of African American special ed males that seem to find their way into Physical Science at Alderwood High School."

The district was facing a civil rights investigation for racial disparities in tracking across subjects, and especially in physics. A few years prior, the district had prohibited the requirement that students obtain a teacher signature to enroll in advanced coursework. That decision, as the administrator reminded everyone now, came when district officials began asking, "Why are physics teachers not signing for Black kids?"

The problem was formulated as one of disproportionate representation. This seemed to demand an equally mathematical solution. Could better data use bring the course demographics back into proportion? The hope was that data, unlike teacher signatures, would be free of subjective bias.

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[46] All quotes in this section are from the same set of meeting fieldnotes.

The administrator proposed designing an algorithm to figure out which Physical Science students were in fact ready for Physics:

> Are there ways we can identify kids that could be successful in Physics that we could maybe bump in a direction of having a little bit more rigorous curriculum? . . . If we can identify some kids that have been underrepresented in Physics that have the skill set . . . how did they end up in Physical Science? . . . If they could knock down a C in Physics, why are they hanging out here?

Evident here are two interrelated premises. The first is that science courses were organized on a spectrum of increasing rigor. General Physics was a "little bit more rigorous" than Physical Science, and Math Physics was more rigorous still. The second is that not all students were ready for the rigor of General Physics. The goal of the algorithm was to identify which students from underrepresented groups (i.e., African American and Hispanic) already had the right skill set, if not to ace Physics, then to at least "knock down a C."[47]

Discussion turned to which factors would best predict whether a student was ready and able to succeed in Physics. One teacher inquired whether the school's data management platform could figure out those variables and their relative weighting: "Could Data Dashboard mine out the information?" "Data Dashboard can't do it," the administrator replied, "but I can do it." He went on to suggest:

> Let's look at students who knocked down A's and B's in Physical Science the last two years, and let's see what story they tell. What grade did they get in Algebra? How did we miss them, you know? What was the GPA? Were they regular attenders?

[47] A third premise of the administrator's statement was that those who *were* ready to succeed in Physics must have a different problem that explained why were enrolled in Physical Science—implied here as their complacency in "hanging out here." Later in the meeting, this premise was made explicit, with comments like, "They just have no interest in it," and "Kids are avoiding challenging work" (see chapter 5 on Interest).

Within the inductive logic of data mining, the first step would be to search for variables correlated with higher performance in last year's students. By running those numbers, the resulting algorithm would ideally predict which "Phy-Sci" students could move up to Physics with the least risk of failure. The assumption was that individual students possessed stable levels of skills and behaviors that would reveal themselves in the same ways, regardless of where they were placed. Also notable here is the desire for Data Dashboard to "mine out" the information all by itself.

What an algorithm—or, the idea of an algorithm—promised was the possibility of transforming a contentious decision-making process into a technical procedure of data mining. This resembles the epistemic virtue of mechanical objectivity, where numbers tell the truth without the contamination of human judgment (Daston & Galison, 2010). Quantification has long served as a replacement for personal trust, offering what historian of science Theodore Porter (1995) calls a "technology of distance" (p. ix):

> In public affairs, reliance on nothing more than seasoned judgment seems undemocratic. . . . Ideally, expertise should be mechanized and objectified. It should be grounded in specific techniques sanctioned by a body of specialists. Then mere judgment, with all its gaps and idiosyncrasies seems almost to disappear. (p. 7)

Historically, that power vested in numbers has been especially valued where faith is shaken in the impartiality of expert recommendations. Given that AHS administrators and teachers faced scrutiny from district officials and the U.S. Department of Education, it could be that numerical data offered the best possibility of verifying that course placements were based strictly on cognitive skills, rather than stereotypes.

At the same time, one could argue that there is no such thing as "raw" data (Gitelman, 2013). The variables that seemed most salient to include in the algorithm—grades in prior courses, overall GPA, and school attendance—could not be read directly off of an individual's mind. Each reflected complex interactions between students and teachers within larger classroom and school dynamics. Any social, cultural, or racialized dimensions of curriculum and schooling would have to be stripped away to produce a stand-alone data point that was ostensibly "about" the student (e.g., 2.75 GPA, 88% attendance). The precision of these numbers would only be gained by erasing the contingencies, complexity, and context that went into their calculation (Mehan, 2001; Poovey, 1998). Throughout the study, AHS teachers raised many concerns about the limits of the information captured in Data Dashboard (Braaten, K. Kirchgasler, Bradford, & Barocas, 2015).

Indeed, not everyone in the Physical Science meeting agreed with the proposed algorithmic solution. Upon hearing an administrator describe the "student need picture" of Physical Science in statistical terms, one teacher spoke up:

> And I agree that students' needs are what's most important. But why I'm here is because I teach these students as freshmen. And I have a lot invested in these kids, and Physical Science doesn't count to get into a four-year college. And it's demoralizing to my students. . . . It's a low-level dead-end class and they know that.

A new formulation of the problem was now on the table. Rather than Physical Science referring to a distinct type of student, the course had been re-envisioned as a toxic environment—one that harms "my students" by changing how they are seen and treated. In this new framing, the algorithm made little sense. What use was there in moving a few individuals out of Physical Science if the problem was endemic to the "dead-end" space that the course created?

Prior studies have classified teachers as either supportive of or resistant to reforms aimed at detracking. One way to analyze the Physical Science meeting, then, would be to set up a binary between individuals based on their apparent ideological stances. On one side might be teachers who insisted on keeping Physical Science around as a place for "those kids" to mature. On the other side might be teachers, like the one who just spoke up, who demanded the elimination of this "dead-end" track. Yet as an analytical move, this dichotomy hides more than it helps (see appendix G).

Picking up where I left off in the meeting, the teacher who had just critiqued Physical Science's demoralizing effects went on to suggest an alternative solution:

> If there's some way we can bypass Physics—because the students that are going into Physical Science, I don't see many of them being successful. Even though they *were* successful in [Biology], I don't know that they will necessarily be successful in the applied mathematics of Physics. But [General Chemistry] *would* be accessible.

The statement seems to concur with the premise that many students were not ready to be successful in Physics and required a different, more accessible science class. Like Physical Science, General Chemistry was a lower-level course, but unlike Physical Science, it did count as a science in the college admissions process.[48] As a result, General Chemistry seemed to be a better option for those perceived as not "math-ready" for Physics (Meeting fieldnotes, 2013).

I want to suggest that the debate over Physical Science illustrates a need to rethink power relations in education. As we saw with Terman and Dewey in relation to IQ testing, it is possible to vehemently disagree over how students should be sorted into different classrooms and yet

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[48] General Chemistry had previously been called "Chemistry in the Community," but the name was changed when technical colleges and the National Collegiate Athletic Association (NCAA) refused to recognize this as a science class on high school transcripts (see chapter 7). By the end of the study, the name "General Chemistry" was poised to change again due to similar concerns.

subscribe to some shared principles. In this case, those principles include: 1) that students' minds develop at different rates and operate at distinct levels in terms of what they are ready to access; 2) that those levels are stable, knowable, and useful in predicting a student's likelihood to succeed in a future course; 3) that science courses vary in degrees of curricular rigor and cognitive demand; and 4) that these levels of cognitive demand can and should be matched with students' levels of cognitive development and skills. Because these principles are treated as settled knowledge of how children learn, it is important to question the presumed separation of knowledge and power.

Knowledge—in the form of student data, research findings, and psychological theories—can be understood as effects of power (Foucault, 1991). Distinctions in Readiness are generated by specific principles and practices of knowledge production that emerge through power relations. Those power-knowledge relations can get frozen in place when they achieve a high enough degree of facticity, rendering them virtually invisible (Foucault, 1988; Latour & Woolgar, 1979). They become the transparent infrastructure that "does not have to be reinvented each time or assembled for each task, but invisibly supports those tasks" (Bowker & Star, 2000, p. 35). The result is that theories and techniques that produce differences in Readiness powerfully govern classroom practice, teacher preparation, and educational scholarship, and yet are rarely seen as part of the politics of schooling. Before moving to these broader domains, I want to consider how Readiness also contributed to organizing science curricula and pedagogy across AHS.

Matching Readiness to Rigor at Alderwood High School

In observing any given class at AHS, it was clear that no one student was an exact replica of the others. Variation abounded. The question for the teacher (or educational researcher) is what to make of the unceasing fluidity and complexity unfolding in any classroom. While answers to this question differ dramatically, they are not strictly a matter of individual discretion. Recognition as a professional (whether teacher, administrator, or researcher) demands submitting to rules and techniques that train the observer to see and sort difference in prescribed ways (Crary, 1990). Across the school, there was talk of different levels of students: high, medium, and low achievers; students who were ahead versus behind; fast and slow learners; abstract versus concrete thinkers. How did difference get formulated not as random variation, but as discrete categories of students? And not as equivalent categories, but as levels ordered in time?

To mark time requires an observer guided by tools of observation to distinguish past, present, and future. Drawing on classroom observations, teacher interviews, and meeting artifacts, I will consider how Readiness could be conceptualized and calculated through two interrelated techniques for marking time (see appendix G for methodological considerations and limits). The first is the developmental scale, which located students in stages progressing from concrete to abstract. The second is the standardized test, whose scores purported to reveal the degree of each mind's development, clock its pace of learning, and calculate its future trajectory. Together, these tools generated distinct types of science learners arranged along a temporal sequence and a hierarchy of value (Popkewitz, 1998/2017).

Developmental scale: Staging students from concrete to abstract. Science coursework at AHS divided students into lower and higher pathways, referred to as general-level versus honors-level. First-year students took either General or Honors Biology, while sophomores took Physical Science, General Physics, or Math Physics.[49] According to how the courses were

[49] See appendix C for more details on the course map. Some juniors went on to take General Chemistry, Math Chemistry, or Chemistry Honors/Advanced Placement (AP). A smaller subset of seniors elected to take Math Physics 2, Advanced Science and Engineering, Anatomy & Physiology, or Advanced Placement (AP) Environmental Science. Other upperclassmen took Biology 2 (see chapter 5), Biotechnology, or Earth Science.

discussed by teachers, administrators, and curricular guides, they followed a sequence from relevant to rigorous, and from concrete to abstract. Generally speaking, lower-level courses aimed to make science more accessible through pedagogies that were slower-paced, multimodal, and applied to everyday life. Higher-level courses targeted those regarded as ready to access traditional science instruction that was fast-paced, math-heavy, and theoretical.

What made higher-level science courses appear more rigorous? In some cases, rigor was attributed to the constraints of external demands (e.g., an Advanced Placement exam) (Interview RS, 2014). In other cases, rigor meant maintaining the "integrity" either of a subject matter (e.g., physics as a body of logically organized knowledge and skills) or a pedagogical approach (e.g., Modeling Instruction) (Meeting fieldnotes, 2014). Teachers of higher-level courses described feeling compelled to adhere to a greater rigidity in their content, instructional format, and pacing. For instance, one teacher cited the need to "prepare [students] to do well on their college anatomy and physiology courses, which notoriously weed out the kids" (Interview HD, 2013). Curricular flexibility and pedagogical responsiveness appeared to be luxuries that honors-level students could not afford (see chapter 7 on "future needs"). The rigidity envisioned to exist in future educational settings became rendered as a restraint on pedagogical possibilities in the present.

In contrast, the relevance of lower-level courses appeared necessary for those deemed unready to conform to the rigid expectations of traditional science courses.[50] Rather than responding to the disembodied demands of AP exams or the scientific disciplines, teachers of lower-level courses expressed a responsibility to "make them accessible to different students—

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[50] This is a logic that, in some form, dates back at least to 1920: "For a student going to college, the content of the course in physics or chemistry is fairly definitely predetermined by the requirements of the college. For students not preparing for college the material included in the science course of study and the method of attack may be varied to meet the needs of individual groups" (Gerry, 1920, pp. 13-14)

not have a lecture-based class, for example, which isn't completely accessible at all" (Interview EP, 2014). Teachers critiqued the rigid instructional format and pacing of upper-level courses: "Some teachers want it like a college class: 'If they can't sit and listen to me lecture, they shouldn't be in my class'" (Interview SF, 2014). As another teacher put it, "Certain populations can't fit into the box of, 'Here's a worksheet, here's vocab words, here's a book, here's what we're gonna learn, here's our little lab, okay we're done. Now we're gonna do it again" (Interview DI, 2014). Dilemmas arose for these teachers due to tensions between what carried prestige as rigorous college preparation, and what they considered to be good, responsive pedagogy.

Linked to this rigor/relevance scale was a distinction of abstract/concrete. While higher-level courses aimed to prepare students for theoretical abstractions in future science coursework, lower-level courses focused on concrete applications of science in everyday life. However, the abstract/concrete dichotomy is not as self-evident as it first appears. During a typical 90-minute science class—regardless of course level—students listened, spoke, read, wrote, and interacted with physical objects of some sort. Yet, only some of these curricular activities were described as "concrete," while others were upheld as "abstract." Lectures on biochemistry, genetics, and evolutionary theory were considered "too abstract" for General Biology students; instead, the course would "apply evolution to concrete examples," like watching videos on specific insect adaptations and human genetic diseases (Interview EP, 2014). Higher-level courses also permitted students to manipulate objects, chemicals, and other concrete materials, but it was as if these physical items (e.g., Bunsen burners, motion sensors, and microscope slides) were assembled into a network of "materials that belong in a science supply room," and as such, transcended their concrete physicality to become tools of abstract inquiry. Others items (e.g., candy, toothpicks, marshmallows) were classified as "concrete" in that their apparent function was to serve as "pedagogical accommodations" to make science concepts more accessible to a "general" audience via multimodal representation and hands-on activities.

Abstract/concrete distinguished not only methods of science instruction, but also the types of thinking (and thinkers) that the courses were designed to serve. Physical Science students were regarded as "much better with concrete things—to have to say something about them is a really difficult skill for them" (Interview LC, 2013). In contrast, Math Physics students were assumed to "see a greater degree of concreteness in abstract representations" like graphs (Interview MS, 2014). This difference was attributed in part to inferences about students' families: "I would expect that the professions that the parents of the Math Physics students are in involve those kinds of skills, and that some of those things have been shared with their children" (Interview MS, 2014). Making concepts tangible through hands-on demonstrations was described as "not necessarily bad" for Math Physics students, but it was "vital for the General Physics students to see those things" (Interview MS, 2014). Within this logic, abstract thinkers could understand concrete instruction, but these activities would only slow down the transmission of disciplinary knowledge and skills. What this discussion has not yet addressed, however, is how a particular student could be mapped along this developmental scale as requiring greater rigor versus greater relevance. Under what rules of perception, or through what techniques, could one "see" readiness for science learning?

Standardized science tests: Calculating probable trajectories. In schools today, only certain techniques generate "data" recognized as reliable and valid indicators of what a particular student needs or whether those students or their teachers are making adequate progress. What transforms a particular interaction or inscription into data—versus noise—depends on theoretical assumptions about what this data point is about, and what it suggests about a student in relation to specific outcomes of concern. At AHS, scores from standardized tests held top priority in the state's official school report cards and new teacher evaluation system (see Braaten, Bradford, K. Kirchgasler, & Barocas, 2017).[51]

A consensus among AHS science teachers was that data from external assessments provided little of pedagogical value, since they had no access to the specific test questions or to their students' responses (e.g., Interview LC, 2015; see also Horn et al., 2015). Many raised concerns about the tests themselves, arguing, for instance, that the Educational Planning and Assessment System (EPAS) in science was "just a reading test" (Interview EP, 2014). Despite critiques of their validity and reliability, EPAS data carried increasing weight in the course placement process.[52] Officially designated as "assessments of college and career readiness" (ACT, 2012, p. 1), the EPAS data were cited as indicators of students' past effort in each subject, their present knowledge and skills, and their likely future trajectories in terms of college or careers.

Built into the numbers were predictions of time and space. Standardized tests, like the EPAS Science, assessed proficiency in science as a unified domain.[53] Quantified as a single

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[51] While standardized tests were around long before the founding of AHS in the 1960s, teachers in the study reported a recent shift in the status given to standardized test data that culminated in the district's 2013 strategic framework of data-driven reforms (Interview MS, 2015).

[52] The proposed algorithm to identify which Physical Science students were ready for General Physics was not a new idea at AHS. Over the past few years, it seemed to some teachers that guidance counselors had started putting greater stock in standardized test data than course grades, and that as a result, more students were ending up "misplaced" in a course too challenging for them (Interview MS, 2015). Given these concerns, but also recognizing the increasing emphasis on externally validated data, teachers attempted to design an algorithm that used standardized test scores to predict a student's grades in a higher-level course. The idea was to predict who was being "misplaced" in Math Physics by determining a weighted calculation of science and math scores that correlated with last year's course grades. As one teacher explained, the choice to use EPAS scores in designing the algorithm was not out of trust in the test's validity, but as a communicative strategy to give counselors an objective and acceptable formula to guide students' course placement decisions (Interview NM, 2014). Eventually, the attempt was abandoned after finding low correlations between EPAS data and course grades.

[53] Both teachers and students raised concerns about how the notion of a single variable of science achievement obscured important differences in what was expected in a biology, chemistry, or physics class (Interview TO, 2015).

variable, differences appeared strictly along a number line as a matter of degree. The resulting data gave the impression of students scattered across a wide range of levels "in science." While the normal distribution of science achievement may be an artifact of statistical theory and technique, it provided a way of seeing and anticipating reality: "In a perfectly distributed world, you'd get some high flyers in every class . . . you'd have your middle of the roaders, and then you'd have the lower levels" (Interview SF, 2014). Granted ontological status, the normal curve posited different types of learners that should be found in predictable proportions within the student body. The numbers could be extrapolated to infer how abstractly students could reason, how much prior knowledge they brought, and how quickly they could learn.

The ordering capacity of numbers also interacted with populational reasoning (see Rose, 1991). Because numbers are amenable to correlation with categorical variables, purported differences in readiness could be envisioned between demographic groups—a difference visualized most often as the racial achievement gap. This gap appeared in slides at AHS meetings and also came up in informal discussions of equity or diversity (Meeting fieldnotes, 2014). The data made it possible to locate demographic groups at a single point along a number line. Teachers raised concerns that these graphs were frequently displayed, but rarely used to provoke analysis about institutional or interpersonal racism: "It's like, 'Look at this number.' It's not the same as, How are we influencing this? It's not, How does this affect us? How does this affect our classroom?" (Interview AD, 2015). One teacher brought up the Pygmalion study of teacher expectations (Rosenthal & Jacobson, 1963) in questioning the impact of repeated displays of achievement gap graphs: "Would there be sort of a Pygmalion effect? . . . Is seeing these comparisons affecting us and how we teach? Probably not consciously, and no one would admit to it being consciously. But subconsciously, I'll bet it does" (Interview NM, 2015).

Data were to guide teachers in setting SMART goals, or objectives that were specific, measurable, attainable, results-focused, and time-bound (Interview MS, 2015). Since number lines presume an even spacing between each integer, it appeared logical to calculate a specific percentage improvement as a realistic goal for particular demographic of students. The AHS School Improvement Plan used disaggregated data to highlight two focal groups of concern: African American students and students with special needs (Meeting fieldnotes, 2013). The plan established distinct numerical targets for each focal group. Since only 43% of African American students were currently considered "on track to graduate," the official objective was an incremental 5% improvement, or getting 48% of this group on track to graduate. In recognizing "where" a particular demographic group seemed to be starting, the logic was that setting an attainable goal would motivate those students and their teachers to move at least five percentage points in the right direction. In this way, achievement data calibrated expectations of realistic student growth, clarifying the boundaries of educators' responsibility.

Even when achievement gaps were taken to indicate unequal experiences in past schooling rather than internalized attributes of learners, the proposed solution was not necessarily to give all students access to the same curriculum. Proposals to reduce the number of science course levels were seen as a "disservice" to students from underperforming groups, given the perceived mismatch between their "achievement level" (generalized from demographic data) and the rigorous expectations and pacing of the upper-level course (Interview MS, 2015; see also Horn, 2007). The number line brought a new precision to discussions by calculating readiness in racialized terms, circumscribing what appeared pedagogically possible and educationally equitable for a particular demographic group.

In district-wide communications, standardized test data were upheld as having greater objectivity and external validity than any teacher-designed assessment or evaluation. The message was that the data could and should override a teacher's in-person perception of student capabilities (Braaten, K. Kirchgasler, Bradford, and Barocas, 2015). The Biology 2 course, for instance, had been redesigned to provide a "less challenging" option in light of demographic shifts in the district (see chapter 5). EPAS data shaped perceptions of students in the new course:

> Late bloomer is a good expression to describe the nature of Bio 2. So you come in here, and they seem to be pretty focused on the task at hand. But most of them will probably be at 16, 17, 18, 19 on EPAS scores for science. You know, they're not strong science students. Yet their behavior would lead you to believe otherwise, because they typically are attending very well. They're just in catch-up mode. . . . So I probably focus more on science process from a simplistic point of view . . . like here's what most of them can handle, and then we keep tweaking it and pushing. (Interview KC, 2014)

In other words, while the students' daily actions in class suggested that they were "strong science students," their lower average scores (16-19) on the EPAS test for science achieved a greater truth-value. These data provided more definitive evidence of the "nature of Bio 2" as a distinct kind of student—in this case as "late bloomers" who remained in "catch-up mode." This developmental lateness was taken as indicating a need for curricular differentiation by adopting a more "simplistic point of view," and tailoring instruction to "what most of them can handle."

Terms like "late bloomer" did not likely appear in the score reports of the EPAS system. This speaks to the way that multiple psychological theories and metrics overlapped and converged to produce the problem space of the "Bio 2 student." The merging of standardized test data and the developmental scale made it possible to map readiness and rigor onto the same number line. In broad strokes, lower-level courses focused on getting students up to benchmark on assessments of college and career readiness. Students scoring below benchmark were assumed to lack a basic level of scientific or abstract reasoning, and therefore to benefit from more concrete forms of instruction. In contrast, higher-level courses aimed to serve those who had already surpassed benchmarks of minimal proficiency. For this subset of students, the emphasis would more likely be placed on preparing for college science courses through more rigorous, abstract, and "math-heavy" modes of instruction.

To Defer and to Make Differ: Why Historicize Readiness

If I return to the AHS video presented to students to guide their course selection (see chapter 2), the question posed was, "What makes an honors student?" The teacher in the video responds:

> A successful honors-level student is well-organized, and has really good attendance, and is intellectually curious, and is willing to do an hour or so of homework a night. . . . If you're ready for that, then you're welcome. Come! (Classroom artifact, 2014)

The issue here is not when but if you are ready to be the kind of person recognized as an honors-level student. While some of the criteria appear to be voluntary choices (e.g., "willing to do homework"), others involve the verb to-be (e.g., "is intellectually curious"). Even though not ready could imply a delay rather than an exclusion, the stages of general and honors do not occur in sequence but as simultaneous events.[54] General-level is not something you do to get to honors-level—it is something you are. In this way, the qualities listed of the honors-level student are not

[54] As one teacher explained, "I don't know how it is that students are chosen for Honors Biology, but once they're set on that Honors Biology track, then it's the Honors Biology students that generally take Math Physics, and Math Physics students that generally take Chemistry Honors and AP, and then students that took Math Physics with very few exceptions are the students who go on to take Math Physics 2 and Advanced Science and Engineering. And the Honors Bio students are typically the students who go on to take Anatomy and Physiology" (Interview MS, 2015). Another raised the concern that: "People say, 'They're not ready.' But then they don't have the chance to take it if they were ready in the future" (Interview PB, 2015).

goals to work towards, but signs of a different type of student upon whom welcome is bestowed. The non-honors student is both deferred (in the sense of being postponed) and made to differ (Derrida, 1982, p. 7). Readiness is not a temporary state, but a kind of person.

As explored in this chapter, Readiness made up the "general-level student," the "Bio 2" student, and the "Phy-Sci kid." The latter, for instance, was discussed as "not ready" with the "math skills" or the "school skills" they need to succeed in General Physics (Meeting fieldnotes, 2013). Do the not-ready need more time before being welcomed to the space of the ready, or is not-readiness the marker of never-ready, or arrested development?[55] The ambivalence of Readiness is also registered in the AHS curriculum guide:

> Physical Science is intended to meet the second year requirement in science for those students who are not intending on electing another science course. This course may also be a good stepping-stone for students, who received a C or D in Biology, but want to eventually take more science courses, such as physics, chemistry or Biology 2. (AHS Curriculum Guide, 2013-2014)

Physical Science operates here as an oppositional space, intended for "those students" rather than these. It is both a science course and not a science course, recognized as a science for high school graduation, but not in the college admissions process. While the explicit rule—a minimum requirement for "those students"—is only two science courses to graduate, the implicit norm—which "these students" follow—is taking the three or four science courses required by colleges. And yet Physical Science does not count as one. Physical Science, then, is intended for those who are not intending (or intended) to take another science course; that is, to attend college. Deference in time—a delay—is achieved through a difference in space (Derrida, 1982). Physical

[55] Lesko (2012) discusses this phenomenon in her analysis of the history of adolescence, where psychologists distinguished between the white male who had to pass through adolescence on the way to adulthood versus the females and racialized groups who were presumed to languish in adolescence, never-ready as fully rational adults.

Science may serve optimistically as a "stepping stone"—a detour—yet the delay of "eventually" produces distinct eventualities by making a different kind of person: the "Phy-Sci student."

There is a strange grammatical construction here: "Physical Science is intended for those students not intending to take more science courses." Who is the subject of this proposition? It could be "those students," for they are figured here as not intending to take more science. Yet the first subject is effaced: Physical Science is intended for a particular group of students, but nobody is present to do the intending. No one *means* for Physical Science to be the only science course that is actually not a science course in the eyes of college admissions, and one that predominantly serves students of color. In fact, the subject is perpetually absent: "Physical Science is a dumping ground" (Interview LC, 2013). "We do have the combination of African-American, special ed males that seem to find their way into Physical Science" (Meeting fieldnotes, 2013). "The largest amount of non-graduating students will have passed through here [i.e., Physical Science]" (Interview LC, 2013). Are these effects of unintended causes? Actions without subjects?

How can we begin to account for the historical production of those rules of perception—or for the delegated intentions of historical actors that lie as "sleeping policemen" (Latour, 1994) within inherited tools and techniques—and how these rules and tools act in the present, albeit in nondeterministic ways? Of concern is not only tracking as an institutional imperative and its discriminatory effects, but also the principles and practices of differentiation that undergird tracking. Sorting students into hierarchical levels is not an aberration but a normal part of U.S. schooling, one embedded in the frequent call amongst school administrators and teacher educators for teachers to meet all students "where they are at."

Consider how the new state teacher evaluation system, with its focus on quantitative achievement data and “actionable” goals, asked teachers to set distinct percentages as “realistic” student learning outcomes for target racial and ethnic groups (Meeting fieldnotes, 2014). Similar notions of realistic goals appear in pre-service teacher evaluations. In current teacher education reforms, a core dimension of professional expertise is determining what kind of instruction is developmentally appropriate for a particular group of students (e.g., Stanford Center for Assessment, Learning and Equity [SCALE], 2015b).

What appears as developmentally appropriate is linked to distinctions of concrete versus abstract. In the pre-service teacher performance assessment called the edTPA, one of the criteria assessed is how well secondary science teaching candidates are “using knowledge of students to inform teaching and learning” (SCALE, 2015b, p. 9). A response that invokes “deficit thinking” earns a candidate an “AUTOMATIC 1” (the lowest score) (p. 9). However, this edTPA rubric for secondary science gives as exemplary (level 5) a statement that identifies a class of students in developmental terms: “My students are in the concrete operational stage of Piaget’s cognitive development theory,” and so are just “starting to make sense of abstract thinking (temperature)” (p. 11). Rather than deficit thinking, this statement is given as the strongest exemplar of using knowledge of students to inform teaching by explaining “how principles of research or theory support or set a foundation for their planning decisions” (p. 10). When, how, and under what assumptions was that foundation laid?

The classification of science learners as concrete, for instance, appeared in 1970s science education research inscribing Black high schoolers as “arrested” in this Piagetian stage and as thus benefitting from hands-on lessons in low-level courses (e.g., Nordland, Lawson, & Kahle, 1974; Chiappetta, 1976). This raises the question of how pre-service and in-service teachers today may be disciplined (e.g., through new performance assessments and systems to rank educator effectiveness) to use data and theories that reinscribe links between student diversity and levels of developmental readiness.

The next chapter explores how it became possible to see student "diversity" as "heterogeneity" along a linear scale, where a spectrum of cognitive readiness is matched with a hierarchy of curricular rigor. Consider attempts to eliminate the cultural bias of specific items on standardized tests of science achievement—a goal that holds out the possibility of purifying psychological metrics of anything cultural. The chapter will demonstrate how practices of science education research and pedagogy—including "scientific thinking" as a psychological attribute and a pedagogical objective—are cultural phenomena in a much deeper way than is usually assumed.

Tracking research often invokes a dichotomy of dominant versus marginalized groups in order to advocate for more proportionate representation in high-status spaces, or to design pedagogies for heterogeneous classrooms. A limit, however, is that the criteria by which students are classified as heterogeneous—e.g., higher or lower in science achievement, knowledge, skills—are not usually called into question. Returning to Rancière's (2009) question, "could we not invert the terms of the problem by asking if it is not precisely the desire to abolish the distance that creates it?" (p. 12). Inherited from the past and continually reconfigured, how do the theories and techniques of Readiness contribute to producing the very distinctions they mean to eliminate?

Chapter 4. The Making of Scientific Americans and Unready Others: From "Immature Minds" to "Underperforming Groups"

The recent U.S. Next Generation Science Standards (NGSS) seek to address inequity by "making diversity visible" (NGSS Lead States, 2013a, p. 364). Highlighting the problem of some racial and ethnic groups being historically underserved in science classrooms, the proposed solution, however, is not giving all students the same science education. Rather, the NGSS recommend providing "equitable learning opportunities," where equitable means adapting instruction to the "learning needs of the nation's increasingly diverse student population" (p. 359). There is a paradox here. Diagnosed with diverse learning needs, students from underrepresented groups are prescribed distinct pedagogies in the name of equity. This chapter explores how it became possible to think about different "kinds" of students as requiring different forms of science education—more abstract and advanced for some, and more concrete and applied to daily life for others.

While the NGSS maintain that all children can and should be taught to think more like scientists, some individuals and groups are projected as further along that imagined trajectory than others. Those identified as "major racial and ethnic groups" or "economically disadvantaged" are matched with strategies to make science more accessible and concrete (e.g., multimodal representations to review below-grade-level material) (NGSS Lead States, 2013b, 2013c). Meanwhile, those identified as "gifted and talented" are to be given instruction that is more open-ended and abstract (e.g., self-directed projects to explore above-grade-level material) (NGSS Lead States, 2013h). How is it that "equitable learning opportunities" rest on the premise that demographic categories are not equally ready for abstract thought or open-ended inquiry? How did it become reasonable to suggest that sociopolitical classifications of race and ethnicity would have anything to do with a person's cognitive congruity with scientists? And how did the figure of the scientist become a prototype that the mind of every child is hoped to approximate?

Exploring these questions requires rethinking the conflation of science and school science (see chapter 1). Despite comparisons of K-12 students to miniature scientists, schoolchildren are not professional scientists. Given the dynamic nature of scientific disciplines, selections must be made about what to include in the curriculum and what to leave out. These decisions cannot be deduced from the natural sciences but are informed by some sense of why children in a particular society should learn science. Science education, then, is not just about science, or having students do what scientists do. It is also about schools fostering the development of certain modes of thought and behavior in their future citizens. At issue is how social science theories and techniques have cut and spliced the natural science disciplines together with other elements to project "science" as a unique feature of rational, developed minds.

The previous chapter considered how practices to measure, classify, and cultivate students' Readiness for scientific thinking function as an ordering strategy in a U.S. high school today. I explored how developmental theories coupled with standardized test data generated distinctions in Readiness that seemed to necessitate maintaining a tracking system beset by racial disparities. In this chapter, I consider how Readiness only appears as a scientific object through what Latour (2000) calls a historical network of production. While the elements of this network have been substituted and rearranged, two psychological techniques have remained central over the course of the twentieth century: the developmental scale and the science standardized test. Over time, these techniques have acquired, discarded, and reforged linkages to other elements, including evolutionary theories, narratives of American exceptionalism, constructs of scientific thinking, Piagetian stage theories, political discourses of accessibility, and new protocols of data-driven decision making.

These partial substitutions and rearrangements make it hard to recognize that, while many elements have changed, today's network of Readiness still generates distinctions in both individualizing and demographic terms. As the analysis in this chapter suggests, the following assumptions persist: 1) that each child's mind possesses a stable and calculable amount of scientific reasoning that develops along a predictable trajectory; 2) that scientific reason is not uniformly distributed in the U.S. citizenry; and 3) that some populations are, on average, much farther than others from the qualities and habits of mind that allegedly distinguish scientific experts.

It is striking that these hierarchical distinctions have managed to escape notice in our present moment of increasing sensitivity to concerns of equity and diversity. In fact, as noted above, binaries of concrete/abstract and non-dominant/gifted-and-talented appear in the very same documents that emphasize the dangers of biased stereotypes and deficit thinking (e.g., NGSS Lead States, 2013a). This may owe to the fact that theories and practices linked to Readiness remain deeply lodged in science education as a field of study and as a school subject. Generated by a heterogeneous set of elements, the notion of a demographic difference in scientific reasoning has become taken for granted as itself the inequality that pre-exists inspection, and that must be remediated in order to permit greater social equality, political access, or cultural inclusion.

National Hopes and Fears: Visualizing Achievement Gaps and Unassimilated Attitudes

> In America, it should be possible, even essential, to elevate the achievement of low-performing at-risk groups while simultaneously lifting the ceiling of achievement for our future innovators.

—National Science Foundation, 2010 (cited in NGSS Lead States, 2013a, p. 370)

> The science teacher of today [must] realize that his place in the democracy is that of bringing this unassimilated material into at least as close harmony with the original stock of the nation as it is possible to do.

—George W. Hunter, *General Science Quarterly,* 1922 (p. 526)

Almost a century apart, the NGSS and *General Science Quarterly (GSQ)* link their calls for science education reform to hopes and fears about the country's future. Both assert a difference between populations—whether the unscientific minds of the unassimilated masses (1920s), or the science achievement gap between demographic groups (2010s). Both connect these distinctions to national anxieties—whether the U.S. students lagging behind international competitors (NGSS Lead States, 2013a), or the degeneration of the American race (Grier, 1920). Within this reasoning, those feared to have fallen below the norm—i.e., "low-performing at-risk groups" or "unassimilated material" (see epigraphs above)—need science that is concrete and applied to daily life. Hope is placed in the potential of education to include—and improve—those future citizens. Meanwhile, those who already exemplify the country's ideals—i.e., "our future innovators" or "the original stock of the nation"—appear to require more advanced and abstract science to ensure the nation's progress. These quotes are not just rhetoric. They materialize a comparative reason that divides children entering science classrooms, launching them onto distinct and hierarchical trajectories.

As discussed in prior chapters, different types of students had already been formulated as a pedagogical concern by the 1920s. Science education scholars began calling for a new cultural purpose for teaching science that would Americanize students by democratizing science (Massachusetts State Committee on General Science, 1916). How did this become a reasonable statement? How did populations cast as not-yet-American also appear as not-yet-scientific, and therefore as incapable of accessing the existing science curriculum? Put another way, how did school science solidify as a set of cultural dispositions, and therefore as capable of Americanizing students?

Throughout the chapter, my concern is not with the internal validity or reliability of test items used to assess science ability, achievement, or readiness, but with how changing practices of psychological experimentation and pedagogy provided new grounds for seeing differences between children and matching them with distinct levels of science education.[56] The analysis brings into focus an irony of current policy reforms. That is, strategies recommended to make science instruction "culturally relevant" to "low-performing at-risk groups" in the 2010s closely resemble those recommended to adapt instruction for "immature minds" in the 1920s. In historicizing Readiness, I am interested in how shifting distinctions of who is and is not ready for scientific thinking became entangled with social appraisals of who is and is not American.

The chapter is organized as follows. First, I examine early twentieth-century science education scholarship and its call to use psychology to visualize differences in pupils in terms of the development of scientific attitudes. Next, I highlight two of these psychological techniques. The first is the developmental scale, which mapped the reasoning of individuals and racial groups as more or less scientific. The second is the standardized test, which conceptualized science ability as a calculable trait. I will argue that these techniques formed a grid of practices that contributed to the stratification of high school science, with a higher level for preparing potential scientists and a lower level targeting those seen as unready for basic scientific reasoning. I conclude by returning to the NGSS to ask how strategies for teaching science to

[56] As discussed in chapter 2, the aim is to draw attention to the historically available practices that permitted such statements to be thought, articulated, and corroborated in their respective times as peer-reviewed research rather than unjustified stereotype.

"diverse" groups rely on similar classificatory techniques that may undermine efforts to promote equity.

General Science: A Course to Americanize "Immature Minds" (1920s)

Today, the science achievement gap between racial and ethnic groups is a taken-for-granted part of the educational landscape in the United States. It provides a central framing of equity and diversity in recent policy, operating as what science studies scholars call an obligatory passage point (Callon, 1986) for scholarly inquiry and policy reform. It organizes classroom practice, orienting the aims and methods of higher- versus lower-level science courses in U.S. high schools (see chapter 3). In its current ubiquity, it is easy to forget that the achievement gap is a relatively new invention. It was not always possible to think of students as belonging to categories that differ in their Readiness to access higher levels of science knowledge and thinking.

I will return now to the 1920s. School science was becoming reorganized through psychology, a discipline that provided new grounds for deciding what should to be taught to whom, and in what order. Drawing on psychological theories and tools, U.S. high schools were becoming stratified into curricular levels ordered along a developmental scale. Scientific thinking became a measureable trait, assumed to vary along factors of mental capacity, sex, and racial stock. Given this confluence of changes, this section will treat the 1920s as a vantage point to recall how today's formulation of a science achievement gap was not a foregone conclusion but emerged out of particular social conditions, epistemic virtues, and administrative concerns.

The Social Question: Psychologizing the American mind.

> Looking at the problem from a psychological point of view, it is not so important whether one is teaching biology, physics, or general science to these students, as it is important

that the scientific attitude is aroused in these adolescents.

—N. J. Quickstad, *General Science Quarterly*, 1917 (pp. 156-157)

In the early 1900s, public schooling promised to instill the qualities needed for American citizenship. While the "proper training of the rising generation" had long been an objective of U.S. common schools, nineteenth-century scholars had viewed the "cause of Education" in religious terms as the "highest earthly duty of the risen" (e.g., Mann, 1867b, p. 149). A twentieth-century innovation, as Quickstad explained to fellow science educators and scholars (see epigraph), was "looking at the problem from a psychological point of view." In place of the child who could become "angel-like or fiend-like" (Mann, 1867a, p. 346) was a new human kind that emerged as a scientific object in child-study and educational psychology: the adolescent. This section briefly considers how arousing a scientific attitude amongst particular adolescents became a pedagogical objective linked to national anxieties.

At the turn of the twentieth century, the imagined unity of Americanness gravitated around a notion of science that evoked qualities of autonomy, independence, and absolute power (Morrison, 1992). Founding images of an enlightened city on a hill combined with a new vision of America as the height of civilization, whose evolutionary progress depended on maintaining the inventive genius of the American people (Popkewitz, 2008). At this time, the Social Question expressed hopes and fears of how rapid social change both enabled and threatened America's exceptional status, located in technological innovation, modernization and urbanization. As Nye (1994) argues, this marked a shift in the nation's sense of exceptionalism from the supreme power of its natural landscapes (e.g., the Grand Canyon) to its superior command over nature through technological progress (e.g., the Hoover Dam). Throughout *GSQ,* many articles highlighted the feats of technology transforming the modern American home and city, while science was positioned as the antithesis of the tradition, superstition, and ignorance of foreigners.

Also around this time, the social sciences began applying principles of scientific planning to human improvement, directed toward new sociological and racial typologies as sites of study and intervention. Deviance changed registers from willful recalcitrance requiring punishment to unintentional behavior needing psychological diagnosis and pedagogical management (Franklin, 1994; Rose, 1985). Of utmost concern was the moral disorder of cities attributed to the migration of "Negroes" and immigration of "foreigners" from southern and eastern Europe. Societal problems were imputed to the minds and habits of these racialized populations, and mass schooling took on importance as a site of their rescue and reform. High schools became tiered and acquired a new stated purpose: Americanizing the masses.

Since science came to figure prominently in the renewed narrative of American exceptionalism (Nye, 1994), science education could see itself as having a special role in transforming the masses into "straight-thinking Americans" (Whitman, 1921, p. 88). Yet this new notion of science—as superior reasoning, civilized living, and national belonging—was not part of the curriculum in existing courses. Physics and chemistry became seen as inappropriate for the masses—specialized subjects suitable only for the few judged capable of quantitative abstractions (Woodhull, 1918, p. 223). General science was proposed as a new kind of science education to help the masses develop scientific attitudes through concrete projects.

The problem of pedagogy was reformulated as a mismatch between existing curricula and the "immature minds" entering schools (e.g., Downing, 1925). Psychologies of learning—including G. Stanley Hall's child study, Edward Thorndike's connectionism, and John Dewey's functionalism—codified school science as universal knowledge and a unified method of thought whose transmission must be tailored to children's distinct natures, interests, and needs—an "epistemology for the masses" (Ruldoph, 2005a, p. 341). Science education scholars proposed a shift from following the logical organization of the disciplines to a psychological organization (Quickstad, 1917). Instead of cultivating pupils' moral character, science educators would now seek to foster a scientific attitude—a quality feared lacking in certain adolescents (see epigraph, above). For Hall and his contemporaries, "adolescence was singled out as a crucial point at which an individual (and a race) leaped to a developed, superior, Western selfhood or remained arrested in a savage state" (Lesko, 2012, p. 29). The general science goal of developing scientific attitudes among the masses would emerge from a grid of classificatory techniques that fabricated categories of students as not-yet possessing the powers of independent thought and autonomous action ascribed to the idealized American.

School science, then, was no mere subset of the scientific disciplines, but expressed historically and culturally specific norms of who the child was and needed to be, and which families and communities were deemed least prepared to raise their children for responsible citizenship. I am interested here in how the science to be learned in school—e.g., developing into a straight-thinking American—became co-constitutive with pathologizing fears of those who do not think like "us." Next, I explore the first of two psychological tools by asking how a developmental scale of Readiness made it possible to reorganize science education along an evolutionary trajectory.

The developmental scale: Mapping scientific thinking versus primitive minds.

> It is the business of education to take the little animal, the baby, and bring him as rapidly as possible through the stages of savagery and primitive civilization to the twentieth century . . . striving to establish in the pupil the scientific attitude of mind.
>
> —Elliot Downing, *Teaching Science in the Schools*, 1925 (pp. 80-81)

The "scientific attitude," proposed by Downing and others as the objective of general science, was defined as a quality of mind differentiating stages of human evolution. Through this psychological construct, the attributes of the rational American citizen showed up in contrast with those of the animal, the baby, and the "savage" (see epigraph, above). This section examines how a developmental scale stabilized science as a higher mode of thinking distinguishing professional scientists from the public, adults from children, and allegedly civilized races from so-called primitive ones. The scale offered new means of producing and sorting difference in the science classroom by ordering school science aims in a hierarchical sequence.

In *General Science Quarterly (GSQ)*, scientific thinking was both a universal endpoint of mental development and a distinctive feature of the "best American stocks" (Grier, 1920, p. 47). A popularly cited text in *GSQ* was Dewey's (1910) *How We Think.* This functionalist psychology text used everyday examples to outline a classificatory framework of levels of thinking, contrasting a "savage" navigating the wilderness with the systematic foresight of a "civilized man" building a highway (p. 16). Scientific thinking was argued to be the upper anchor of human evolution: just as it "makes the difference between savage man and brute… so this trait makes the difference between civilized man and savage" (p. 15). This vertical chain of comparisons followed the principles of recapitulation theory, which held that the individual passes through all of the stages of the human race from the primitive to the modern, and that only the European was capable of adult rationality (Gould, 1977).

Scientific thinking, as an object of science education research, marked children's progress towards adult rationality along an evolutionary scale that also generated and ordered racial distinctions. The scale projected a historically and culturally particular mode of thought as the total definition of human reason (Wynter, 1995), rendering other modes of thinking—and thinkers—as non-reasoning and unready for civic participation. The non-reason was not merely about reason, but embodied cultural judgments. For instance, the forms of moral disorder that social scientists feared to be gripping U.S. cities—poverty, crime, corruption, pollution, and disease—were all traced back to the allegedly unscientific attitudes of the masses (Caldwell, 1904).

One reformer explained that, "The need of Americanization is not alone confined to the mental attitude of the foreigner . . . a large proportion of Americans are in need of physical and perhaps mental Americanization" (Grier, 1920, p. 47). Evident here is that American is not merely a nationality but a kind of person, because even Americans need to be Americanized. "Straight-line American reasoning" (p. 48) only appeared against the presumed impulsivity, ignorance, and superstition of "foreigners" and "inferior races." In science education scholars' uptake of *How We Think*, the "we" demarcated a uniquely modern American race, while the "think" located racialized distinctions along a trajectory of psychological development. The fabricated essence of those Others helped define who an American was, where the very identity of American relied upon calling forth and casting out a non-identity (Morrison, 1992).

The developmental scale materialized not only in theoretical discussions of different levels of thinking, but also in the daily practices of the general science curriculum. In *GSQ,* concerns about the problematic pupil focused on "inferior southern European stocks" (Grier, 1920, p. 47). Meanwhile, figures of the "Negro" and "Indian"—segregated to non-mainstream schools—appeared instead as foils for scientific thinking and progress.[57]

[57] Concerns over how to adapt science instruction to purportedly immature minds tended to focus on the foreign-born, such as "inferior southern European stocks" (Grier, 1920, p. 47). In contrast, the figures of the "Negro" and the "Indian" were not cast in the same role of problematic pupils in general science classrooms—unsurprising given the legal segregation of Negro industrial education and Indian boarding and day schools.

GSQ featured a play for general science pupils to act out that was titled, "The Evolution of Man's Communication" (Craig, 1924). The play evokes what Nye (1994) has discussed as the American technological sublime, as it extols American ingenuity by depicting the smoke signals of "Indians" in dramatic contrast with a later scene in which Alexander Graham Bell invents the telephone. The telephone scene also features Bell's "negro servant [sic]" who first tries to convince Bell to give up and take a nap, then expresses bewilderment over how the telephone works, and finally declares himself in awe of Bell's genius (p. 435).[58] The play cast "African" and "Indian" as unready to understand or use technologies wrought by purportedly superior minds, let alone to invent their own. As Morrison (1992) describes in *Playing in the Dark*, American literature is replete with examples of a fabricated Africanist (and also Indianist) presence, positioned as belonging to the past and occupying an inferior position in the present.

At stake is not only the negative images of a racialized Other, but the way in which the making of this Other becomes constitutive in inventing an idealized self. The play demonstrates how the contour of the developmental scale takes shape through cultural imaginaries that fabricate not only the primitive "Indian" and "Negro servant," but also Alexander Graham Bell "himself"—depicted as a bright, self-reliant American, uniquely capable of harnessing the power of science to serve the public interest. These figures "flesh out" the psychological theory, permitting the scale to be read onto bodies as distinct human kinds.[59]

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[58] The science teacher notes that the inclusion of the "negro servant" was a deliberate dramatic choice: "According to reliable sources, Bell was assisted by a friend in the invention of the telephone, but for dramatic purposes the group thought it better to have a negro [sic] servant assist him" (Craig, 1924, p. 434). The servant's stage directions make clear the dramatic contrasts being drawn: the servant's yawning in contrast with Bell "busying himself," his apathy with Bell's devotion to improve communication for fellow man, and his "head-scratching" for Bell's scientific understanding (pp. 434-435). These exemplify what Morrison (1992) discusses in *Playing in the Dark* as an Africanist presence (see chapter 2).

[59] Consider the account of one scholar, who closes an article about the purpose of general science education by recounting a moment of discovery:

> Three or four decades ago, if we wanted to indicate that a man had great knowledge we always attributed to him great powers of memory. . . . Afterward it dawned upon us that a table waiter surpassed professors and

The fabrication of racialized Others is also visible in a *GSQ* article outlining the problem that the new general science course was attempting to solve. To explain the conditions giving rise to this problem, Quickstad (1917) offers an "Early History of Science Development," starting with "primitive" tribes wandering in the Sahara (p. 154). Those tribes, Quickstad explained, held wide-ranging views of the world around them; only through the progressive organization of European society (first into guilds and then into nations) did "Man" recognize the inadequacy of these varied explanations of nature and begin to develop "skepticism," which formed the "necessary step in building up the scientific attitude" (p. 154). Consistent with recapitulation theory, the conception of one's own mind and civilization as highly developed relied upon projecting a less developed version. The invention of the "African" as a psychological type served as a conceptual resource not only for theorizing the undeveloped mind of the child (see C. Kirchgasler, 2017a), but also for explaining how scientific progress sprang from the unique psychological traits of those of European descent.

Those traits, Quickstad (1917) went on to explain, were the very ones that public schools must now attempt to cultivate in a changing population. "The scientific attitude is one of the later attitudes that one can come to," he wrote, and since the "intellectual soil is not right for sowing scientific attitude" until adolescence (p. 155), this late window demanded careful planning. High school science would have to be reorganized in order to meet the needs of the "masses of young folk" that did not belong on the "path for the training of research workers," but instead must be "prepar[ed] for the ordinary activities of life" (p. 155). Whereas specialized science courses

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> presidents in the matter of memory. I remember one of the first shocks I got on that theory of education. Many years ago while attending a teachers convention at Saratoga several hundred of us passed into the hotel dining room and a big, burly negro [sic] took our hats without checking them. When we came out he astonished us by handing each his own hat. And I said, "What is the use of a college education?" (Woodhull, 1917, p. 140).

This Africanist figure, in the pattern Morrison (1992) has noted, is narrated as a catalyst for the protagonist's self-realization—the superiority of abstract, scientific reason that goes beyond memorization, occupying a higher order of thought presumed beyond the capacity of a table waiter.

followed the logical organization of each discipline from an “adult’s point of view” (p. 157), general science instead would adopt the “child’s point of view,” using elementary pedagogies to present science “in a concrete form” (p. 157). Children were “not interested in the abstract fact,” Quickstad wrote, but “jump in and speculate, so with primitive man” (p. 154). For the masses of pupils that more closely resembled the child (or “primitive”) than the adult (or “research worker”), he concluded, “We cannot teach science and scientific attitude in the limited time that one year requires. So it seems to me that . . . we must teach the one phase—namely, the scientific attitude” (p. 157).

Several points are salient here. First, the correspondence asserted between the primitive, the child, and the general science pupil translates a distinct psychological “kind” of person into a new pedagogical “kind”: one uninterested in abstract logic and only capable of apprehending science in concrete form. Second, distinctions in time generate differences in space. Because of different rates at which pupils were assumed to reach the critical window of adolescence, they were pinpointed at an earlier stage (or younger age) on a uniform pathway. Because of the limited time pupils spent in high school, educators could not afford to wait until the time was ripe for abstraction, but must instead meet the pupils “where they were at,” and in so doing, to recognize that they were on a different pathway entirely—that of prospective citizen rather than potential scientist. Third, psychological principles not only dictated a differentiation in the methods of instruction (i.e., concrete versus abstract), but also a displacement in its ultimate objective (i.e., not teaching science, but a scientific attitude).

The developmental scale may have been an invention, but it was not an illusion, as it could act on the world in material ways. According to the “recapitulatory point of view” (Downing, 1925, p. 74), it was necessary to reorganize science education as a differentiated, developmental progression (see Figure 4.1). At the bottom end of the sequence (Downing, 1917), everyone could, and must, learn healthy habits (see chapter 8). Moving up the scale, the aims became more specialized and were assumed to be within the mental capacities of fewer students. At the top was the quantitative, abstract knowledge for those seen as mature students of science.

Recapitulatory principles provided the grounds for curricular differentiation on the basis of mental readiness, given that not everyone was thought to progress through the stages at the same rate. According to Thorndike's law of readiness, pupils vary in their readiness for learning due to differences in the bonds (both innate and acquired) between stimuli and proper responses (Kilpatrick, 1922). Following this law, demanding that all students take physics and chemistry would be an attempt "to force nature," forgetting that the requisite attitude develops "relatively late in youthful minds as in that of the race" (Woodhull, 1918, p. 49).[60] After the early stages in which a baby learns bodily movement and object manipulation, the next stage is when "thinking is done in connection with doing," followed by "thinking of a higher order where the interest is the intellectual ordering of thoughts and concepts," and, the psychologist added, "not all reach this stage" (Kilpatrick, 1917, p. 69). The lower-level course would focus on local, concrete, and applied science for the masses yet to develop scientific attitudes. The higher-level course would emphasize universal, abstract, and pure science for the few whose mental maturity could be safely assumed. School science became stratified—developing all towards a single ideal, while preparing students for distinct roles in a hierarchical society.

[60] In Thorndike's behaviorism, any attempt to theorize mental structures would detract from the empirical study of stimulus-response bonds. Brought into science education, the notion that pupils differed in their readiness for pedagogical stimuli provided a basis for reorganizing the aims of science instruction along a developmental scale (Kilpatrick, 1922). The "masses" needed practice in concrete habits to improve daily living, which would eventually lead to the development of a "scientific attitude of mind." This mindset (a collection of stimulus-response bonds) became manifested as a psychological prerequisite for the abstract reasoning required to understand the organized knowledge of scientific disciplines.

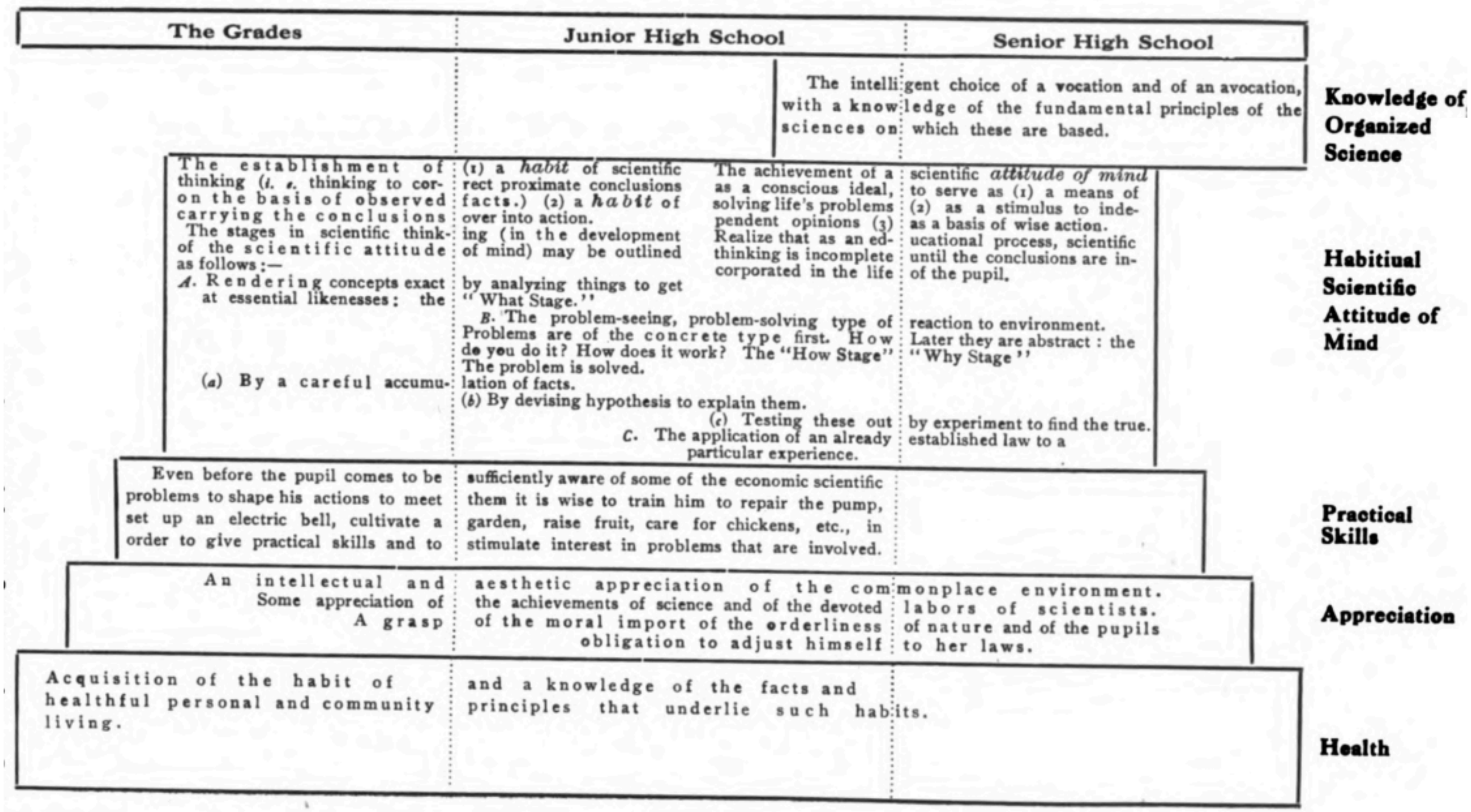

Figure 4.1 A Developmental Sequence of Science Education Aims (Downing, 1917, p. 253). In response to the perceived crisis of different populations of students entering high schools, this diagram offered a sequence of aims corresponding to pupils' stages of development. Moving from bottom to top, the aims became more specialized and were assumed to lie within the capacities of fewer students.

Through the developmental scale, school science transfigured moral principles of how citizens should think and act into a mode of reasoning that seemed to differentiate types of pupils. Reconfiguring science as a mental trait relied upon and reiterated cultural imaginaries of lower races as less capable of scientific reason. The sequential progression ordered both children and curricula, matching kinds of pupils with levels of instruction deemed developmentally appropriate. In this symmetry between psychological and civilizational development, a scientific attitude operated as a switching station for explaining individual differences, delineating national belonging, and regulating racialized groups thought unready for democratic participation. I turn next to a second translation tool—the design of a standardized test that promised to locate pupils on a single scale of science ability.

The standardized test: Measuring scientific knowledge versus superstition.

> It would seem self-evident that the first thing one must do is to find out the exact mental equipment of his students—to find out what the foundation is before he begins to build upon it.
>
> —John F. Woodhull, *The Teaching of Science,* 1918 (p. 83)

Prior to the 1920s, it was not yet possible to make empirical claims about students' exact capacities for science learning. However, as the IQ test and other psychological instruments began entering U.S. schools, a demand arose for a standardized test of general science ability. In part, this demand was tied to the perception that those entering high schools were no longer homogeneous, but "a mongrel lot of pupils of all races" whose foundations for science learning had to be assessed rather than assumed (Woodhull, 1918, p. 224). This section considers a second translation tool of the editing room (see chapter 1) by exploring how standardized tests stabilized science as a set of factual knowledge and sound reasoning in contrast with the superstition ascribed to "foreigners" and "inferior races."

Nineteenth-century racial theories had divided the human into separate species (e.g., polygeny), locating the evidence of these distinctions in the physical body (e.g., anthropometry) (Gould, 1996). The rise of intelligence testing provided a new commensurability for marking differences in the human mind as a matter of degree along a uniform scale (Carson, 2007). Qualitative differences in talents and virtues gave way to quantitative distinctions in amount of talent. The intelligence scale connected all organisms as more or less advanced in a Great Chain of Being. Both individuals and racial stocks could be plotted as having higher or lower mental capacity. The calculation of IQ depended on a linear notion of time, comparing one's "mental age" (determined by performance of specific tasks) to one's "chronological age." One temporal distinction coincided with a proliferation of others: backwardness, mental retardation, developmental delay. Through IQ testing, prior narratives of infantilization—e.g., equating adults of African descent to children of European descent—could be reformulated in more precise temporal terms as differences in mental age and grade-level (e.g., Terman, 1916).

Test scores furnished new grounds to project differences in space and time. Spatially, scores claimed to locate "where" a pupil was currently (a comparison with the standards used to calibrate the scale, and with other test takers), as well as "where" the pupil's mind was likely to top out (a prediction of their mental capacity). Temporally, scores identified "when" a pupil was—whether "ahead" (advanced into the future, beyond one's age or grade level) or "behind" (backward, having been retarded or delayed), as well as the "pacing" at which the pupil was expected to learn going forward. Sharper distinctions in time could be translated into finer differentiations in space. Beyond separate schools for "immature races" and the "feeble-minded" (see Baker, 2002b), separate classes and curricular programs formed within so-called comprehensive schools. Sometimes, those separate spaces targeted “backward” children (Franklin, 1994). Other times, an introductory program like general science was inserted for all pupils, moving existing subjects up to a specialized status for the few judged as advanced.

Modern psychological tests received acclaim within science education scholarship: “Now that we have machinery established for the segregation of low grade mental types. . . we have done much toward solving our teaching problems” (Hunter, 1920, p. 382). However, while IQ tests made it possible to remove those pupils “not able to reason” (p. 382), and were seen as “valuable for the purposes of classification” (Dewey, 1924, p. 465), they did not offer much pedagogical guidance (as Woodhull demands, in the epigraph above) in finding out the “exact mental equipment” of pupils, revealing “what the foundation is” in terms of their range of information, scientific reasoning, and preparation for future learning. In 1919, *General Science Quarterly (GSQ)* published the first of many articles on efforts to design “Standard Tests” of general science ability and achievement for those purposes (Maxwell, 1920, p. 443).

On those early tests, what became codified as science ability was not simply a subset of the natural sciences, but the mental qualities presumed lacking in the masses.[61] Sociological studies of the time defined scientific thinking in opposition to the “folk beliefs” of the “Southern Negro” (Puckett, 1926), and the “superstitions” of the “Italian” and “Jew” (Jones, 1904). Particular religious practices, such as the hanging of rosary beads in Roman Catholicism or of the *mezuzah* in Judaism, were labeled as “superstition,” classifying those groups as less science-

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[61] See also, e.g., Ruch, 1919; Ruch, 1920; Ruch, 1923; Ottmyer, 1924; Downing, 1925; Popenoe, 1925; Dvorak, 1926. Early standardized science tests were alternatively called tests of achievement, ability, or abilities (e.g., Kellogg, 1922). Some scholars distinguished between types of standardized science tests. The earliest type assessed mastery of a range of information from general science textbooks, while a later type sought to assess the student’s ability to think scientifically (Downing, 1925, p. 149). Both types, however, were described as tests of general science abilities that set standards of achievement for the curriculum.

minded than Protestantism, which was upheld as a model of independent thinking that had emancipated itself from the constricts of Old World religious traditions (p. 77). Since general science aimed to free American citizens from superstition (Whitman, 1921), early tests of science ability generated questions to assess "common superstitions or beliefs arrived at through unscientific thinking" (Maxwell, 1920, p. 444). For instance, one question on a test of scientific reasoning asked whether the date Friday the thirteenth was unlucky (p. 449)—a belief classified by sociologists of the era as a "Negro Taboo" (Puckett, 1926, p. xii). Part of what the tests constituted as science ability, then, was pupils' rejection of beliefs presumed to distinguish racialized Others from allegedly rational (or, Protestant) Americans.

Science ability emerged as a theoretical object through the operation of measurement, such that—like intelligence (Danziger, 1997)—science ability became that which science ability tests measured. The new assessment instruments made it possible to conceptualize the mind as having a stable degree of scientific reasoning and to predict one's future capacity for science learning.[62] Also, like other psychological categories of its time, science ability as an individual trait did not derive from abstract theory, but from administrative techniques responding to perceived societal problems. In *GSQ*, early science ability tests followed principles of Terman's IQ test designed to distribute individuals along a bell curve by keeping only those items that could "differentiate bright pupils from dull ones" (Whitman, 1920b, p. 50).

The validity of the test could only be secured through an alignment with pre-existing appraisals of what constituted a mature scientific thinker, which required pre-determining which

[62] A pressing research question of the time concerned the relationship between science abilities and overall intelligence (Downing, 1925). Were they essentially the same—a heritable trait of one's capacity for a higher order of reflective thought and reason? Or perhaps, a pupil's intelligence affected the development of scientific thinking abilities by affecting the efficiency of their thought and setting an upper limit of mental capacity. Until such problems could be solved, scholars recommended administering intelligence tests alongside the new general science tests, as "both educational and mental ability must be utilized in sectioning classes and in making comparisons between groups of pupils" (Ruch, 1923, p. 196).

pupils were bright and which were dull. At various points, these judgments were supplied by calibrating the tests against IQ tests (Dvorak, 1926), and also with teachers' grades (Ruch, 1920).[63] In particular, test designers asked teachers to rank their students by "diligence, classroom behavior, personality of the pupil, punctiliousness with assignments, neatness, spontaneity, and many others" (p. 17). Of course, these categories are not neutral but embody specific social values and norms. Consider "spontaneity," a positive intellectual quality presumed to distinguish the American from the "Frenchman" "bound by tradition, inert and pessimistic" on the one hand (Downing, 1925, p. 174), but also from the random impulsivity of the "savage" (Dewey, 1910, p. 14) on the other. In this way, cultural norms of belief, conduct, and expression came to serve both as universal indicators of scientific ability and as signs of American exceptionalism, articulated as "our own buoyancy, alertness, and ability to tackle forcefully and efficiently the changing problems" (Downing, 1925, p. 174). The external validity of standardized science tests, like other psychological instruments (Rose, 1985), relied on registering as subnormal those individuals who were already designated as problematic by institutions like schooling.

Stabilizing science content on standardized tests spatialized difference along a numerical scale. In rendering a particular performance into a generalized attribute, the notion of scientific thinking, already racialized and culturally specific (as evident in the developmental scale), became newly quantifiable. Statistical techniques sorted individual scores along pre-determined categories of difference (e.g., sex, heredity, environment), and demographic averages became inscribed as personal traits. This statistical style of reasoning made available new types of truth claims, such as test data suggesting that girls have more difficulty acquiring science knowledge

[63] "It is to be presumed that the teacher through his intimate daily contact with pupils . . . will be able to judge fairly well the student's mastery of the subject taught" (Downing, 1925, p. 145).

than boys (Dvorak, 1926), or that students from “typical Chicago high schools” do not grasp fundamental science concepts (Downing, 1925, p. 148). In these findings, numerical data reordered pupils and administratively inscribed populations (e.g., pupils within typical Chicago schools), marking their distance from social norms abstracted and universalized as science knowledge and conceptual understanding. By claiming to discover natural differences in a mechanical way, the tests promised an objective basis for differentiating courses into fast- and slow-moving sections (Ruch, 1923), and guiding students toward vocations for which they were mentally fit (Whitman, 1922).

In reviewing the progress of science education scholarship, Downing (1925) devoted an entire chapter to the new tests. These tests, he explained, would “give the teacher a means of detecting the pupils of marked scientific accomplishment and those with inadequate preparation” by “showing the levels at which pupils are now mastering the important scientific principles” (p. 147). Evident here is a slippage between past, present, and future. Differences in the particular information students had already been taught were presumed to reveal distinct overall levels of mastery in the present, as a means to detect whether or not students were prepared for a certain level of future accomplishment. Downing goes on to pose a thought experiment of two pupils, scoring 2% versus 68% on a “range of information” test at the start of a general science course: “It is hard to conceive of these two pupils profiting even approximately equally by the same instruction. Apparently one should have been placed in more elementary science work, the other in more advanced” (p. 148). Despite stated concerns over whether such tests measured prior exposure to “unimportant details” (p. 147), it had become self-evident that the numerical distance between scores revealed fundamental differences in educability that required stratified curricular pathways (i.e., “elementary” versus “advanced”).

Through the concrete practices of designing and validating the first standardized science tests, a transformation can be observed. Extant theories of racialized differences in group beliefs, behaviors, and IQ became sedimented in tests of science ability. The tests assessed the degree to which an individual adopted information codified as scientific, adapted to the social norms of the classroom (e.g., spontaneity), and rejected those views labeled as superstitious (e.g., Friday the 13th). By calibrating standardized tests to teachers' assessment of pupil's personalities, specific cultural values gained momentary visibility in methodological discussions before becoming embedded and effaced through statistical procedures of quantification and correlation. This science had less to do with the natural sciences than with social science practices of classifying mental qualities of populations to guide their education and Americanization. In these ways, the data generated by the assessments produced the differences that they purported to reveal. Fabricated distinctions between biological races and sociological types became tethered to and reconfigured as a split between scientific and unscientific minds—one that could now be measured as degrees of science ability or achievement.

In historicizing general science, I have argued that school science was constituted in part as a set of norms comprising the good, rational, American citizen. The developmental scale and standardized test offered new modes of producing and sorting difference in the science classroom. The child could now be seen as a pupil passing through detectable developmental stages and possessing measurable mental attributes. Normative definitions of science emerged as an attitude of mind consisting both of a mode of reasoning (i.e., scientific rather than immature), and a set of beliefs about the world (i.e., factual rather than superstitious). These forms of "science" were hoped to eventually unify all U.S. general science students, yet they functioned to divide by making new differences visible, calculable, and governable. One of the "earmarks of a good science teacher" had become knowing how to "study and direct immature minds," being quick "to diagnose and remedy them" (Downing, 1926, p. 35). In projecting school science as a set of universal ideals, difference could only be seen and studied as deviation from norms of accurate knowledge and mature reasoning.

As U.S. high school science became bifurcated, what constituted general science in part was what the social sciences defined as lacking in the "masses" and "lower races": the concrete knowledge of healthy habits, and the scientific attitude required for democratic participation. Demonstrating these mental and moral habits became a prerequisite for further scientific study, particularly for those seen as outside the unity of science-minded Americans. Meanwhile, the specialized sciences became a site of restricted access for those understood as already belonging to this unity, especially if their beliefs and experiences aligned with those cultural norms stabilized as science. As such, techniques like the developmental scale and the standardized test positioned children along a hierarchical progression that a) ordered racialized groups along stages of mental maturity, and b) sequenced science curricula hierarchically from the local and concrete to the universal and abstract.

The next section explores shifts that appear to separate current reforms in U.S. science education from the early 1900s premise of a natural racial hierarchy of science ability. Gradually, terms like intelligence, science capacity, and aptitude were dropped in favor of achievement. Over time, equity-oriented concerns would arise and argue that racial and gender disparities in performance did not indicate a natural hierarchy, but problematic disparities facing groups that had "largely been bypassed in science and mathematics education" (AAAS, 1990, p. xviii). Despite this important shift, many of the early twentieth-century practices that projected "immature minds" as less ready for abstract science had by the mid to late twentieth century been reconfigured but not replaced.

Next Generation: Effective Strategies for Low-Performing At-Risk Groups (2010s)

Returning to the opening paradox, the NGSS formulate equity as a technical problem of "making diversity visible" to differentiate instruction for various demographic groups (NGSS Lead States, 2013a, p. 364). However, this chapter suggests that making diversity visible is not a neutral, passive reading of social reality. Embodied in school science are cultural norms that become productive of new distinctions. To conclude, I propose two editing room tools in the NGSS that demand further investigation: the developmental scale and standardized test data. Each exhibits continuities and discontinuities with those of *General Science Quarterly (GSQ)*.[64]

Developmental progressions: Making science accessible to all. As in *GSQ*, a developmental logic divides children and curricula into different kinds ordered on a hierarchical scale. The case studies depict "gifted and talented students" as above grade level and "economically disadvantaged students" as below grade level (NGSS Lead States, 2013h; NGSS Lead States, 2013b). Being above or below on this scale is linked to different curricular content and pedagogies. The gifted and talented are matched with more abstract, open-ended, and complex pedagogies (NGSS Lead States, 2013h). In contrast, economically disadvantaged students and major racial and ethnic groups are said to require pedagogies that connect science to the physical dimensions and problems of their local community (NGSS Lead States, 2013b, 2013c).

However, there are crucial differences between the developmental scales in *GSQ* and the NGSS. Rather than presuming racial categories to differ by nature as in recapitulation theory, distinctions now appear through numerical data taken to indicate that not all are ready for the

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[64] Setting aside the question of authors' intentions, I focus here on the classificatory techniques that make certain differences appear as objective entities to which teachers must respond—given as the "learning needs of the nation's increasingly diverse student population" (p. 359).

same level of instruction. Moreover, the politics have changed. Whereas *GSQ*'s locally focused project method was discussed as Americanizing the unscientific masses, the NGSS' place-based, project-based approach is stated as empowering for students from historically underserved groups. Yet, in this effort to empower, local and applied aspects of science are positioned as compensatory strategies for making science accessible to non-dominant groups—contrasting with the pedagogies designated for children labeled as gifted and talented.

Standardized test data: Making up populations as above or below baseline. Unlike *GSQ*, the NGSS reject hereditary notions of mental ability and refute deficit stereotypes by asserting the capability of all students to learn science: "[R]eports continually highlight that when provided with equitable learning opportunities, students from diverse backgrounds are capable of engaging in scientific practices and constructing meaning" (NGSS Lead States, 2013a, p. 359). The absolutist language of incapacity is out. Yet, talk persists of relative differences in students' current capability, or readiness, to access a certain level of cognitive demand:

> [A]chievement gaps in science and other key academic indicators among demographic subgroups have persisted. . . . As these new standards are cognitively demanding, teachers must make instructional shifts to enable all students to be college and career ready. . . [and] to ensure that the NGSS are accessible to all students. (p. 359)

Talk of inability has been supplanted with that of achievement gaps.

In name, the focus has shifted from a problem within the child (e.g., cognitive deficit) to a problem with the curriculum (e.g., its cognitive demand). Yet, because raising cognitive demand is presented as key to national competitiveness, the problem is not ultimately located in the curriculum, but in the mismatch posited between populations of students and cognitively demanding curricula. Numerical data reinscribe distinctions between non-dominant groups that "traditionally struggled to demonstrate mastery [on] less demanding standards" versus "those who can and should surpass the NGSS" (p. 359). Achievement data also make it appear sensible to promote a two-pronged approach to K-12 science education, where "low-performing at-risk groups" must be elevated to the baseline of the standards through pedagogies that make science more accessible and "concrete" (NGSS Lead States, 2013c, p. 6), and "our future innovators" need access to science instruction that is more advanced and "abstract" (NGSS Lead States, 2013h, p. 2). Rather than critiquing tracking as an equity problem, the stratification of science courses is naturalized as a reasonable response to the distinct achievement levels ascribed to racialized groups.

Similar to *GSQ*, then, the NGSS take standardized tests as objective measures of something called scientific thinking. Achievement data distribute individuals and demographic groups onto a numerical scale assumed to reveal relative amounts of scientific knowledge, conceptual understanding, and reasoning. Through psychometric techniques, the scientific disciplines in all their dynamic diversity are transfigured into "science" as a universal quality of mind—one that differs in degree, appears unevenly distributed in the population, and differentiates racialized groups. Data fabricate a division between certain racial and ethnic groups as requiring interventions to meet the standards, and their unmarked peers as deserving opportunities to exceed this baseline.

Where *GSQ* scholars relied on sociological studies to identify superstitions, the NGSS reject the tendency of prior research to focus on the deficits of non-dominant groups, and instead call for valuing these students' diverse backgrounds. Nevertheless, because the standards conceptualize science as a universal set of analytic concepts and practices derived from the disciplines, not all backgrounds are equally valued. Specifically, the NGSS contrast the "academic backgrounds" of dominant groups with the "cultural knowledge" of non-dominant groups (NGSS Lead States, 2013a, p. 359), where the latter must be filtered for connections and disconnections with science (p. 364). Here, the standards have already stabilized the science from which (dis)connections can be seen, while the backgrounds of dominant groups are presumed to rise above culture (i.e., academic rather than cultural) and correspond with a universalized science.[65] Despite calls to value cultural diversity, the objective of school science becomes helping non-dominant groups "transition from their naïve conceptions of the world to more scientifically based conceptions" (p. 363).

The past is not repeated in the present, but new assemblies of tools and theories continue to codify science as a universal ideal that generates cultural distinctions, dividing students and the science instruction they appear to demand. At issue is how it became possible to conceive of human beings as different types of thinkers, of students as more or less ready for a particular "level" of thought, and of science as existing in discrete but sequential forms (i.e., concrete to abstract) that correspond to these kinds of minds. As comparative distinctions, science ability and achievement depend on the production of abnormal Others as lacking in ability or behind in achievement. These notions are not natural, but emerge from a network of heterogeneous theories and techniques, and the epistemic, political, and moral principles they carry. To reduce all of these elements to a psychologized problem of deficit thinking within the mind of the teacher would be to obscure how the ordering strategy functions.

[65] As Wendy Brown (2006) observes, where once culture was elevated as the unique property of "civilized" societies versus "primitive" groups cast as closer to nature, today culture tends to label groups positioned as yet to enter the global knowledge economy. This dangerous logic presumes that while the cosmopolitan "we" may have culture, culture *has* "them" (p. 151).

The concerns I raise are not to reject the political power of identity categories, but to question which differences have implications for the kind of science education students require or deserve. If diversity continues to be located within Othered populations rather than within science, and if science education continues to see difference through normalizing techniques, then the danger is that racialized groups will continue to be positioned, inadvertently, at the lower end of a naturalized developmental trajectory. Consequently, there is a paradox in current efforts to promote equity through the paradigm of achievement. As measures of science achievement interact with developmental progressions of school science, they fabricate different "kinds" of students and match them with hierarchical levels of science education. The call to make diversity visible through achievement data abjects some as outside the realm of reason—whether the unassimilated masses of the 1920s or the low-performing at-risk groups of the 2010s—demanding that they be brought closer to a fabricated ideal of scientific Americans.

PART II. Interest as an Ordering Strategy

Part I of the study explored how it became possible to order students by presumed differences in their Readiness for scientific thinking. I argued that techniques like the developmental scale and the science achievement test not only fail (in a technical sense) to capture what differentiates a scientist from a layperson. Rather, what has come to constitute "scientific thinking" depends on rules and standards that project a Scientist as a distinct kind of person, whose intellectual and moral qualities all citizens must approximate. These distinguishing features are asserted as if the field has reached a consensus or an empirical determination of "how scientists think." I argued instead that these rules and standards have historically made distinctions that are irreducible to science, with the effect of racializing some people as less science-minded than others. The qualities of the Scientist's mind are presumed as latent in human nature, but not as unfolding spontaneously, or uniformly, in all. The question of how quickly this development occurs generates another set of distinctions: To what extent does the child *desire* to think, feel, and act like the Scientist?

Part II introduces "Interest in Science" as a second ordering strategy—one that classifies students by differences alleged in their desire as opposed to their cognition. Analytically, I use Interest (with a capital I) to refer to a range of practices that classify students' emotions, motivation, or attitudes toward science.[66] These practices instantiate principles about human nature, specifically concerning what drives the child's thoughts, feelings, and behaviors. As an ordering strategy, Interest designates efforts: a) to infer how students feel about the subject, b) to

[66] Current research makes precise distinctions between interest in science writ large versus interest in science as a school subject, and between attitudes toward school science versus academic motivation across subjects (e.g., Osborne, Simon, & Collins, 2003; Renninger, Nieswandt, & Hidi, 2015). In the following chapters, however, I will argue that the boundaries between these constructs have not always been as sharply defined either in policy discourse or classroom practice. I will refer to all of these constructs under the ordering strategy of Interest.

reach those lacking interest in science by appealing to their prior interests, and c) to bridge those prior interests to science.

Recent studies in science education operationalize student feelings through psychological constructs of interest, attitudes, engagement, motivation, self-efficacy beliefs, identity, dispositions, or career choice. Each appears as a technical construct whose history can be recalled through a literature review of prior studies employing this term.[67] An effect of internalist, linear tracings (cf., Bang & Valero, 2015) is to disconnect the field from a broader history of educational research and pedagogies that have sought to know and transform the desire of the pupil.

Even if desire has no technical definition or stable referent, there has been persistent concern about the “impossibility of pedagogy as the management of ‘desire’” (Baker, 2005, p. 54).[68] I follow Foucault (1990) in treating desire not as natural and repressed by the law (as in Freudian psychoanalysis), but as historically and culturally produced. Butler (2011) argues that Foucault’s notion of desire acknowledges the “cultural construction of desire . . . which disavows any appeal to a desire that has a natural or metaphysical structure said to exist either prior or posterior to linguistic and cultural laws” (p. 215). In other words, desire, like knowledge, is an effect of power, and does not emerge from a pre-discursive material reality or from an individual’s psyche. Desire can be understood as constituted by the regulatory practices that

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[67] See the following reviews on attitudes toward science (Osborne et al., 2003), science attitude instruments (Blalock et al., 2008); interest, motivation, and attitude toward science & technology (Potvin & Hasni, 2014); interest in science (Krapp & Prenzel, 2011); and interest in science and mathematics (Renninger et al., 2015). For an analysis of key shifts in the discursive formation of interest in science, including its recent emergence as a tool of international ranking, see Bang and Valero (2015).

[68] Compared to terms like “interest,” desire may sound less scientific. Yet, the term “desire” appears frequently in science education research, whether in studies of college students’ desire to understand and study biology (Baldwin, Ebert-May, & Burns, 1999), or the desires of African American parents with respect to informal science learning (Simpson & Parsons, 2007). In U.S. science education policy, a primary purpose of the new curricular standards is to “excite many more young people about science-related subjects and generate a desire to pursue science- or engineering-based careers” (NRC, 2012, p. 10). Likewise, the addition of engineering standards is an effort to “interest students and may give them a desire to pursue STEM careers” (NGSS Lead States, 2013a, p. xviii).

attempt to describe and control it: “structured by power, but not subsumed by it” (Stoler, 1995, p. 192). Extending Foucault’s analysis, Stoler notes that colonial authority was exercised through an “education of desire”— the microphysics of power involved in producing and governing a broad range of sentiments, sensibilities, and affections (p. 192). While such processes have operated across domains and institutions, schools have played an important role historically in the cultivation and regulation of students’ desires (Baker, 2005).

The chapters that follow explore how Interest became a tool for mapping interior desires that also serves an administrative function of delineating a topography of individual merit. What came together in early twentieth-century U.S. psychology was a notion of Interest formulated through theories of human nature, the child’s mind, and learning. U.S. psychology inherited a much older notion of the will as an internal force that could (to some extent) be directed externally to transform one’s mind and behavior (Danziger, 1997). In the mid-1800s, children were discussed as having warring parts of their nature that made them more “angel-like or fiend-like” (Mann, 1867a, p. 346). This made teaching into “a holy ministry upon earth” through training the child to tame the “animal appetites and sensual properties of our nature” (pp. 346-7). Winning souls would require the teacher to become “acquainted with the inmost character and tendencies of his pupil. The pupil’s whole mind and heart should be spread out, like a map, before the teacher for his inspection” (p. 346). Mapping the animal appetites inhabiting the child’s soul soon gave rise to a more mechanistic understanding of the will.

The will became reconfigured through new empirical methods, stimulus-response studies, and technologies that offered models of the mind as an engine with calculable drives, motives, and energies (Danziger, 1997). Rather than taming an animalistic spirit, the teacher’s job would be to adopt techniques for assessing the pupils’ interests in order to induce behavioral change and the acquisition of superior mental habits. The psychological categories of learning, motivation, attitudes, and interest were all emerging as empirical objects around the time when U.S. psychologists were becoming enrolled in naming and solving problems of mass schooling (Danziger, 1997). This was also a period in which drives, desires, and attitudes—as well as differences in racial stock, sex, and sexuality—were emerging as entangled objects of surveillance and administration (e.g., Somerville, 2000).[69]

While much has changed, today's Interest retains associations with motivation and learning. It is still conceived of as a mechanism by which learning can be turned on or off (Valero, 2012). Interest posits a stable emotional relationship between an individual child and an academic domain that varies in strength and direction (positive versus negative feelings). My analysis traces how a mix of psychological and sociological distinctions converge in Interest to produce distinct subject positions that have little to do with the scientific disciplines. I do not approach race and gender as *a priori* categorical distinctions about which differences in interest were produced. Instead, I conceptualize Interest as generating differences that make up different kinds of people as objects of study. These productions have historically operated to racialize and gender people as types ordered along a biopolitical spectrum, marking some as passionate, confident, and curious, others as passive, apathetic, and lacking self-efficacy, and still others as mistrusting, alienated, and resistant to scientific expertise.

Chapter 5 opens with a vignette from Alderwood High School (AHS). The vignette explores anxieties about a group of students perceived as disengaging, or already disengaged, from science and school. A course called Biology 2 was redesigned in an effort to "re-engage"

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[69] Important to recall as well is the long history in which demands for civil rights and liberties have been pathologized as indicators of inappropriate desires (e.g., *drapetomania)* and unfitness for self-government, and targeted for medical, psychological, and pedagogical intervention (e.g., W. Anderson, 2006; P. Gilbert, 2007; Metzl, 2009; Stoler, 1995).

those students, keeping them emotionally "connected" with science and school. Next, I trace a broader set of administrative and pedagogical strategies at AHS that map students as having more or less interest in science, and match them with different forms of curriculum and pedagogy. I argue that Interest made tracking appear to reflect students' individual choices, or self-selection. Interest operates as a switching station between psychological theories of adolescents' "natural" interests linked to personal preferences, sociological inferences about the quality of socialization in one's home and cultural upbringing, and moral imperatives of the teacher's responsibility (for those lacking that intrinsic quality or upbringing) to spark an interest from the outside. These rules, which dictate what counts as an engaging, effective, and equitable teacher, have a jurisdiction much wider than a single high school, circulating across teacher education, motivational psychology, and the learning sciences and aligning with a reform strategy to address student diversity through a focus on Interest. I conclude by making a case for reimagining Interest—not as a natural way of sorting students, but as a historical product whose conditions of formation require further scrutiny.

Chapter 6 goes on to historicize Interest by examining how it emerged as a calculable attribute of students that became mutually constitutive of social distinctions, including gender, race, poverty, nationality, urban/rural, dis/ability, and religious differences. Drawing on science education research and policy statements, my analysis suggests that although Interest in science has repeatedly materialized as a marker of difference, an important shift has occurred. In the early 1900s, differences in interest by sex and racial stock were presumed as natural consequences of biological evolution. In contrast, by the early 2000s, gender and racial disparities in interest in science were measured using numerical statistics and interpreted as unnatural products of social inequity. Despite this shift, the focus on Interest in equity discourses today retains a danger of abjection. By locating their desires as the source of a presumed distance from science, underrepresented groups are marked as different from the norm and in need of remediation.

Chapter 5. Only What "Their Appetites Demand": Diagnosing Student Feelings toward Science

> Unless we are sure that we are sufficiently wise doctors in education to safely prescribe a dietary distasteful to the pupils, it would seem to be better to give them bread than a stone, because their appetites demand it. They receive more, they work over it more diligently, and they digest it better.
>
> —Science education scholar (Woodhull, 1918, p. 20)

> How do you support those kids? How do you make them feel good about science? . . . I would need to keep them motivated, keep them connected to science—especially if they're a combination ADHD kid, economically impoverished kid, maybe minority—learning it another way.
>
> —AHS science educator (Interview DI, 2015)

Science is often portrayed as a site of cold calculation rather than warm emotion.[70] Despite this stereotype, or perhaps because of it, there has been a persistent concern over students' feelings toward the subject matter. The idea that some students do not feel good about science has preoccupied educators for at least a century. For high school science teachers today, it has become part of the job description: Create a positive learning environment that excites and motivates all students to learn science. To fulfill this duty, teachers must identify those who derive little pleasure from textbooks or problem sets, and help them learn science another way. Rather than rely on teacher intuition to remedy disengagement, educational research has worked

[70] Contrary to the media portrayal of science as a site of rationality divorced from affect—itself an effect of boundary work (Gieryn, 1999)—science studies scholars have examined the affective registers of scientific practice, whether in heated controversies (e.g., Rabinow, 1999; Shapin & Schaffer, 1985/2011) or everyday observational routines (e.g., Daston & Galison, 2007). See Daston (1995) for a discussion of the moral economies of science that go beyond questions of motivation or ideology.

to convert student attitudes into empirical objects that can be monitored, classified, and regulated. The feelings of the science learner have become a science in their own right.

A century ago, U.S. science education scholar John F. Woodhull envisioned the teacher as a medical physician (see first epigraph, above). Emulating a "wise doctor," Woodhull's ideal teacher would diagnose pupils' varying tastes to determine what type of education would be safe to prescribe. This statement exemplifies the entangling of moral and medical discourses at the turn of the twentieth century. Judgments of social deviance were moving from a religious problem of taming unruly appetites to a biological register of treating the ill function of the human body and mind. In the 1910s, the IQ test had just entered schools, promising a precise measurement of mental capacity. Yet, Woodhull and his colleagues felt IQ metrics failed to capture the attitudes that helped to determine whether a pupil's mental capacity would actually be fulfilled. Scholars began to publish studies of students' science-related interests. The hope was to identify a causal mechanism, akin to the biology of the digestive tract (in Woodhull's analogy), which could explain why some pupils seemed to eagerly devour science instruction, while others seemed to find it distasteful.

The demand to know what students feel—and how they can be made to feel differently—has not disappeared today. Consider the dilemma posed by a teacher at Alderwood High School (AHS) in 2015: How do you make students feel good about science? (see second epigraph, above). This dilemma does not belong to one teacher. A growing body of research examines interest as a non-cognitive psychological factor of great significance for science learning (Alsop, 2005; Osborne, Simon, & Collins, 2003; Renninger, Nieswandt, & Hidi, 2015). Many studies seek to offer more definitive guidance to science teachers wanting to know how to motivate their students. The second epigraph above links concerns about motivation to a "combination" of risk factors through neurological, socioeconomic and racial classifications. Categories of "ADHD," "economically impoverished," and "minority" are assembled as potentially salient to students' feelings toward science. These classifications embody theories about the nature of who the child is, who the child should be, and who is not that child (Popkewitz, 2008).

In both epigraphs, the anxiety does not pertain to a single child's dislike for science, but to a specter of collective disinterest. At the turn of the twentieth century, scholars like Woodhull decried a declining interest in science among the U.S. citizenry that was attributed, at least in part, to the latest wave of immigrants from southern and eastern Europe (e.g., Caldwell, 1917).[71] Science education scholars of the time considered it only natural that abstract science lacked universal appeal,[72] but worried that the masses lacked a basic appreciation for scientific expertise. This was taken as a bad portent for American civilization—a fear that the nation was "steadily losing the Anglo-Saxon spirit of resolution and responsibility which has sped the republic in the past" (Grier, 1920, p. 47). Given the alleged changes in the U.S. population, scholars advised science teachers to discard their dry chemistry textbooks and physics laboratory exercises, and instead attempt to arouse in those masses a desire for the science of daily living (Quickstad, 1917).

Much has changed in the intervening century, but what remains durable is an anxiety over how to properly monitor and manage students' desire to learn science. At AHS, for

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[71] Initial evidence for declining interest in science derived from statistics indicating a decreasing share of high school enrollment in physics and chemistry courses (e.g. Caldwell, 1917). Yet by the mid-1920s, these data had been reevaluated. Ironically, enrollment in science had not decreased with the influx of students from southern and eastern Europe, but rather shifted from these older science courses (now designated as "specialized") toward newer courses like general science and civic biology (Downing, 1925, pp. 25-27), which had tended to target those very populations.

[72] Evolutionary theories of the era depicted "racial stocks" as having distinct mental traits like IQ, and moral traits like interests, desires, and ambitions (e.g., Grant, 1916). Physics and chemistry, some science education scholars argued, ought to be reserved for the few with an inherent desire for pure knowledge (e.g., Gerry, 1920). The problem, then, was not that the "foreign-born masses" seemed to lack ambition to pursue scientific careers (keeping in mind, of course, the newness of the sciences as university-based professions).

instance, declining enrollment in advanced science courses was also attributed to a "changing population" (Meeting fieldnotes, 2014).[73] In school meetings, a frequently cited concern was that this "new clientele" was not as motivated, engaged, or interested in science or school (Meeting fieldnotes, 2013). Unlike a century prior, these alleged disparities in interest were diagnosed not as products of biological inheritance but of societal inequity (e.g., opportunity gaps). Yet a similar solution came to light: to shelve the dry textbooks and lectures in lower-level courses, and instead try to help those students appreciate the relevance of science for everyday life.

In broader U.S. policy and research, Interest in science sits at the nexus of crises of international competitiveness and of gender and racial disparities (Business Higher Education Forum, 2010; National Science Board, 2014; Renninger et al., 2015). The U.S. Next Generation Science Standards' (NGSS') *Framework* asserts that schools must "excite many more young people about science-related subjects and generate a desire to pursue science- or engineering-based careers" (NRC, 2012, p. 10). The concern is that the United States is losing its competitive edge in STEM fields and that a loss of interest may be to blame. Despite the policy emphasis on increasing the number of students pursuing careers in STEM-related industries, the goal of current reforms is not in fact to set every student on a scientific career pathway. As one half of a two-pronged approach (see chapter 1), a primary policy objective today is to ensure that all citizens acquire a basic understanding and appreciation of scientific expertise. Like a century ago, that appreciation is feared missing in some more than others.

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[73] Alderwood High School (AHS), as described in staff meetings, was perceived as undergoing an "ethnic shift" with a "quickly growing ESL population" and African Americans moving from nearby cities. This narrative of a "changing population" was not isolated to AHS staff, but circulated in media outlets and public officials in the city (see chapter 2). Importantly, not all teachers agreed that lower enrollment in advanced science courses owed to a drop in interest. As several explained, a shift in district policy had created an incentive for students to double up on advanced math courses rather than science courses, allowing them to earn college credit (paid for by the district) for math courses at the state's flagship university. As such, many students reported choosing to take advanced math but to "balance" their schedule with lower-level science courses (Meeting fieldnotes, 2015). Similar to the case of general science, the existence of alternative explanations for declining enrollment did not necessarily counter the concern that the population was changing and losing an interest in science.

The perennial invocation of a "changing population" who lack an interest in science requires greater scrutiny. While research studies ask how "learners" in general develop connections to science, what gives this research its broader importance is the continuing underrepresentation of women and "particularly Blacks and Hispanics" in science and engineering (Renninger et al., 2015, p. 2). Reigniting interest is asserted as a central strategy to repair the "leaky pipeline" of students pursuing STEM-related careers (e.g., Blickenstaff, 2005). Curricular and extracurricular programs—whether focused on robotics, urban gardens, or STEAM (STEM plus the Arts)—aim to reengage underrepresented groups and to motivate broader participation in science. What goes unasked in this research is how Interest came to appear not as an individual feeling, but as a national crisis linked to problematic subpopulations.[74] The next chapter will historically trace the formation of Interest in science as an object of scientific analysis and public concern.

Before adopting this wider historical lens, however, I want to investigate how Interest operates as an ordering strategy in the details of high school course placement and science pedagogy. By drawing the ethnographic study at AHS together with broader trends in educational research and policy, this chapter asks: How did "feeling good about science" become a curricular priority for "those kids" rather than for these? This is to destabilize a long-standing notion: that the segregation of students in upper- and lower-level science courses is largely a matter of self-selection—or in Woodhull's terms (see first epigraph), just a response to differences in "what their appetites demand."

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[74] As discussed in the introduction to Part II, my concern is not simply the negative representation of particular groups, but how Interest divides and differentiates people—generating race and gender (among other categories) as distinct kinds of science learners, and ordering them along a biopolitical spectrum from the ideal of properly managed desire to the pathologization of the child's will as apathetic, impulsive, alienated, or insecure.

Vignette: Feeling Good about Science in Biology 2

Teachers today are inundated with messages of how to recognize and respond to the diversity in their classrooms. The concern expressed in the second epigraph above—how to help students feel good about science—is worth citing at greater length. The statement illustrates how Interest figures into a broader concern of how to differentiate for various kinds of student diversity:[75]

> Kids with disabilities are probably the most obvious. You identify the kids with IEPs [Individualized Education Plans], and boom, you've got it. Kids with limited English proficiency, most of those again are identified there [in the school's data system]. You're given some supports. But sometimes it gets complicated. . . . Economically disadvantaged kids—I mean all kids can be temperamental or sensitive—but if I'm going to have a nurturing side to me, how do you support those kids? How do you make them feel good about science? You know, if one of them stepped into my class and I go, "Here you go, I want you to write a scientific abstract," like I do with my AP kids . . . "You're writing a scientific abstract—you've gotta learn how to do it." But these kids, I would need to keep them motivated, keep them connected to science—especially if they're a combination ADHD kid, economically impoverished kid, maybe minority—learning it another way, so it's not just, "Worksheet, boom, me talking, here's the book, boom." (Interview DI, 2015)

Here, the teacher explains that the school system had already flagged differences for some categories of students, matching them with pre-specified special education services and second

[75] In this interview, the teacher was perusing a list of "diverse student groups" named in the NGSS as needing different instructional strategies. During final interviews with AHS teachers, I laid out on the table a number of artifacts from the school, district, and national policy that displayed messages directed at teachers of how to think about equity and diversity (see appendix E).

language supports. But it was more "complicated" to consider diversity outside these administrative categories. This was especially the case when moving from clear-cut metrics of proficiency to the more nebulous realm of attitudes, temperaments, and sensitivities. When it came to "economically disadvantaged" or "minority" students, was it safe to assume that students' socioeconomic or racial backgrounds might have something to do with their interests or attitudes toward science? How could a teacher know how students really felt about the subject, or how they might react to a difficult assignment? And even if teachers could predict the interest profiles of their classes, what should be done pedagogically in response?

The statement above expresses a worry about treating the "ADHD kid, economically impoverished kid, maybe minority" kid the same as "AP kids." According to the statement, the "AP kid" could be given rigorous assignments in a no-nonsense manner: "You're writing a scientific abstract—you've gotta learn how to do it." On the other hand, the "ADHD kid, economically impoverished kid, maybe minority" was described as having a distinct temperament or sensitivities that required extra effort to "keep them motivated." The concern seemed to be that subjecting all students to rigid standards of success and traditional modes of instruction would fail to effectively transmit the content, and worse, could threaten any progress made to foster positive feelings toward science.

Notably, the hypothesis of categorical differences in Interest seems to go untested. Consider the conditional tense and subjunctive mood: *if* one of them stepped into my class and were asked to write a scientific abstract—but these kids, I *would* need to keep them motivated. There is a preemptive logic here. Rather than wait for a particular population to lose interest in scientific technicalities, better to avert this outcome by adopting a pedagogy that prioritizes affective goals. Within this logic, the effective teacher—like Woodhull's wise doctor—engages in preventative care.[76] Yet even if this logic appears sound, how could a teacher make an accurate diagnosis? How would one infer whether a particular student is more like an “AP kid” who can handle dry content and tough assignments, or instead needs something easier to digest in order to stay connected to science?

This tension sits at the center of current teacher education reforms’ approach to equity and diversity. On the one hand, teachers are called to look for differences in their student interest and motivation, and to respond by differentiating instruction. On the other hand, teachers are cautioned not to see those differences as deficits or to lower their expectations. The statement above seems to thread that needle. It bears little resemblance to the cold rationality often attributed to tracking, where seats in higher-level courses are hoarded for the select few. The teacher’s explicit concern is how to create a more nurturing environment for students from marginalized groups—not rationing their resources, but investing even more energy to adapt the curriculum. Student motivation is identified not as a permanent deficit, but a malleable product of the teacher’s own instructional decisions. Rather than dismissing some as “unmotivated,” the teacher expresses an open inquiry (i.e., How do you support those kids?) and personal responsibility (i.e., *I* would need to keep them motivated). In all these respects, the statement exemplifies a prevailing vision of the reflective practitioner who inquires how to differentiate instruction for students’ diverse needs and interests.

Rules for teacher reasoning about diversity. Precisely because the statement follows these “rules” for teacher reasoning about diversity, it can point to the limits of those rules. By rules, I mean standards and norms generated through the language of curriculum and teaching to guide the beliefs and practices of teachers and teaching candidates. These rules appear in

[76] To extend Woodhull’s analogy, instead of giving everyone stones and waiting for some to choke, it would seem wiser to infer students’ appetites, and give some bread at the outset.

curricular standards, as well as in rubrics used to train and evaluate pre-service teachers. To identify and illustrate rules on Interest, I will briefly cite examples from the NGSS and a teaching performance assessment called the edTPA, looking specifically at the rubrics for secondary science.

The three rules pertaining to Interest ask teachers to: 1) see diverse interests; 2) differentiate instruction; and 3) avoid a deficit view. Beyond simply describing these rules, my goal is to raise questions about how teachers are learning to see differences in interest. Scientific observation, far from a timeless virtue or static method, has undergone many historical shifts, which generate new ways of being an observer and new objects to be observed (Daston & Galison, 2010; Daston & Lunbeck, 2011). Recalling Crary (1990), learning to observe differences between students is to conform to historical rules and techniques governing what can be seen and said to exist, and how such assertions can be verified.

Rule 1 is that teachers must acquire knowledge of differences in students' interests and motivation. This rule positions interest as central to what teachers should look for as potentially differing among their students. The edTPA (SCALE, 2015a) asks teaching candidates to consider what they know about their students' "interests" (p. 12). Likewise, the NGSS' *Framework* calls teachers to "build on students' interests and backgrounds so as to engage them more meaningfully" (NRC, 2012, p. 283). Both documents position interest as central to teachers' knowledge of student diversity. Interest is framed as a type of diversity in its own right (i.e., the "diverse interests" of any class of students), and as a key dimension on which demographic populations are predicted to differ (i.e., the distinct interests of "culturally diverse students").

Rule 2 is that teachers must use this knowledge of students' differing interests to differentiate instruction. This rule obliges teachers to change their teaching on the basis of the inferences and predictions made in Rule 1. The edTPA (SCALE, 2015a) states that, “students may bring interests . . . which a teacher can draw upon to support learning” (p. 48). The NGSS’ *Framework* affirms that, “for students to develop a sustained attraction to science and for them to appreciate the many ways in which it is pertinent to their daily lives, classroom learning experiences in science need to connect with their own interests” (NRC, 2012, p. 28). In other words, teachers must connect the subject matter to students’ prior interests to help develop an appreciation for science. For students perceived as less interested in the subject, their heightened need for responsiveness is not a once-and-done task, but sets in motion a new protocol: experimenting with different curricular topics and pedagogies, monitoring student engagement, and using that feedback to make continual readjustments to one’s instructional practice.

Rule 3 is that teachers must avoid a deficit view. The edTPA (SCALE, 2015b) defines a deficit view as making assumptions “based primarily on students’ cultural or linguistic backgrounds,” which result in “a pattern of low expectations” and “not taking responsibility for providing appropriate support” (p. 9). Likewise, the NGSS’ *Framework* warns against “biased stereotypical views about the interests or abilities of particular students or demographic groups” (NRC, 2012, p. 281). Both operationalize “deficit” or “stereotypical” views as making demographic generalizations *without empirical justification*. This will become important in a moment. The rule against a deficit view insists that evaluations of student interest be based on objective knowledge, and that if lower interest were to be identified, this cannot be used as an excuse to lower expectations for student learning.

These three rules enjoy strong face validity. They appear reasonable and consistent with common sense (i.e., of course, not all children share the same interests), with ethical standards (i.e., one should not devalue students’ diverse interests), and with one another (i.e., teachers should get to know their students and their interests, rather than rely on stereotypes). Yet on closer analysis, the appearance of smooth consistency gives way to sharp irregularities.

Two caveats appear in the interplay of the rules. First, avoiding a deficit view means that interest should ideally be assessed for individuals rather than for groups. And yet, under Rule 1 of knowing students' differences, a group-level generalization is sometimes permitted if endorsed by research.[77] If studies find that demographic variables correlate with motivational variables, then can the lower interest of certain groups be permitted as a research-based "finding" rather than a deficit-oriented "stereotype"?

Second, avoiding a deficit view usually entails adjusting the methods of teaching without lowering the end goals. However, Rule 2 demands differentiating instruction based on what is "known" about interest. As a psychological construct, interest is "known" as a starting condition for learning; as such, can the goal of triggering student interest be prioritized over other learning goals? It may appear necessary to modify the immediate aims of instruction if increasing student motivation appears as a prerequisite before any other goals. A danger is that, within these rules, it becomes permissible to temporarily alter, lower, or defer the academic standards and aims for a particular group of students—so long as that group is perceived as insufficiently interested or motivated in the subject.

The upshot is that under the current "rules" for effective and equitable instruction, teachers are not just allowed but expected to look for populational differences in students' interest. Overriding the injunction against a deficit view, the rules direct teachers to see individuals and demographic groups as potentially having higher or lower levels of interest in the

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[77] This caveat appears in the NGSS' *Framework.* Immediately after emphasizing the danger of biased stereotypes, the framework cites the importance of attending to "factors that may motivate or fail to motivate students from particular demographic groups" (NRC, 2012, p. 281). In chapter 6, I examine how studies that have generated claims of racial and gender differences in interest in science rely on tools and techniques inherited from previous eras.

subject. As I explore in the following chapter, these looked-for differences in Interest authorize prioritizing distinct instructional aims and methods, often along gendered, racialized, and ableized lines.

Such rules do not lie inert on the page of rubrics or policy.[78] They demand that the same teacher differentiate instruction when switching between course levels. Consider the AHS teacher cited above, who taught both an Advanced Placement course and a course called Biology 2. It was in the latter where the teacher felt compelled to develop a “nurturing” side:

> Engagement is huge with them. And I think a lot of kids, if they’re not engaged, they don't want to learn. And if they don’t want to learn, then it’s painful for all of you. It’s painful for me if they’re not into it. . . . Maybe I’m sensitive to kids that aren’t into it and I don’t like that. (Interview DI, 2014)

For some students, engagement becomes an overriding objective and a prerequisite for other aims. The rules for seeing and sorting Interest govern not only what teachers should think and do, but also how they are expected to feel—taking on the pain of students’ perceived disengagement as an impetus to further modify the curriculum. Interest demands that teachers first classify their students and then calibrate their emotional sensitivities and moral obligations based on those classifications. Beyond these daily adjustments, I consider next how Interest played a role in revising the Biology 2 course at AHS to adapt instruction for an increasingly “diverse” population.

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[78] In what S. Y. Lee (2018) explores as a bioapparatus, teacher education can itself be understood as a site that inscribes particular epistemological assumptions of observation and temporality. These assumptions, whether embedded in new evaluation rubrics or older frameworks of action research, reshape teaching practice by training teachers’ vision to diagnose “problems” (in this case, interests) and conduct “needs assessments” (see chapter 7). Through the historical fashioning of professional expertise, they shape how teachers are perceived and evaluated by generating principles that guide daily practice and reflection.

Rules driving the redesign of Biology 2. The Biology 2 course at Alderwood High School (AHS) had recently been redesigned, because more first-year students had been failing Biology 1 and taking it over again their junior year. Forcing these students to repeat the original course was thought to exacerbate their original problem of disengagement. Discussions turned to alternative ways for these students to earn a life science credit. One teacher recalled:

> We said, let's change Biology 2, which used to be sort of an honors course. Let's change that into, "This is your second chance at Biology if you failed." . . . It was, I'm almost certain, a more challenging course before that change was made. (Interview NM, 2015)

From one year to the next, Biology 2 changed from an honors-level elective to a general-level course. Originally intended for "college bound students interested in majoring in the biological sciences" (AHS Curriculum Guide, 2015), the repurposed course would focus on sparking an interest in science among those regarded as least motivated.

In the redesign, Biology 2 multiplied its sections to serve a "wide array of kids" (Interview KC, 2014). Besides those who had failed Biology 1, these included "very disengaged students" in truancy prevention programs, students transferring in from alternative education programs, and students juggling work and school to help provide for their families (Interview DI, 2013). Teachers noted that a few students in each Biology 2 section seemed to be a holdover from the original course, described as an "AP group" who must have signed up because they were actually interested in the subject (Interview DI, 2013). This perception of an "AP group" within Biology 2 is an exception that illustrates the rule: the rest of the class was presumed to lack a genuine interest in science. What made students into "AP kids," then, was not the course title on their transcript, but a speculation about their true feelings toward science. That speculation does not stem from the assumptions held by one teacher. It is embedded in the collective rules for vision—previewed in the prior section, and historicized in the next chapter—which direct teachers to speculate on Interest as an essential dimension of curricular differentiation and a demonstration of one's professional expertise.

A primary aim of the redesigned Biology 2 course was to increase students' interest in science. Biology 2 teachers described constantly trying new strategies to "hook" students, to "get them back in," and to "wake them up a little bit"; they were "always on the hunt" for interesting news articles and other media that could demonstrate the relevance of science to local and global problems (Interview DI, 2013; Interview KC, 2014). Rather than repeat the same content and instructional methods from Biology 1 that had presumably failed to engage students the first time, Biology 2 would offer more interactive pedagogies (e.g., outdoor field studies) and more engaging topics (e.g., environmental crises and human epidemics). Through the ordering strategy of Readiness (see chapter 3), the premise was that, while most of the juniors in the course were already off the college-bound track deemed necessary to pursue science-related careers, important work could still be done. Biology 2 would become a place to help those "late bloomers" catch up as much as possible and gain an appreciation for the science needed for responsible citizenship (Interview KC, 2014).

A key strategy in connecting students to science was to personalize the Biology 2 curriculum by picking health concerns most likely affect to affect those students and their families. In one unit, the teacher aimed to leverage the social drama of a recent legislative debate over compulsory vaccination laws:

> It's a way to motivate them. You know, it's like, 'They shouldn't make you get a shot.' You know, but why would they want to? And then examine the reasoning and then look at data that seem to support that. (Interview KC, 2014)

The teacher went on to explain that bringing in the vaccination debate was a way to provoke indignation that could "open the door for me to slide in this [article] as a technical reading" (Interview KC, 2014). Here, Interest was conceptualized as a closed door for some students, one that had to be deliberately unlocked for them to engage in the rigor of a technical reading. Besides working on literacy with informational texts, the unit aimed to make Biology 2 students more "data literate," helping them distinguish between scientific facts and the fear-based opinions of "people at a typical legislative hearing" (Interview KC, 2014). A further objective of the unit was for students to "change their minds" on vaccination and to persuade family members to get vaccinated (Interview KC, 2014) (see chapters 7 and 8).

Demonstrating the relevance of science to matters of personal and family health was envisioned as the opening needed for a certain type of student to become a literate, responsible, and healthy citizen. This logic reflects a long-standing theme of research on science and mathematics learning. As Valero (2012) argues, these fields have tended to conceptualize interest as "an intrinsic human mechanism of engagement that resides in the individual," such that "if teachers or students themselves do not 'turn on that mechanism,' nothing can be done" (p. 74). In other words, Interest is located in the nature of the child as the ultimate prerequisite: a barrier to attention and cognition that inhibits any possibility of learning until a solution can be engineered.

The intertwining of Interest with Readiness is evident in the developmental scale of science education aims discussed in the prior chapter (see Figure 4.1). In Elliot Downing's (1917) first version of the scale published in *General Science Quarterly*, the aim of Health forms the bottom rung, with Appreciation directly above it: the acquisition of hygienic habits being the primary objective, and developing an interest in the achievements of scientists and a desire to adjust oneself to their guidelines for daily life as a means toward that end of public health.[79]

Recent scholarship in science education articulates a similar link between interest and citizenship preparation:

> The lack of interest among young students not only threatens the production of the next generation of scientists, but more importantly, impedes students from becoming scientifically literate citizens, as they are unlikely or even unable to engage with important science-related societal issues. (Swarat, Ortony & Revelle, 2012, p. 515)

Within this logic, those allegedly lacking an interest in science are cast as a double threat. First, positioned as furthest from the pipeline of future scientists, they appear unlikely to advance the nation's progress. Second, perceived as unwilling to engage with any science-related concerns, they are positioned as endangering the democratic process itself.

Dispositions that current teacher education reforms seek to cultivate—a responsiveness to diversity, a sensitivity to student feelings, and a willingness to read students' negative affect as a call to make the curriculum more relevant—all appear in the Biology 2 redesign. Besides transforming the curriculum and pedagogy, the repurposing of Biology 2 entailed a reinvention of the teacher. The new Biology 2 student—prototyped as the "ADHD kid, economically impoverished kid, maybe minority" kid—seemed to demand a more nurturing side in order to see oneself (and be seen) as an effective and equitable teacher. New dispositions appeared necessary to navigate interactions that did not feel as fraught when dealing with "AP" or "honors" kids—including a caring attention to differences among students, a humility to admit the irrelevance of one's prior practice, and an eager commitment to learn which problems are

[79] As I explore in the next chapter, Downing simplified and revised this scale for his 1925 monograph to place Appreciation as the bottommost step.

most relevant to students' everyday lives. My argument is not that such dispositions are good or bad, but that they can be dangerous (Foucault, 1983).

The danger rests in a comparative reasoning that undergirds the divides presumed between logic/caring, cognition/affect, rigor/relevance, scientist/citizen, and AP/minority. These divides, combined with the tracked structure of high school science, make it hard to visualize the diversity of student interests outside a pre-given hierarchy of value. As if trapped within a mercury thermometer, the construct of Interest is read off a vertical scale, where it only appears to rise or to fall. Those who register as having a high degree of interest in science are free to carry on with the business of preparing for rigorous coursework and qualifying exams. But a different protocol kicks in when it comes to those with signs of low energy or enthusiasm; teachers are to focus on what researchers call "igniting and sustaining interest among students who have grown cold toward science" (Jack & Lin, 2014, p. 792). This protocol is treated as a form of triage, where getting students' interest back to the normal range takes precedence over the typical activities and aims of school science.[80] The new Biology 2 course can be read as a prescription for the diagnosis of students as lacking a healthy affinity and appreciation for science. The caring teacher, the focus on affective aims, and the curriculum made relevant to lay citizen needs—all show up within the triage protocol as compensatory interventions, positioned in opposition to the qualities associated with high-status credentials.

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[80] The redesign of Biology 2 to focus on Interest coincided with its downgrading in the hierarchy of AHS coursework. It had become a "general class," dropping out of the "higher-tracked honors classes" like Anatomy & Physiology officially recognized as having "a rigorous curriculum" (Interview GA, 2015; AHS Curriculum Guide, 2015). I use triage here in a slightly different way than Gillborn and Youdell (2000), Booher-Jennings (2005) and Horn (2013). For these authors, triage refers to the institutional practices by which the "neediest students get passed over for additional instructional resources in favor of those on the cusp of proficiency" (Horn et al., 2013, p. 27). This suggests that those classified as "neediest" are in fact "neediest," focusing critique on the policies creating perverse incentives that restrict resources from this "neediest" group. While sharing many of the authors' concerns, I want to extend critique not only to policies that act disproportionately on different groups, but also to the theories and practices that make up students as different in the first place. In this case, I do not assume that those labeled as the "neediest" of highly motivating science instruction are in fact different, but instead ask how some individuals and demographic groups become projected as needing external sources of interest and motivation (see chapter 6).

The danger of this comparative reasoning differs from conventional discussions of deficit thinking. As a psychological concept, deficit thinking locates the problem in negative stereotypes about a group of people based on their background (e.g., Valencia, 1997; SCALE, 2015b). Within this logic, there exists a biased, false, and baseless group claim that must be combatted with valid knowledge of individual students. Deficit thinking suggests that negative biases have infiltrated an otherwise objective reading of the interior of the child's mind, leading to an epistemological error or uncertainty that could be corrected with more data or better metrics. Where this formulation of the problem falls short, however, is its failure to question how the very basis of any knowledge claim about student diversity is not a passive description but an active remapping of the subjectivities of the teacher and the child.

Like Readiness (see Part I), the ordering strategy of Interest presumes the existence of distinct types of students who must be matched with different aims and methods of science education. It divides the population in two: those self-motivated to learn science versus those who do not immediately see its appeal. Those contrasting attitudes are projected onto students—registered as pre-existing conditions to which tracking appears the only appropriate response. Next, I consider how Interest operates across courses at AHS to classify students and to anticipate the science curricula they would most likely prefer.

Interest as Mapping Different Courses and Kinds of People

Talk of students' varying degrees of interest was common practice at Alderwood High School (AHS), as at many schools. In this section, I discuss a few means by which distinctions in Interest were made visible within and between science classrooms at AHS. Throughout, I gesture to similar classifying practices in policy and research. This is to keep in view how the ordering strategy of Interest circulates across U.S. social science and schooling as a taken-for-granted approach to promoting equity and diversity.

Tracing interest as topography. Interest was designated as a key factor differentiating the science course levels at AHS. Administrators and teachers were deeply concerned with learners getting "misplaced," particularly as greater control devolved to students in the course selection process (Meeting fieldnotes, 2013). Besides Readiness (see chapter 3), another way that a student could be misplaced was a mismatch between the course level and their level of interest in the subject.

On the official map of science courses, Interest showed up in the map's legend. Honors or advanced science courses were marked with a double asterisk (**) to indicate that they were "designed for the *serious* student who *plans to pursue* a science-related career or *wants* in-depth knowledge of a science area" (AHS Curriculum Guide, 2013; emphasis added). The asterisks set apart this serious student from the rest of the student body, whose desires and ambitions were left unmarked. Official course descriptions underscored the message that Interest is what delineated two types of students and the courses where they belonged. Higher-level course descriptions put motivational attributes front and center:

- Biology Honors was "designed to challenge and *motivate* students with high ability and *interest* in science."
- Anatomy and Physiology was "designed for *motivated* students with high ability in science, especially those *interested* in careers in the health sciences."
- Chemistry Honors was "suited for students who are *self-motivated*, highly capable, and *take responsibility* for their learning." (AHS Curriculum Guide, 2013; emphasis added)

Lower-level course descriptions neglected to mention personal attributes, sticking to a list of curricular topics to be covered. Left implicit were the converse qualities ascribed (by default) to the non-honors student: low ability and interest, unmotivated, uninterested in science-related careers, not self-motivated, and unwilling to take responsibility for their learning.

The course descriptions also exhibit a slippage between distinctions tied to one subject area (e.g., interest in science) versus those of a more general nature (e.g., self-motivated). Recalling the video designed to guide students' course selection (see chapters 2 and 3), the attributes making someone an "honors student" included that the person has "really good attendance, and is intellectually curious, and is willing to do an hour or so of homework a night" (Classroom artifact, 2013). Here, the desire to attend school, the curiosity to learn new things, and the willingness to do homework were not assumed as universal qualities of the student population, but projected as unique to the honors-level student. This raises the question: Is there a difference in the making of an "honors student" versus the "Bio Honors student"? Is "curiosity" conceptualized as a science-specific attribute or a moral quality of the generally well educated? Despite concerns raised about homework completion as affected by situational and socioeconomic factors rather than internal traits, homework completion also served as an indicator of who belonged in advanced physics versus who was misplaced, as well as who had the devotion to succeed in medical school (Interview MS, 2015; Interview HD, 2013).[81]

Not only did Interest appear within the course map's legend, it also functioned as a legend in its own right: projecting a bimodal student body by inscribing itself as what honors students possess and what non-honors students lack. At once a free-floating symbol and a

[81] This quality of being "willing to do an hour or so of homework a night" resembles the Protestant work ethic, as well as an American imaginary of the single-minded dedication of the Scientist bent over the lab table or the Inventor whose genius is 99% perspiration. This brings to mind a related cultural thesis, where distinctions in Interest intertwine with narratives of grit (C. Kirchgasler, 2018), and one's appreciation for science is justified not by faith but by works.

precisely drawn contour line, Interest showed students how to read the academic landscape and locate themselves topographically amongst the higher or lower tracks. It also instructed teachers on how to place students. Yet how can this be? How could a student's interest be visible or knowable from the outside? Next, I consider two key markers used to recognize who was affectively prepared for and welcome within those spaces marked as higher intellectual terrain.

Projecting dis/interest onto body language. One marker used to infer interest was students' body language. This ranged from the bodily presence or absence of students in class (e.g., quantified as attendance data) to finer grained distinctions in qualitative aspects of a student's classroom presence. Teachers often discussed student engagement as evidence of whether or not a class went well. In Biology 2, for instance, a teacher described gauging the overall engagement by students' "energy level," "whether or not their heads go down on the desk," and "how quickly they start getting to task without being told what to do" (Interview KC, 2014). Exterior qualities of students' bodies—visual cues like slumped posture or the speed of compliance with classroom directions, and auditory cues like the volume and tone of a class discussion—became data points of students' hidden feelings toward science. Recent research studies adopt similar proxy measures of posture, facial expression, and tone of voice to operationalize interest, motivation, and emotional engagement in science learning (e.g., D'Mello, Chipman, & Graesser, 2007; Jaber, 2015).

In research studies and in AHS classrooms, the act of attending to students' feelings is articulated as a means of caring about students and their emotional well-being. At the same time, reading body language as data revealing students' affective states and psychological attributes may have ramifications for their academic trajectories. As one teacher noted, decisions about which students to recommend for an Advanced Placement (AP) course often relied on assessments of their interest relative to other students: "Does it look like you like it?" (Interview RL, 2013). In recounting these signs of liking science, the teacher cites a student who may not be "not the most academic" in terms of written work, but who sits "right up front," seems to be "having fun" in lecture and lab, and is "very excited to jump into the conversation." This is the student who is likely to receive a handwritten invitation to sign up for AP Chemistry. In contrast, "the kid that I miss sometimes is the one that's really quiet and just doesn't say much. And I'm like, wow, I never knew you even liked it [chemistry]" (Interview RL, 2013).

Another teacher expressed consternation that "when you say 'honors students,' half the time that just means they're well-behaved" (Interview IY, 2014). "Even if they don't *like* my science class," the teacher went on to say, "I wonder if that's our prototype of what we want out of a student . . . quiet, studious white girl" (Interview IY, 2015). In this statement, the teacher's concern is with how racialized, gendered norms for "well-behaved" appear to contradict those of "liking science class," raising questions about who merits encouragement to pursue higher-level science coursework and careers. Studies on the hidden curriculum (e.g., Jackson, 1990), as well as the gendered and racialized construction of school science identities, articulate similar concerns (e.g., Brickhouse, Lowery & Schultz, 2000; Emdin, 2013).[82] For my purposes, what these concerns brings to mind is how such categories and qualities are not descriptions of natural kinds, but invented prototypes. As the teacher's comment suggests, built into the prototype's design are certain desires—"what we want out of a student"—where neither the "we" nor the

[82] Jackson (1990) argued that schools reward the passive conformist, creating a set of demands incompatible with values of "curiosity" and "challenging authority" that constitute real intellectual mastery (p. 36). Similarly, Emdin (2013) contends that school science, especially in urban settings, promulgates compliance to classroom rules and strict memorization, and in so doing, fails to recognize the qualities shared by scientists and by youth and artists engaged in hip hop. Likewise, Brickhouse and colleagues (2000) argue that science classrooms incentivize a "good student identity," which may work against the recognition of girls' strong scientific interests especially when they violate gendered norms and stereotypes.

desired student is universal. A particular genre of how to properly think, feel, and act as human is overrepresented as generic (Wynter, 1995).

Through the prototyping of the un/interested and non/honors student, spaces of differences are produced that historically have racialized and gendered kinds of people. As Interest is read onto and off of bodies, external perceptions of how a student feels toward a certain teacher, class, or school enter the calculus of their inherent attitude toward science writ large. Attendance and behavior data, typically disaggregated by race, facilitate generalizations of demographic differences in motivation and interest. Cultural norms and values of how to properly display one's "energy level" or "liking" of a subject can easily shape assessments of a teacher's effectiveness at engaging the class, or a student's desire for advanced science coursework.

Projecting dis/interest onto "self"-selection. A second marker used to infer Interest was a student's course enrollment. AHS teachers and administrators frequently referred to students as "self-selecting" or "self-tracking" into different course levels (see also Tyson, 2011 on "*laissez-faire"* tracking). The fact of one's physical presence in an honors course might suggest that the student was interested in science—unless proven otherwise by poor attendance, body language, or homework completion. In lower-level courses, the converse was often true. Students in non-honors courses were typically assumed to have eschewed a scientific career path, unless they gave explicit evidence to the contrary.

Of course, it was understood that a student's course placement did not depend on Interest alone, but also on their cognitive or academic Readiness (see part I). Yet common sense suggested that cognitive and motivational attributes were tightly correlated: "Often they go together—if it's easy, you like it" (Interview RS, 2013). Within this logic, a student's course enrollment gave a reasonably reliable estimate of their level of ability and interest in the subject.

The narrative of self-tracking took center stage in the debate over why the lowest-level Physical Science course disproportionately served African American and Hispanic students (see chapter 3). In a meeting on how to redress this disparity, an administrator proposed figuring out which students from underrepresented groups "have the skill set" for Physics, and yet remained in Physical Science (Meeting fieldnotes, 2013). The question was first posed as, "How did they end up in Physical Science?" and then rephrased as, "Why are they hanging out here?" This pair of questions can be read as illustrating how Interest generates a sliding attribution of responsibility. The first question interrogates an institutional sorting process (i.e., how did they end up here?), while the second slides the problem onto psychological terrain by questioning the motives driving a student's choice (i.e., why are they hanging out here?). The discussion later turned to why students were "refusing" to take the harder course. Posited explanations included that "they just have no interest in it," that "kids are avoiding challenging work," and that "there aren't advocates at home for some of our kids" (Meeting fieldnotes, 2013). In these ways, Interest seemed to obviate consideration of institutional sorting practices, directing inspection instead at the psychological attributes of underrepresented students and their families.

Despite the ubiquitous narrative of self-selection, many AHS teachers questioned or contested whether enrollment was really the students' choice, citing multiple ways in which their course placement was externally constrained. First, an 8^{th} grade teacher's initial recommendation—of Regular versus Honors Biology—set students onto one of two course pathways from which it was difficult to deviate (Interview MS, 2015). Second, despite removing strict prerequisites, recommended course sequences in science and math continued to guide students in “self”-assessing which course was the best fit (Meeting fieldnotes, 2014). Third was a process called “re-routing,” where teachers were asked to mark initial course rosters for students who had been “misplaced” and should be encouraged by guidance counselors to reconsider their course request (Meeting fieldnotes, 2014). Fourth, some upper-level science courses used pretests to screen for baseline proficiencies and give students a sense of whether they were in the right course (Classroom fieldnotes, 2014). Fifth, students could be switched midsemester—more commonly from honors to regular—if a teacher saw a need for a “level change” (AHS Curriculum Guide, 2013).[83] The course where a student ended up, then, did not necessarily reflect a personal preference; to varying degrees, a student’s choice was prearranged and guided, and in some cases, re-routed, screened, or overruled. Notwithstanding, the narrative of self-selection persisted and permitted moral judgments, as it became possible to view the track where students ended up as either revealing their inherent desire for knowledge, or indicting them for “hanging out” on the path of least resistance.

Two ironies emerge from Interest’s circular logic. The first is that when a student in a non-honors course expressed interest in science, this could be read as a sign of a misplaced “honors student.” This was evident in the prior discussion of a subset of “AP kids” within Biology 2. Likewise, when a student in Regular Biology asked curious questions—why carbon monoxide was a gas—it could be said that this was “really an honors student” (Interview EP, 2013). As discussed in chapter 2, the system of tracking becomes self-authenticating, since anomalies can be explained as the mistaken placement of an individual student rather than a mistaken premise about lower-track students.

[83] The recommendation to move a student up a level mid-semester was much rarer, in part because the upper-level class was considered to move at a faster pace (see chapter 3), meaning that the new member of that class would be even further behind.

A second irony appears when data-driven reforms attempted to rectify racial disparities in science course enrollment. One of these reforms was a program called Advancement Via Individual Determination (AVID), which encouraged a cohort of students to sign up for higher-track courses. Yet the notion of Interest as an internalized attribute made it possible to conceptualize AVID students as passively driven by external programmatic pressures rather than independently taking an interest in advanced science. In a department meeting to re-route students' course placements, teachers expressed concern that some students who signed up for AP Chemistry had been "pushed by AVID" (Meeting fieldnotes, 2014). The worry was that their choice had been unduly influenced by "the AVID people," whose own motives were rendered suspect by an accountability system requiring them to report how many students in AVID had signed up for AP courses. Given the extrinsic/intrinsic divide in psychological theories of motivation, it seems that the suggestion of outside influence cast doubt on whether these students possessed the "self-motivation" said to distinguish an "honors-level student." Paradoxically, AVID's effort to rectify disparities seemed to work against the wider recognition that these students' decisions to advance in science might be based on their individual determination.

Interest invested very particular actions with pedagogical significance as subtle signs of dis/engagement. Laughing at a chemistry joke, for instance, might confirm that the child is one of the few who has fun with science and would respond well to a push to enroll in AP courses. The act of bringing one's family to a science museum might defy policy narratives of certain families as less likely to seek informal science education.[84] Through a network of associated signs, Interest generated a map to visualize differences between course levels and the populations

[84] As discussed in chapter 6, the NGSS (2013a) formulate the problem of inequity in terms of needing to increase the interest in science of students from non-dominant racial and ethnic groups, as well as the interest of their families. The standards highlight concerns about "parent involvement" in education generally, and in informal science education in particular, citing the importance of "helping non-dominant groups see museums as worthwhile destinations for their families" (p. 367).

they served. Next, I consider how Interest entered into curricular decisions of whom should be taught what, how, and why. At issue is how pedagogical strategies to engage particular populations contain administrative norms of how children and their families should think, feel, and live.

Differentiating Instruction by Interest

Presumed differences in Interest demanded distinct pedagogies. At AHS, lower-level courses tended to focus on motivating students. Higher-level courses assumed that students were already motivated to learn science, and thus could offer instruction that, while considered dry and difficult, aimed to prepare students to pursue science-related careers interests.

Engineering, candy, and football: Piquing their interest in lower-level courses. As discussed in Biology 2, a primary goal for students in lower-level courses was fostering greater interest in science: “How do you make them feel good about science?” (Interview DI, 2015). This aim demanded distinct criteria to evaluate student success and the efficacy of one’s teaching. One measure of success in lower-level courses was the degree to which students expressed liking the class (and hopefully by extension, science). When reflecting on whether a Biology 2 lesson went well, “the affect is a huge thing” (Interview DI, 2014). Teachers of lower-level courses described a heightened responsibility to engage all students: “They either come into my class and get excited because I provide them with an exciting lab and that gets them interested, or I’m not pulling my weight and not drawing them in with something that can get everybody” (Interview IY, 2015). Nevertheless, there was a limit to what teachers felt they could control: “In the end, I really feel like I am only taking people who want to do well and getting them from A to B. . . . You can do ice cream and fireworks and not get every student” (Interview IY, 2015). Teachers across lower-level science courses discussed using strategies to provoke a situational interest. These included connecting science to everyday life, bringing in science-related news stories, interspersing pop culture references, and using extrinsic rewards and prizes. Physical Science lessons usually incorporated a question of the day, a classroom demo, and video clips from popular science YouTube channels, children's shows, and sitcoms (e.g., *Veritasium*, *Bill Nye the Science Guy*, *The Big Bang Theory*). Notably, these pedagogical techniques—a problem of the day, classroom demos, and video presentations—come recommended by research as "three instructional strategies to pique students' interest as a basic emotion" (Reeve, W. Lee, & Won, 2017, p. 87).

A major strategy to promote situational interest was to make lessons more "hands-on." This was deemed crucial in lower-level courses like Regular Biology, ESL Biology, and Earth Science. Engineering design competitions (e.g., bridge construction, egg drop) stood out as a way to reach students who "really enjoy building stuff and testing it" (Interview IY, 2015).[85] Candy made frequent appearances in lower-level courses, where it served as a "strong motivator" for positive behaviors and correct answers (Interview IY, 2015).[86] Candy also offered an inexpensive, high-interest way to represent the rock cycle, ecological populations, and molecules (Interview IY, 2015). As another teacher explained:

> I try to help get them the content, and I try not to lecture the whole time. . . . I try to be more hands-on and more active. In our DNA unit—because I don't have a lot of DNA things we can do in class because I don't have a ton of equipment like in [higher-level

[85] This invites further investigation into how engineering, for instance, became formulated in science education policy as an inclusionary strategy that serves to "recognize the contributions of other cultures historically" and to "spark interest" for "students who traditionally have not recognized science as relevant to their lives" (NGSS Lead States, 2013a, p. 363).

[86] This raises the question of what science pedagogy has to do with the scientific disciplines—long discussed as a domain of conjectures and refutations (e.g., Popper, 1962) rather than "positive behaviors and correct answers." At the same time, it is worth considering whether the governing practices of pedagogy that normalize the child as future citizen take on a particular form in science education.

> courses]—it's like, okay, we can color DNA, or we can make DNA candy, or we can cut it out. (Interview SF, 2014)

Hands-on activities, as noted here, promised two key benefits: 1) making science concepts more accessible (i.e., to “help them get the content”); and 2) making science instruction more engaging (i.e., to be “more active”). Through ordering strategies of Readiness and Interest, the purported benefits of hands-on instruction appeared more necessary in lower-level science courses. Students in these courses were positioned as having less developed cognitive skills and interest in science, such that the quantitative abstractions ascribed to higher-level courses appeared both inaccessible and unmotivating.

Notably, higher-level science courses were not devoid of engineering challenges or hands-on activities. As the quote above suggests, higher-track classrooms featured a “ton of equipment” that allowed students to manipulate objects, chemicals, and other concrete materials. Yet, as noted in chapter 3, while some physical items seemed to be assembled in the network of “materials that belong in a physics or chemistry supply room,” others had become linked to a distinct network of “motivating devices” considered pedagogically necessary for those perceived as “concrete” thinkers and “disengaged” learners.

The strategies outlined here are so ubiquitous that it’s easy to treat them as pedagogically self-evident: of course, teachers should attempt to connect science to what all students are interested in. Yet putting these strategies in juxtaposition with higher-level courses does highlight a significant contrast. Where the science interests of those in higher-level courses were discussed as highly individualized (as explored in the next section), interests in lower-level courses were usually given in general developmental or broad demographic terms.

Regular Biology, for instance, aimed to "spark some interests in genetics" and its everyday applications, because teenagers are "always interested in sex" (Interview EP, 2013). In Biology 2, the focus on health was discussed as a motivating strategy tied to a basic self-interest: "It's more of a general interest type of thing. . . because kids are innately interested in their own health and wellbeing" (Interview KC, 2013). In addition to these generalized interests ascribed to kids and teenagers, lower-level courses incorporated topics of potential interest to particular demographic groups. Biology 2 introduced ecosystem dynamics by doing "a lot of urban ecology, because I find kids are interested" (Interview DI, 2013). Physical Science taught about Newton's laws of motion through a video and article about the science of the NFL (National Football League). When asked the main idea of the article, one student replied, "It was about football. It's *always* about football" (Classroom fieldnotes, 2013). In debriefing the lesson, the teacher explained, "The main point of doing that article is to get them thinking about how physics does really relate to things in their real life. And football is hopefully appealing, to some of them anyway" (Interview LC, 2013). The tendency to describe interest in demographic terms has a long history in science education research and policy. As I will explore in chapter 6, the NGSS recommend that for some groups more than others, interest must be strategically fostered through incentives, situational triggers, and demographic appeals to demonstrate the appeal of science.

Pre-med or string theory: Pursuing individual interests in higher-level courses. Higher-level courses at AHS tended to presume a baseline of interest and an ambition to consider careers ranging from disciplinary research to medicine to engineering. This premise obviated efforts to demonstrate the entertainment value or everyday relevance of science. A logic invoked in recent studies (e.g., Durik, Hulleman, & Harackiewicz, 2015) is that for students of high individual interest, such strategies might only distract from the inquiry at hand.

At the same time, higher-level courses frequently exhibited a joking rapport and pop culture references. However here, playful interactions were not articulated as a deliberate pedagogical strategy, but a natural byproduct of student-teacher affinity. In contrast with Regular Chemistry, one teacher noted that in Math Chemistry, "I could put a subtle little joke out there, and I'd get a good laugh from it. . . . It's a different clientele here" (Interview TN, 2014). Student engagement in higher-level courses was less frequently attributed to the teacher's strategies and more often to the non-cognitive traits of higher-level students. For instance, when asked why a lesson went well, one could reply, "It's Honors Bio. These are kids who generally are really putting effort into it" (Interview IY, 2013).

As noted above, the course levels also differed in whether student interests were conceptualized at the level of the subgroup or the individual. Students in higher-level courses were discussed as having highly specific, individualized interests: each "came in interested in particular things" (Interview MS, 2014). While some advanced courses were constrained by covering the material on an AP exam, others had more room to play. For the latter, the priority was identifying and deepening students' specialized interests. The pedagogical ideal in this space was to "let the kids self-determine," initiating projects like designing a high-altitude balloon (Interview MS, 2014). Higher-level courses, then, were not devoid of a focus on student interest, hands-on activities, or engineering design challenges. What marked the contrast with lower-level courses, rather, was that the high-altitude balloon was not conceptualized as necessary to spark an interest, to motivate an appreciation for science, or to demonstrate the relevance of science to citizens' daily lives.

Rather, teachers of higher-level courses expressed a sense of responsibility to identify, expand, and refine students' interests in science-related careers. On the first day of Anatomy and Physiology, students completed a survey of their college and career plans, followed by a discussion of university courses in the pre-medical track (Classroom fieldnotes, 2013). In Advanced Science and Engineering, the teacher also began with a survey of individual interests:

> What are you planning to do in college? Knowing that it will change in some way for many of you. . . . And so what do we need to—what am I preparing you for basically? And what are your particular interests? (Inverview MS, 2014)

This teacher ended up creating a new unit on fluid dynamics, since the results of the interest survey suggested that:

> Many of these students will not be physicists—they'll go on to be engineers. . . . If you're going to do aerospace or chemical, biomedical, civil, mechanical, nuclear—all of those fields of engineering depend on a pretty good basis in fluid mechanics. (Interview MS, 2014)

Later in the semester, the teacher invited a theoretical physicist from a nearby university to discuss how he became interested in string theory, and to address any other questions students were curious about (Classroom fieldnotes, 2014). The aim of surveying career interests was not only to tailor the curriculum to existing inclinations, but to introduce students to new fields that "maybe you'd be even more interested in if you knew it existed," such as sharing how a former physics major applied his quantitative skills as a successful Wall Street investment banker (Interview MS, 2014). In these ways, students in higher-level courses were positioned as potential doctors, researchers, or engineers, or, at a minimum, as interested in pursuing college and high-powered careers.

Such logics are not unique to AHS but permeate educational policy and research. Chapter 6 explores how Interest makes similar demarcations in the NGSS—contrasting the pedagogical needs of girls and non-dominant racial and ethnic groups with those of gifted and talented students. Similar to the pattern at AHS, the NGSS described the interests of girls and non-dominant groups in demographic terms, such as using "aesthetic aspects" of science to engage girls (NGSS Lead States, 2013f, p. 11) and local place (e.g., "smashed cans in the neighborhood") to engage economically disadvantaged students (NGSS Lead States, 2013b, p. 4). In contrast, the interests of gifted and talented students are described in individual terms, such as Jerry's "naturalist interests" in butterflies (NGSS Lead States, 2013h, p. 2).

Research studies on interest in science and math education propose mapping interest as a developmental trajectory (Hidi & Renninger, 2006). This trajectory locates the experience of extrinsic interests as a precursor for developing interest as a stable internal attribute. At its lower end, the scale conceptualizes a set of students who have yet to develop an intrinsic interest in science, and who therefore require pedagogical strategies to trigger a situational interest. At its upper end, the scale imagines a set of students for whom an interest in science is already deeply embedded in their cognitive schema. Students at the two ends of the scale are projected as needing opposite pedagogical approaches, making the differentiation strategies of upper- versus lower-level courses at AHS appear as a reasonable response to this theoretical premise.

Moreover, research studies distinguish whether it is worthwhile to pursue the individual interests of academically motivated versus unmotivated students:

> Ideally, catering to the personal interests of individuals in the classroom would promote learning for all students, but in reality, this could be an extremely time and effort consuming task, especially if classes are large. Many teachers in these settings are unable

> to provide each student with individualized programs, particularly since not all children have interests that are easily adaptable to school settings and academic learning. (Hidi & Harackiewicz, 2000, p. 157)

In the case of higher-level courses, a prioritization of students' personal curiosity might be justified based on the premise that those interests are already in line with science. Meanwhile, lower-level courses did not tend to cater to students' individual interests—perhaps dismissed as less "easily adaptable" (as in the statement above) to the task at hand of learning science. In this way, Interest generates a rationale for using generalized strategies in lower-level courses to stimulate a situational interest in the subject.

Like trajectories of mental or cognitive development (see part I), the developmental trajectory of interest in science could offer a new way of producing distinctions, ordering students and subgroups, and matching them to different administrative techniques.[87] The principles of Interest make it possible to equate "underrepresented" with "alienated from science," to translate "disenfranchised" into "disengaged," and to treat "responding to diversity" as synonymous with strategies to nurture an emotional connection to science that could not, according to the ordering strategy of Interest, be assumed for all students.

Beyond Cold versus Warm: Why Historicize Interest

Critical perspectives in education often presume a dichotomy between cold and warm. On the cold side sit technological rationality, positivism, curriculum standardization, and economistic models of education. On the warm side sit progressive values, interpretivism,

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[87]Within the logic of differentiation by demographic subgroup, separate classrooms offer a way to target (allegedly) shared interests by gender or social background. The logic obeys a new norm of "niche standardization" (Epstein, 2007, p. xxxv), wherein differentiation by gender or race is positioned as a progressive step toward, and temporary substitute for, personalization. It also produces a two-pronged approach (see chapter 1), where "the challenge for researchers and teachers is to identify instructional enhancements that can maintain or amplify the motivation of those with existing high individual interest as well as cultivate the motivation of those with low individual interest" (Durik et al., 2015, p. 15).

curricular responsiveness, and humanistic models of education. This dichotomy brackets off where power is assumed to operate. Repressive power relations tend to be associated with the cold side, as dominant groups use institutional structures and testing regimes to secure advantage for their children in a zero-sum game of educational opportunity. Meanwhile, marginalized groups are left with an impoverished pedagogy that drills low-level content and kills students' interest in a subject. If the problem is a rationality that divides cognition from affect and alienates many students in the process, then the solution would seem to be a return to the unfulfilled values of progressive reformers (e.g., Dewey and colleagues) that emphasized the child's interests as central to education. Taking student interest into account is upheld as a way to bridge cognition and affect, and in so doing, to bridge the gap dividing underrepresented groups from an otherwise uninviting subject like science. The hope is that the repressive power of rationality can be counteracted by the warm caring of pedagogies centered on student interest.

What the cold/warm dichotomy obscures, however, is that power relations are not solely repressive, but also productive of the very modes of conceptualizing students as having different interests and emotional needs. Interest, along with related constructs of motivation, attitudes, and affect, actively contributes to differentiating what it means to be a good teacher for different categories of students. Rules for seeing and sorting Interest shape the boundaries of pedagogical expertise and professional discretion. Through the lens of Interest, teachers are expected to look for different levels of vulnerability and alienation and to differentiate the curriculum accordingly—matching some with unyielding demands and others with more nurturing pedagogies.[88]

[88] On principle, these demands need not be mutually exclusive. Delpit (2012) discusses the need for teachers to be "warm demanders." Arguably, what makes this phrase striking is precisely its juxtaposition of what are typically treated as opposite approaches to teaching.

Prior scholarship has challenged the narrative of "self-selection" as explaining racial disparities in science coursework (Tyson, 2011) and careers (B. Lewis, 2003). These studies have scrutinized the premise that the underrepresentation of students of color and female students in upper-level courses or science-related careers is by "choice." As Oakes (1985/2005) contends, tracking decisions cannot be considered a genuine choice, restricted and informed as they are by standardized test scores, grades, and recommendations from teachers and counselors. In these analyses, structures constrain individual agency, both of the student whose "choice" is overdetermined and of the teacher who makes a biased recommendation based on stereotypes rather than true measures of student interest and motivation.

Critiques of deficit thinking have argued that narratives of "unmotivated students" tend to blame marginalized groups for failing to try hard enough to succeed, shifting responsibility away from inequitable teaching and schooling practices (Valencia, 1997). Within this literature, an aim is to debunk the myth of the "unmotivated" subpopulation by arguing that such a claim "lacks empirical verification" and is "more ideological than scientific" (p. 2). While this critical framing offers an important counterpoint to prior research, it also maintains the premise of binary oppositions between ideology and science, between theory and empirical data, and between power and knowledge. Such binaries cleave the objects of social science from inspection. They leave in place that there is naturally a stable quantity of "interest in science" within each student that could be calculated, if only biases could be neutralized in its perception and measurement. The temptation to dismiss past research as ideology or pseudoscience obscures how the very standards of what counts as empirical or scientific have historically transformed alongside mutating classifications of race, gender, and psychological traits. In the well-intentioned attempt to redraw the boundaries around science to exclude what is clearly objectionable in the past, it becomes harder to examine the boundary work involved in turning Interest into a scientific category taken as objective and empirically verified science. As such, the binaries foreclose analysis of how what happens to be well-established in educational research or the learning sciences today is likewise not free of cultural norms or power relations.

It is not merely that negative stereotypes misrepresent Black and Latino/a students as having less interest in science, or girls as lacking an affinity for the so-called hard sciences. Interest not only divides and stratifies along pre-existing representational categories, but also is productive of new modes of difference. It instantiates principles of moral order that affirm or rebuke student and teacher alike. It sets criteria of administrative success in goals of promoting equitable pedagogy and broadening participation in STEM fields. I am interested in how theories and techniques for assessing interest as a psychological attribute carry in them normative principles that order students along a hierarchy of value. These principles and practices make up people as racialized and gendered subgroups at the same time that they make up the mind as possessing a stable, calculable degree of motivation for science learning.

The next chapter examines the historical conditions and practices out of which Interest in science precipitated as a scientific object. As many have discussed, interest formed a core element of child-centered pedagogy in U.S. Progressive Education. Across subject areas, interest was part of a drive to shift from teaching the disciplines to teaching the child. What made a focus on interest appear progressive was that, in contrast with IQ, interest was amenable to external intervention and could be grown: progress was possible, even for those who appeared farthest from the ideal. However, as I will explore, the dividing practices of IQ and interest were not mutually exclusive but deeply entangled. The general science movement would draw on functional psychology, child study, and the sociology of urban masses to first acquire knowledge of the pupil and their differing interests, and second, to adapt science education to those interests—in Woodhull's terms, to engineer a "bread" that these populations were both ready and eager to digest. At issue is how these early notions of interest—explicitly linked to evolutionary theories of differences in sex and racial stock—changed over the course of the twentieth century, and what it means for efforts to promote gender and racial equality in science education today.

Chapter 6. Strange Precipitate: How "Interest in Science" Produces Different Kinds of Students

> Race and sex differences in students' interest in, and affinity for mathematics and science have been reported in a number of studies. . . . Black and female students express lower levels of interest and affinity for mathematics and science than white and male students.
>
> —Gail E. Thomas (1986, p. 31)

> Educational experiences designed to leverage the personal interests of learners have been used to increase the participation of girls in middle school, of urban high school youth of color, and of elementary school children from immigrant families.
>
> —*Framework for K-12 Science Education* (NRC, 2012, p. 286)

The idea that demographic groups exhibit different levels of interest in science is treated as a matter of fact in U.S. science education. Decades of research have taken *interest in science* as an object of analysis. Despite variation in how it is studied,[89] it is generally assumed to be a measurable quantity of the mind. That is, a student has a more- or less-developed interest in science than someone else or than a population average. This comparative aspect makes it possible to contrast not only individuals but also subgroups, such as the race and sex differences reported in research from the 1980s (see the first epigraph, above).[90] When the problem of inequity is formulated in this way, the solution seems clear: Teachers must connect science to students' personal interests. This is regarded as good for all, but particularly important for those

[89] As mentioned in chapter 5, there is significant variation in the operationalization of interest and the science toward which that interest is directed (e.g., science in general versus school science).

[90] Throughout the study, I cite the precise classificatory terms used by historical sources, such as presumed differences in "sex" and "racial stock" in the early 1900s, or in "gender" and "nondominant groups" in the early 2000s. Tracing these shifting classifications is a strategy to denaturalize these categories and examine their historical production within distinct grids of scientific and schooling practices.

assumed to lack an affinity for science: identified in a 2012 U.S. policy framework (see the second epigraph, above) as girls, urban youth of color, and children from immigrant families. Knowing and leveraging the interests of these subgroups is promoted as a method of achieving equity and inclusion.

Because underrepresented groups are diagnosed with different interests—and in certain cases, less overall interest in science—it has become reasonable to prescribe different teaching strategies for them. This plays out in daily classroom practice (see chapter 5), as well as in national policy documents. Building on the 2012 framework above, the U.S. Next Generation Science Standards (NGSS) present case studies for how to make science "accessible" to diverse subgroups (NGSS Lead States, 2013a, p. 359). Interest is a key factor marking those subgroups as pedagogically distinct. What defines a subset of students as gifted and talented is, in part, their "intense interests and motivation in science" (p. 365). In contrast, girls' interest in science is said to "dramatically decline" compared with boys' (NRC, 2012, p. 281), and "non-dominant" racial and ethnic groups are identified as having "traditionally been alienated from science" (NGSS Lead States, 2013a, p. 366). These claims have acquired such a high degree of facticity that specific studies are no longer cited to back them up. They are now matters of fact (Latour & Woolgar, 1986).

From a Matter of Fact to the Conditions of its Materializing

Borrowing from chemistry, it is possible to think of Interest in science as something that only becomes real through a reaction—not a permanent object, but a solid precipitate. In chemistry, a precipitate is a solid substance that falls out of solution during a reaction under a certain set of conditions. I use the notion of precipitate to suggest that while Interest in science has acquired solidity as an object of research and reform, it did not always exist in its present state as a psychological attribute differentiating students by gender and race. Treating Interest as a precipitate is to shift the analytical focus from a matter of fact to the processes of its materializing. It calls attention to the fluid reactions taking place just before this precipitate solidified. This chapter investigates the swirling set of historical conditions and practices out of which “Interest in science” precipitated as a solid attribute of persons—one that has repeatedly crystallized around notions of difference in sex and race.

The chapter juxtaposes past and present to question a particular common sense: that attempting to connect science to the interests of underrepresented groups is an unproblematic good. Efforts operating within this common sense tend to analyze power in terms of identities and representation. These studies ask: Are the interests of students from diverse groups being included in the science classroom? Neglected in these analyses, however, are the power relations that operate through the production and regulation of different kinds of people (Foucault, 1990; Hacking, 2007). Categories of diversity are neither natural nor neutral. What becomes seen as diverse depends on the cultural production of a norm against which difference, or abnormality, can appear (Somerville, 2007). Just like categories of diversity, the scientific concepts we use to describe their distinct attributes are not natural (Danziger, 1997).

Interest in science is not the same thing in different times and places. A century ago, U.S. science educators spoke of interest in science as a democratic ideal that defied measurement (e.g., Kilpatrick, 1921). Today, it is quantified in the individual, mapped in the brain, disaggregated by subgroup, and used to rank nations around the world (see Bang & Valero, 2015). Rather than assume Interest in science constitutes a timeless dimension of human nature, I will approach it as a contingent product of human history that changes based on how it is conceptualized, measured, and deployed.

The chapter asks how Interest in science has operated in the production and regulation of difference in U.S. science education as it was configured and reconfigured as a pedagogical concern at two moments: the rise of the general science course (1916-1926) and the release of the U.S. NGSS (2013).[91] In the early 1900s, general science was launched to adapt science to perceived differences in girls and the "masses" entering high school at the time—including their disparate interests. Almost a century later, interest in science shows up in the NGSS as a strategy to promote equity by adapting instruction for girls and non-dominant groups. Both *GSQ* and the NGSS warn science teachers to attend to differences in students' interests, and in both cases this concern was linked to national anxieties about a "changing population." I am interested in the collective, historically contingent rules that generate interest in science as a working object that social scientists and science teachers are trained to identify and act upon.

The chapter explores the confluence of conditions and practices that allowed today's common sense to materialize (Butler, 2011). I am interested in how past distinctions and fears have solidified in contemporary categories of those who must be motivated to take an interest in science and apply it to their daily lives. I am especially concerned with how Interest in science emerged as a psychological construct contemporaneously with other dividing practices of sex, gender, and race that were mutating and mutually constitutive over the past century (Somerville, 2000). How did Interest in science become a measurable attribute that some gendered and racialized groups appear to possess less of than others? And how has it operated to produce different kinds of students who appear to require distinct forms of science education?

[91] The analysis in this chapter focuses primarily on (a) the NGSS and their associated *Framework for K-12 Science Education* (*Framework*), and (b) the journal *General Science Quarterly* (*GSQ*) published from 1916 to 1929. As noted, *General Science Quarterly,* one of the earliest science education journals, initially emphasized research on how to adapt instruction to the pupils entering so-called comprehensive high schools. These high schools were by no means comprehensive, since separate institutions existed for those classified as "feeble-minded," "Indian," and "Negro," among others. Rather than treat deployments of interest, gender, and race as self-evident, I examine how such distinctions have been historically produced.

Invented as a conceptual resource to guide the work of researchers and educators, Interest in science does sociopolitical work by dividing children and curricula.[92] The concern this raises is not to dismiss interest-oriented courses or informal science programs as the source of the problem. The solution is not necessarily to distribute an abstract, decontextualized science course to all students, as this would accept as natural its claims to science as an abstract and universal quality of mind (see chapter 3). Rather, it is the hierarchical relations between these bodies of knowledge (and the student bodies they address or produce) that I am trying to question.

I organize the analysis as follows. First, I consider how interest in science emerged in the early 1900s, as researchers drew on evolutionary theories to infer natural differences in interest by "sex" and "racial stock." Second, I highlight an important shift over the next few decades from inferring differences in interest by nature to calculating interest by the numbers through empirical techniques. Third, I explore how interest in science became linked to the problematic of underrepresentation, so that it now seems common sense for the NGSS to identify girls and non-dominant racial and ethnic groups as requiring distinct pedagogies to boost their affinity for science. As discussed in chapter 5, my concern is how Interest produces divisions that generate race and gender (among other categories) along a biopolitical spectrum from a proper management of feelings to an attitude pathologized as apathetic, impulsive, alienated, or insecure. I conclude by considering how Interest in science depoliticizes questions of justice—erasing historical processes and installing the barrier to equity as an attribute of gendered and racialized subjects: their perceived lack of desire for science.

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[92] These case studies target demographic subgroups, including gifted and talented students, girls, and race and ethnicity As outlined in chapter 2, a psychological category like Interest can be understood as a fabrication in both senses of the word (Popkewitz, 2012b): It is *made up*, a fiction imposed on the world, but it is simultaneously *made into* reality. That is, it is not just a social construction in terms of language and ideas, because it acts on the world in material ways.

By Nature: Inferring Interest from Theories of Racial and Sex Differences

At the turn of the twentieth century, interest in science had already solidified as a working object discussed by psychologists and teachers. To see how Interest in science is not just naturally there, then, requires going back to a time before it became a common-sense way to describe students.

From a will for God to an appreciation for science. Education in the United States has long been concerned with managing pupils' desires (Baker, 2005). During the nineteenth century, this inner desire was not conceptualized as interest but as the child's will. In the mid-1800s, science education sought to promote moral character and to bring each pupil's will into alignment with the Divine Will through learning to obey God's natural laws as revealed by science (e.g., Mann, 1867b). Within this logic, what held back the so-called "savages" was a difference in their souls, as indicated by their use of heathen incantations rather than Christian medicine (p. 147). At this time, interest in science was not yet thinkable as a psychological trait existing in the mind and varying by degree. Nevertheless, the notion of a pupil's will located in the soul bears some resemblance to the later notion of a student's interest located in the mind. In both cases, the goal was to harness some motive force within the individual child to promote an idealized mode of conduct.

By the early 1900s, the popular understanding of humans as religious beings with varying virtues was gradually substituted with a biological model of humans as natural organisms with distinct degrees of intelligence (Carson, 2007; Wynter, 1995). Normal human nature was defined scientifically by studying those imagined to be less evolved races (Gould, 1977). Recapitulation theory, pervasive across the U.S. social sciences at this time, posited that the individual human develops through all of the stages of the human race—from primitive Negro to civilized

European, and from feminine emotion to masculine reason (Fallace, 2015). In science education scholarship, these principles made it possible to reorganize science education from a "recapitulatory point of view" (Downing, 1925, p. 74). If the natural stages of mental development follow the evolution of man, then "it seems to be the function of education to expedite the child in his passage through these primitive stages and to bring him as rapidly as possible to a comprehension and appreciation of the cultural heritage of mankind" (p. 54). Recapitulation theory made it possible to configure the educational space as a trajectory of hierarchical stages, and a revised scale of science education aims placed the first stage as *Appreciation* (bottom step), a term used interchangeably with interest (Downing, 1925; see Figure 6.1). Only once this stage was acquired would pupils be ready to move up to *Skill in Thinking* (middle step), and finally up to *Knowledge* of the sciences (top step). By following this sequence, science education scholars argued, the natural hungers that drove the child and primitive man could be developed into the appreciation for abstract knowledge that distinguished the mature scientist and civilized man (Clark, 1921; Quickstad, 1917).

Expediting the child's passage up this trajectory would require knowledge of which pupils already possessed an interest in science, and which were still driven by "emotional attitudes rather than reasoning" (Downing, 1925, p. 74). To acquire this knowledge of the pupil, teachers were urged to study psychology, sociology, and pedagogy (Elhuff, 1916b). These fields were understood as having accumulated "a rapidly growing mass of fact" (Downing, 1925, p. ix) regarding the "important factors which must be recognized by the modern teacher," including sex and racial heredity (Hunter, 1920, p. 385).

Separate spheres: The mutual fabrication of man/woman and civilized/savage. First, interest in science was to be distinguished by sex. Anthropological studies drew on evolutionary

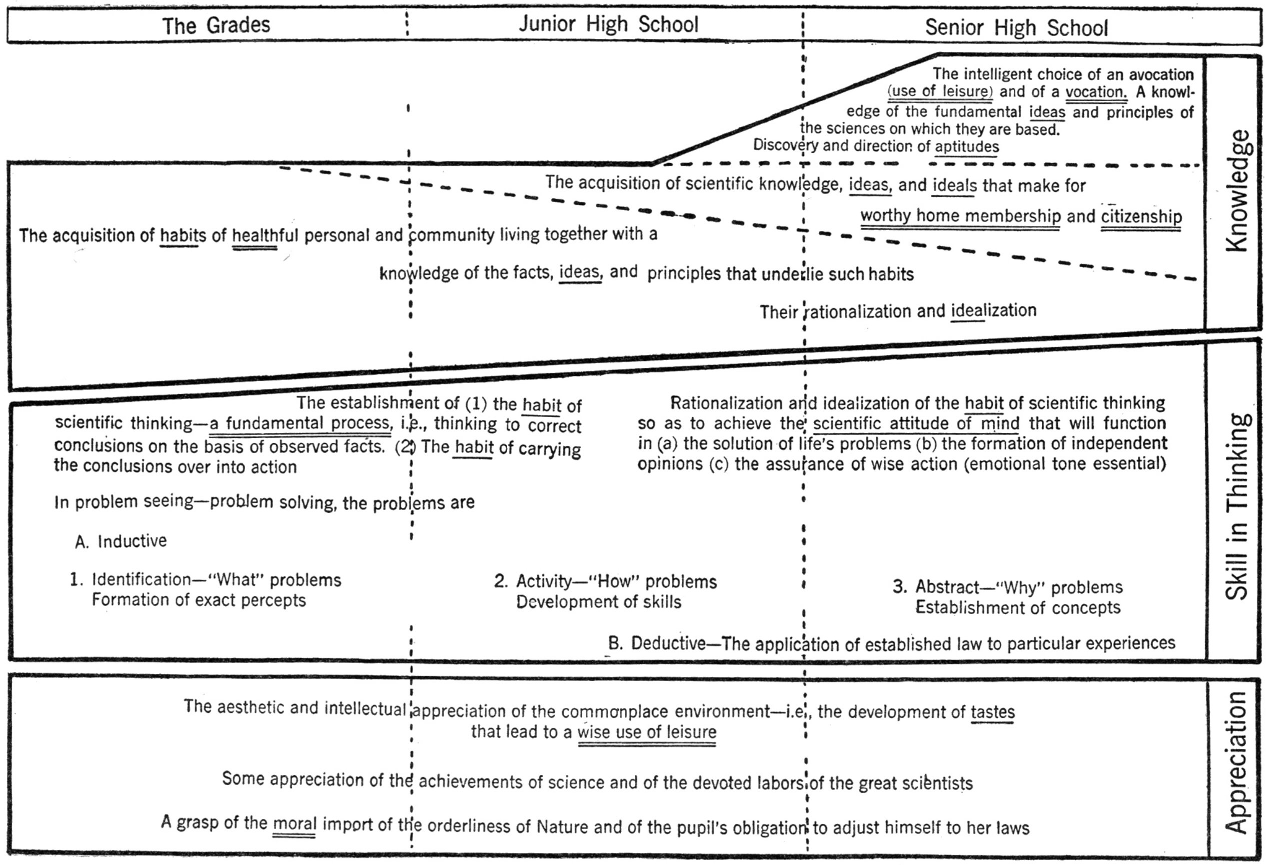

Figure 6.1. A Revised Developmental Sequence of Science Education Aims (Downing, 1925, p. 83). In 1925, E. R. Downing published a revised version of his 1917 sequence of aims shown in Figure 4.1. In this streamlined version, Appreciation takes the place of Health as the bottom, prerequisite step for moving up to Skill in Thinking or Knowledge.

theories to assert that in so-called "savage races," men and women were more similar to one another in anatomical features and societal roles (e.g., Delauney, 1881; see Russett, 2009). Greater sexual differentiation became a sign of civilizational development—a principle that informed educational efforts to reinforce the proper roles of men versus women (see Lesko, 2012). In a modern civilization, science education scholars explained, boys and girls ought to display different interests by nature. Where boys should be interested in the great industries, outdoors, sports, and the affairs of the world of man, the "predominant interests of girls are in the home and in the activities within the woman's sphere" (Massachusetts State Committee on General Science, 1916, pp. 89-90).

General Science Quarterly provided teachers with separate course outlines by sex, recommending industrial chemistry for boys and household chemistry for girls (Waterhouse, 1917; Gerry, 1920). As the title of one article put it, "Peggy learns that housekeeping is science" (Hanson, 1919, p. 219). By recognizing and responding to those divergent interests, the general science course aimed to further the sexual differentiation understood as essential to ensure that America remained an advanced civilization.

Mental and moral taxonomies: Superstitious impulses versus intellectual interest. Second, interest in science was to be distinguished by nationality and race. Science education scholars drew on discourses of the Social Question in expressing concern that the U.S. population was changing and losing its interest in science (e.g., Bowden, 1924).[93] Sociological studies classified immigrant groups' mental and moral traits to identify what separated each from the "Anglo-Saxon ideal" (Jones, 1904, p. 133). Resulting typologies linked racial heredity with dispositions toward scientific reason and the presence or absence of "intellectual interest" (p.

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[93] As discussed in chapter 1, the early 1900s in the U.S. was an era of immigration quotas and Jim Crow segregation, where national fears of urban disorder and racial degeneration were coupled with hopes that science could provide knowledge of and solutions to societal problems (Chamberlin & Gilman, 1985).

299), such as the "impulsiveness of the Italian" (p. 133) that made them less receptive to science than to "superstition" (p. 76). Similar taxonomic principles emerged in racial science. In an influential eugenics text, the pursuit of scientific discovery was identified as a mental trait of the Nordic race, associated with the moral traits of Protestantism and self-reliance, and with the physical traits of fair skin and blue eyes (Grant, 1916). Across the social sciences, the notion of interest in science as a hereditary and evolutionary trait was produced through (and productive of) racial distinctions.

Recapitulatory principles, coupled with empirical practices of inferring inner differences from external features, allowed for the possibility of reading interest in science off of racialized bodies. By identifying the racial stocks of the school, the child's interests were assumed to reveal themselves to the teacher as scientific observer. One *GSQ* article drew on sociological studies to classify the intellectual desires of the English, the industrial ambitions of the Germans, and the common interests of Italians and Serbs (Caldwell, 1917). In another article, a science teacher inferred pupils' interests based on the section of the city contributing to the school's population.

> [The school] consists largely of various types of foreigners: Italian, Polish, German, Hungarians . . . . A few are bright and alert, some give evidences only of a passing interest in things educative, while a majority perhaps are rich with family tradition and superstition. (Carpenter, 1916, p. 47)

Here racialized hierarchies are not only reinforced but reformulated. Within a given type of foreigner, pupils could be imagined as arrayed along a scale, from a majority interested in superstition up to a bright few with an interest in science.

Out of the evolutionary theories and social science typologies circulating at the time, interest in science solidified as a site for ordering both children and curricula. It simultaneously helped to fabricate different kinds of pupils and the distinct tiers of instruction to which those categories were matched. For some, developing an appreciation for science, as seen in Figure 6.1, would be the primary aim and the prerequisite for any other goals, including scientific knowledge. Instruction for pupils from southern and eastern Europe would focus on “relevant material from sources in their every day [*sic*] life” (Richardson, 1916, p. 33), “rather than making the futile attempt of imposing upon people the special aspects of science which are properly of interest to special students” (Caldwell, 1917, p. 135). In contrast to general science, physics and chemistry became designated as specialized sciences. These courses would now be reserved for the few seen as uniquely interested in quantitative abstractions (Woodhull, 1917). Interest in science thus played a crucial role in the emerging stratification of U.S. high school science, with a lower level offering relevance to daily life and a higher level promising rigor and the possibility of college preparation.

Regulating desire toward “right living” and “straight thinking.” General science aimed not only to respond to pupils’ natural interests, but also to direct those desires toward proper ends. Regulating the supposedly private realm of sentiments, dispositions, and domestic relations has long served as a strategy of governance (Stoler, 2009). Based on the premise that girls and inferior racial stocks were driven by emotion rather than reason, the general science strategy was to reach these pupils “through sentiment” by appealing to their existing interests (Grier, 1920, p. 48). This strategy dates back at least to the founding of the U.S. republic. As Wood (1993) contends, the founding fathers did not believe the masses were capable of reason, and instead must be governed by cultivating their sentiments and attachments to restrain vices, promote virtues, and unite affections toward the nation (see Popkewitz, 2008).

The ultimate aim of general science was not to entertain but to incite an “interest in the science of right living” (Bowden, 1924, p. 481) in terms of physical, mental, and sexual hygiene. Returning to Figure 6.1, access to higher tiers of science education became dependent on demonstrating an appreciation for science, defined as “a grasp of the moral import of the orderliness of Nature and of the pupil’s obligation to adjust himself to her laws” (Downing, 1925, p. 83). To take an interest in science meant following the rules of hygienic living now attributed not to Divine Will (as seen in the mid-1800s) but to Nature’s laws as revealed by scientific experts. At issue was not only the boundaries of national belonging, but also the seeming limits of democracy:

> For it is under a popular form of government that we find the selfish and the cruel passions in serious conflict with the good and noble impulses that seek to establish honesty and virtue—public purity—in social order. . . . The question of the hour is how we shall educate for intelligent participation in a social democracy. The principles of modern psychology point the way. (Bowden, 1924, p. 478)

Echoed in this “question of the hour” are much older Enlightenment debates over the possibility of self-government as dependent on taming the passions of the masses and fostering their appreciation for those experts seen as uniquely capable of guiding the progress of an enlightened society (Broman, 2012).[94] What was more properly “of the hour” in the early 1900s was that the “principles of modern psychology” could develop and monitor individual pupils’ appreciation for science as a guide for one’s mental, moral, and behavioral habits.

In pedagogical efforts to incite an appreciation for the science of right living, bodies gendered and racialized as lacking an interest in science were especially targeted for regulation.

[94] By the 18th century, it became possible to argue, “the social order must be based on the natural order, and for this to be possible, the public must be educated in science, in order that it be able to appreciate the rational basis of society’s laws” (Broman, 2012, p. 200).

General science's emphasis on applying science to everyday life permitted greater surveillance of the nation's "unassimilated material" (Hunter, 1922, p. 526) that must be Americanized and trained in "straight thinking" (p. 530). This included acquiring proper (i.e., heteronormative) attitudes towards sex and sexual restraint for "race betterment" (i.e., avoiding miscegenation) (Clark, 1921, p. 129). General science was also concerned with policing desires for certain kinds of knowledge and societal roles. As we have seen, "Peggy" must learn that for her, housekeeping *was* science (Hanson, 1919), just as the "masses" must come to appreciate that physics and chemistry were properly of interest only to the few (Caldwell, 1917). In *GSQ*, then, interest in science functions as a "dense transfer point for relations of power" (Foucault, 1990, p. 103)—a site for monitoring the boundaries of proper desires, sexual spheres, racial belonging, and American citizenship.

So far, I have considered a few of the conditions out of which interest in science precipitated in the early 1900s. I have argued that in science education scholarship from the 1920s, interest in science was constituted *by nature*—where differences in interest were not directly assessed but inferred based on theories of race and sex differences. Biological and social scientific theories provided teachers with knowledge of their pupils to classify their interests and determine what pedagogy they would require. In the next section, I trace key shifts in how a student's interest in science could be seen and sorted. By the 2010s, interest in science would no longer rely on evolutionary theories widely rejected as sexist and racist. Rather, as I explore below, it would now be constituted *by the numbers* through quantitative data. In a strange inversion, it is today racial and gender differences that are not assumed *a priori* but are nonetheless inferred to exist based on numerical comparisons of these subgroups' interest in science.

By the Numbers: Inferring Racial and Gender Differences from Data on Interest

Interest in science does not refer to the same thing in the 2010s as it did in the 1920s. In the intervening century, there has been a shift from explicit theories of natural difference to numerical data as the arbiter of educational reality (Popkewitz, 2012a). Nevertheless, as evident in the NGSS case studies, interest in science still functions as a distinction-making measure. Before turning to the NGSS, however, I want to highlight three events that made possible today's notion of interest in science. The first is the use of survey techniques to visualize presumed differences between categories of pupils, such that the data embody implicit theories of human difference. The second is the emergence of *attitude* and *motivation* as measurable psychological constructs. The third is the linkage of these constructs and survey techniques to the problematic of underrepresented groups. Despite these shifts in how interest in science is verified and deployed, it continues to produce and regulate distinct kinds of students in ways that potentially undermine its use as a strategy for equity.

From early surveys of science interests to attitude studies and Likert scales. At the turn of the twentieth century, efforts to generate scientific evidence of human difference were moving from exterior features (e.g., cranial measurements) to the interior of the mind (e.g., mental testing). Through a comparative mode of reasoning, individualizing techniques operated to generate and display distinctions in interest as statistical and stable attributes of demographic categories. Though the pedagogical salience of these categories may only be hypothesized at the outset, the study's procedures of classifying, counting, and correlating data solidify them as distinct types and link them to new attributes and evidence of difference—in effect, making them up as different kinds of people (Hacking, 2007).

In the early 1900s, differences in sex emerged as an empirical object of science education research through psychological tests and survey techniques. By 1920, IQ tests had entered U.S. schools where they promised to objectively reveal pupils' mental capacities, including differences in sex (e.g., Hunter, 1920). Science education scholars lamented that there was not yet an instrument like the IQ test to measure pupils' attitudes toward science (Kilpatrick, 1921). An early attempt adopted sociological survey techniques to determine the science topics of interest to boys versus girls (Lyon, 1918). In this study's design, natural differences in interests between the sexes were presupposed and empirically verified as a seemingly automatic inscription of self-reported differences. For instance, the survey results were said to reveal that "removing stains naturally held the girls," while boys were "naturally ahead of the girls" on magnetism and electricity (p. 389). While this 1918 interest survey indicated sex differences in preference for some science topics over others, it was not yet possible to calculate interest in science as a general quantity of mind.

An emerging research agenda brought together techniques from the child study and nature study movements to compare children's science-related interests along two factors: sex (boy versus girl) and environment (city versus country). A 1919 *GSQ* article on the "Collecting Instinct" drew on the questionnaire method of G. Stanley Hall to generate data both on what items children collected (e.g., stones, flowers, cigar-bands, stamps) and the reasons they gave for collecting (Hunter, 1919). The article's first sentence highlights its large data set, disaggregated by sex: "The data for this paper was obtained from a questionnaire sent to some 5,000 pupils, 4,000 of whom were boys" (p. 133). Through multiple graphs and data tables, the article reported that "environmental conditions as well as the sex determine what the child will collect" (p. 134). This reflects a fairly new mode of truth telling, where differences in the interests of boys versus girls could not simply be asserted as natural and normative, but had to be revealed through statistical norms. Whereas earlier studies had taken for granted the claim of recapitulation theory that a "collecting instinct" was one of the "primitive activities of children" (p. 133), this 1919 study sought to use questionnaire data to disambiguate a complex of psychological instincts thought to contribute to an interest in science. Asking children to report why they collect, the study took this "self-analysis and introspection" as "bona fide expressions of the real self of the child" (pp. 136, 139).

The results generated new distinctions that contributed to differentiating kinds of people in gendered, classed, and racialized ways without being reducible to those divisions. For instance, it would now be possible to distinguish some children as collecting natural objects out of "pure instinct," where one's inquisitiveness was demonstrated through "*acquisitiveness,*" exemplified by the drive to "get the rare ones for his cabinet" (p. 137).[95] The study also differentiated between those with "pure instinct" from those who credited someone else for the "opportunity for collecting" (e.g., "aunt collects with her"), and also from those who explained their collections as owing to "aesthetic appeal" (e.g., "wants to know wild flowers") (p. 138).[96] The study also reported that, "With city boys, especially among those of foreign parentage, the material value of the thing collected is of importance" (p. 139). For Hunter, that emphasis on the extrinsic use of coins, stamps, or insects was an indicator of "foreign parentage" that separated these children from the normal child who possesses an intrinsic desire for science. An irony here is how "pure instinct" or curiosity was manifested through material acquisition ("his cabinet"), and also purified through individualistic self-reports of collecting "by himself; of his own

[95] Notable here is the historically and culturally particular image of science as the collection, classification, and display of nature and other worldly goods—sometimes in furniture called "curiosity cabinets" that were once taken as demonstrating the owner's objectivity and cosmopolitan interests (see Cook, 2007).

[96] It is striking how one's curiosity ("wants to know") was negated by the object of interest ("wild flowers").

accord; a fancy of his; just for fun" (p. 137). The study illustrates an early site wherein self-reported responses appeared to testify to the real self and to the salience of gendered and racialized differences in interest in science.

By the 1930s, one can observe a shift from studies of varying science-related interests to interest as a generalized individual attribute related to motivation. The emergence of the construct of attitude promised a direct link between what was visible on the surface (i.e., written responses) to what was presumed to be going on underneath (i.e., within the subject's mind) (Danziger, 1997). An early study of attitudes analyzed the content of Polish immigrants' letters to map each individual along an evolutionary trajectory of Americanization: from Polish attitudes (e.g., beliefs in religious magic) to American attitudes (e.g., a theoretical interest in the natural sciences) (W. Thomas & Znaniecki, 1920). Since attitudes were conceptualized as shaped by one's home environment and yet amenable to external intervention, interest in science could operate as a site for monitoring individuals' progress toward cultural assimilation.

Soon after, the Likert scale made it possible to measure attitudes on a quantitative scale and along a bell curve (Thurstone, 1928). This statistical technique reconstituted attitude as a trait, like IQ, that would now appear to vary in degree and to be unevenly distributed in the population. From the 1930s on, Likert scales proliferated across domains of schooling, marketing, and political campaigns, as they offered to objectively reveal which subgroups should be targeted in efforts to induce new desires and behaviors (Danziger, 1997). This illustrates how differences among populations can be a historically moving target that becomes individualized in the universalizing of rules and standards of psychology, sociology, and pedagogy.

Interest enters the problematization of underrepresented groups. The constructs and techniques emerging during these early decades of the twentieth century performed key roles in later reforms to help underrepresented groups in science. To be sure, a significant break occurred between the 1920s and the 2010s. In the 1920s, differences by sex and racial stock (e.g., foreign parentage) were taken as natural—as in resulting from nature and also reflecting the normal state of society. By the 2010s, differences in science education by gender and race are now seen as unnatural—disparities that demand research and intervention. Yet this may be less a case of rupture than of reconfiguration.

When gender and racial disparities appeared on national research agendas in the 1970s (e.g., Crowley, 1977), the search for explanations would not begin in a vacuum. It would draw on historically available theories and techniques, including decades of research to acquire knowledge of pupils' differences in psychological terms. According to a national report on underrepresented groups (Marrett, 1987), the tendency to seek individual-level explanations for gender and racial disparities in science "may be the consequence of the theoretical models used to study mathematics and science education," particularly "various motivational theories" (p. 26). Already-circulating notions of interest in science thus participated in forging the research agenda concerning underrepresented groups, asking: Why are girls and minority students *less interested* in studying science and *less motivated* to pursue scientific careers?

Interest served to both differentiate and link together gender and racial disparities in science. One hypothesis for the underrepresentation of women and "minorities" was a lack of academic preparation (i.e., Readiness). Project Talent, a longitudinal study of high school student cohorts in the 1960s, calculated "science potential" by comparing high school test scores of male students who did and did not become successful scientists (Gilmartin, McLaughlin, Wise & Rossi, 1976). Setting aside the project's circular logic—which precluded the notion that attainment of and advancement in scientific careers might be shaped by situational, relational, or systemic factors (see B. Lewis, 2003)—it is instructive to note how the study permitted new truth claims to distinguish explanations for gender disparities versus racial disparities. A 1977 NSF report titled *Women and Minorities in Science and Engineering* cited the Project Talent follow-up study, which had concluded:

> Clearly, the paucity of women in science careers is *not* due to a failure to develop the requisite abilities prior to and during high school. . . . [Yet] by and large Blacks [sic] and Spanish-surname students have failed to develop the abilities needed for science careers to nearly the degree their White and Oriental peers have. (Gilmartin et al., 1976 as cited in Crowley, 1977, p. 14, emphasis in original)

That contrast was taken to indicate that the primary barrier for women was not ability or readiness, but other psychological factors negatively affecting their *interest* in pursuing scientific careers. In contrast, the report identified background abilities as the primary obstacle for "Black and Spanish-surname students," while going on to flag interest as a secondary obstacle for the few of these groups who did display "scientific potential." The report concluded: "The effect of traditional societal roles has been very strong. Women's and minorities' self-concepts are all-important in determining their career and life goals" (p. 22). The ultimate source of the problem may have been ascribed to society ("traditional societal roles"), but then was immediately psychologized as a matter of self-concept, interest, self-efficacy, and career choice.[97]

During the 1970s and 1980s, psychologists developed numerous Likert-style instruments to measure interest, motivation, and attitude toward science (Newcombe et al., 2009). By constraining the self-report of attitudes to a range from 1 to 5, the Likert scale generated new

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[97] A similar phenomenon can be observed in the Coleman Report (Coleman et al., 1966). Bracketing off the findings of systematic disparities between "white" versus "Negro schools," the report articulates a desire to explain—all things being equal (or rather, unequal)—what allowed some individuals in "Negro schools" to succeed more than others. In order to explain the "variability between individual pupils within the same school," the report suggested further study of student data on "attitudes and aspirations" (p. 23).

equivalencies and hierarchical distinctions. Given the ordering capacity of numbers (Cline Cohen, 1982), it would now be possible to (a) conceptualize interest in science as varying strictly in degree, (b) average individual scores using demographic categories, (c) rank subgroups by these average scores, and (d) establish statistical norms against which an individual or subgroup could be judged. Within this statistical style of reasoning, massive data sets permitted generalized truth claims, such as the reporting of "race and sex differences in students' interest in, and affinity for mathematics and science" (G. Thomas, 1986, p. 31). The data from these studies can be understood as neither passive readings of reality nor deliberate misrepresentations. Rather, they refer to "a reality in which they are themselves heavily implicated" (Danziger, 1997, p. 192). Through social science techniques, historical assumptions of difference are quantified and materialized, reconstituting the problem and its possible solutions (Rose, 1991).

Despite inconclusive and contrary findings, such as higher "positive attitudes evidenced by minority groups" (Kahle, 1982, p. 545), an effect of this research was to crystallize a common sense about female and racial minority students' negative attitudes toward science. By the early 2000s, unsuccessful attempts to ensure science-for-all were attributed to the fact that women and minorities "opt out of a subject that they see as incommensurate with their interests" (Alsop, 2005, p. 4). This logic circulates in recent U.S. science education policy as well.

Interest as a classificatory eye in the Next Generation Science Standards. The NGSS' Framework formulates the problem of inequity around differences in interest. As cited in chapter 5, while acknowledging that one source of inequity has been "biased stereotypical views about the interests or abilities of particular students or demographic groups" (NRC, 2012, p. 281), the Framework goes on to assert:

> Students' own motivation and interest in science and engineering can also play a role in their achievement . . . . Thus attention to factors that may motivate or fail to motivate students from particular demographic groups is important to keep in mind when designing instruction. (p. 281)

Here, the Framework treats interest in science as a key factor explaining achievement gaps, insisting that—separate from biased stereotype—certain demographic groups do require instruction to be made more motivating in targeted ways. This claim—made possible by decades of numerical data from studies like those outlined in the previous section—have become so matter-of-fact that numbers are no longer cited to back them up. Interest in science has materialized as an invisible attitude in an individual's mind, and one that can be probabilistically inferred from a student's gender and racial classification. As I will explore, Interest in science is now co-constitutive with gender and race—the pedagogical significance of each being inferred from the other.

In the NGSS case studies, Interest in science acts as an indicator that teachers can use to recognize distinct types of students and their science learning needs. According to the NGSS, three factors make the demographic groups in the case studies functionally equivalent. First, each has been studied in a separate "research literature on student diversity and equity" and/or addressed by specific policies (e.g., No Child Left Behind Act of 2011) (NGSS Lead States, 2013a, p. 360). Second, those research literatures and policies have designated the case study groups as having "traditionally been underserved in science education" and therefore meriting greater visibility (p. 361). Third, each is designated as having "learning needs" that necessitate "effective strategies" and "instructional shifts" (p. 359). The nature of those learning needs is stated more directly in some case studies than in others. For "students with disabilities" and

"English language learners," the demand to make the NGSS "accessible" is attributed to a clearly documented barrier as preventing their access to "normal" science instruction (i.e., a learning disability, or limited English proficiency).[98] In contrast, for "girls," "race and ethnicity," and "gifted and talented students," what marks their difference is given not strictly in terms of capability, but primarily in terms of interest, motivation, and engagement.[99]

It may be surprising that the NGSS defines "gifted and talented" students as much by their "intense interests" as by their abilities (NGSS Lead States, 2013h, p. 1). While early U.S. psychologists used IQ tests to identify pupils as gifted (e.g., Terman, 1926), by the late twentieth century, a clear distinction was being made between "gifted" versus "science-prone" youth: "*Giftedness* was usually signaled by high achievement in the general scholastic program. *Science prone* students displayed a keen and driving interest, as well as high achievement, in science" (Brandwein, 1992, p. 122, emphasis in original). That distinction emerged in part from studies of national programs (e.g., Westinghouse Science Talent Search) to identify students with "science potential" and give them opportunities to carry on individual research "to develop their interests in science" (Brandwein, 1951, p. 251). The emergent hypothesis was that:

> [T]here is no such quantity as 'science talent' but that very high intelligence (as measured by high I.Q., high mathematical ability, high verbal ability) coupled with an environment

[98] What distinguishes "students with disabilities" is "specified in their Individualized Education Plans (IEP)" (NGSS Lead States, 2013d, p. 1). Arguably, a premise of a difference in ability is built into the biomedical model of disability. Similarly, the case study for "English language learners" draws on federal policy and assessment programs to designate students as "limited English Proficient" and therefore as needing language support strategies and accommodation (NGSS Lead States, 2013e, p. 10). For these two groups, the rationale for having to make science "accessible" is articulated as a difference in a particular proficiency. In contrast, there appears to be more of a question around what distinguishes "girls" and "racial or ethnic minority students," and why they require specific instructional shifts to make the NGSS "accessible" to them. Although beyond the scope of this study, further analysis could explore how "disability" and "limited English proficiency" emerged historically, how they mutate when entering science education research and pedagogy, and how they become entangled with (or productive of) ordering strategies like Readiness, Interest, and Needs that simultaneously generate racialized, gendered, ableized, linguistic, and cultural hierarchies of value.

[99] To reiterate, none of these terms should be taken as natural ways of dividing and ordering people. I cite the exact terms from the policy in order to continually question the self-evidence of these categories and examine how Interest becomes associated with these distinctions.

> favorable to interesting work in science, may produce the individual who is successful in scientific research. (p. 252)

To pursue this hypothesis, the study first used psychological tests and interest questionnaires to identify youth with high science potential, and then turned to interviews with these students and their parents to reveal the factors successful in kindling their latent science interest. By the mid twentieth century, then, Interest—through a shifting assembly of theory, methods, and data—had become an ordering strategy distinct from but entangled with Intelligence.[100] This entangling can be observed in the NGSS case study on gifted and talented students, which refrains from defining this category as having higher intelligence, but recommends that they be strategically grouped with "like-minded peers in terms of ability and/or interests" (NGSS Lead States, 2013h, p. 7).

Interest plays a leading role in demarcating the "gifted and talented" in the NGSS, in part due to this historical intertwining of science talent and interest, but also owing to more recent developments. Since the 1950s, there has been increasing sensitivity to theories of fixed intelligence as both inaccurate (Dweck, 2006) and ideologically problematic (Oakes et al., 1997), as well as to the "biased results" of IQ testing, particularly for "minority students" (e.g., Valencia & Suzuki, 2000, p. 139).[101] What qualifies "gifted and talented students" as one of seven non-dominant groups is not a claim about intelligence, ability, or achievement gaps. Rather, Interest stands as the explanation for why they have been or potentially may be underserved. The concern

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[100] That is, a student's science talent or potential was not a product solely of very high I.Q., as some with high intelligence may fail to display "a keen and driving interest in science" (see Brandwein, 1992, above). Nevertheless, high I.Q. was defined (theoretically and methodologically) as a prerequisite for the identification of that keen interest and talent in science, as the only youth interviewed were those who had already received high scores on initial screening tests.

[101] In fact, the NGSS case study for gifted and talented students highlights the absence of demographic data on this subgroup due to widely varying definitions and identification processes. This absence of data is striking given the NGSS' emphasis on statistical data, and specifically achievement gaps, as delineating the "diverse" or "non-dominant" groups featured in the other case studies as requiring instructional shifts to promote equity (NGSS Lead States, 2013a, p. 359). This case study also references that a single measure (e.g., intelligence testing) has been shown as ineffective in identifying giftedness in students from "underserved populations" (NGSS Lead States, 2013h, p. 8).

is that instruction providing insufficient intellectual challenge and autonomy will place this subgroup at risk of disengagement. To mitigate this risk, the case study explains: "They are *academically engaged* through the strategic grouping of students with *similar interests*, and *intellectually challenged* through the introduction of *advanced* ideas and *student-generated* information" (NGSS Lead States, 2013h, p. 2, emphasis added). Offering alternative activities that allow gifted and talented students to pursue their individual interests (e.g., purchasing class pets for them to investigate and care for) is articulated as a "motivating task" (p. 7). Within this logic, neglecting to provide advanced materials and objectives, autonomy, and homogeneous grouping not only would fail to support these students' in reaching their higher potential, but would potentially demotivate them. That fear is paired with a promise. By recognizing these students' "intense interests" and responding accordingly, their enthusiasm will be "contagious" and "reinforce a prevailing quest for scientific understanding" in the classroom as a whole (p. 2). Interest participates in making a distinction that remakes the "gifted and talented" as one of several protected classes within a politics of identity and representation and a pedagogical imperative of responsive teaching.[102]

Interest also serves to generate distinctions that make "girls" visible as a pedagogical concern in science. A research agenda taking shape in the 1980s and 90s rejected older hypotheses of sex differences in cognitive abilities. The focus shifted instead to differential experiences (e.g. early childhood, classroom), expectations (e.g., teacher, family, societal/cultural), and intersections (e.g., race, ethnicity, and socioeconomic status) as making girls different from boys, and as explaining gender disparities in science (Scantlebury & Baker,

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[102] The NGSS Appendix includes "gifted and talented students" as one of the seven diverse groups that are underserved and non-dominant, and that require instructional shifts to meet their learning needs. Similar discussions occurred at AHS, where equity-oriented reforms such as detracking were contested by invoking the "high-flyers" as its own protected class that would be underserved by offering all students the same science educational opportunities (Meeting fieldnotes, 2014).

2007). A proliferation of studies sought to operationalize constructs of interest, attitudes toward science, self-concept, career choice, and science identity. Meanwhile, reform programs aimed to increase girls' interest in science by challenging the androcentric nature of science (e.g., emphasizing impact on humans and animals), using female scientists as role models, and designing all-girl after-school science programs (for analyses, see J. Gilbert, 2001; Scantlebury & Baker, 2007; Sinnes, 2006). It is largely this assembly of psychological constructs and pedagogical interventions that comes together in the NGSS to demarcate who/what is a girl and how/why gender matters for science teaching.

The NGSS case study on "girls" draws a tight linkage between science achievement, interest, and STEM-related careers:

> [G]irls *lag behind* boys in every grade tested in the National Assessment of Educational Progress (NAEP). By the time girls reach high school, a *disproportionate number steer away* from advanced courses in science—physics, engineering and computer technology—*limiting their options* for STEM (science, technology, engineering, and mathematics) college degrees or careers. Research points to three main areas where schools can positively impact girls' *achievement, confidence and affinity* with science. (NGSS Lead States, 2013f, p. 1, emphasis added)

Here, the girl is made up as lagging behind, with this underachievement attributable to a relative lack of confidence and affinity for science. Unless effective strategies are implemented, girls are envisioned as "passive observers" (p. 2), who disproportionately "steer away" and limit their own options in science.

Interest also plays a key role in making up "students from racial and ethnic groups" as a pedagogical concern (NGSS Lead States, 2013c).[103] Before turning to the details of the case study, it is worth recalling that U.S. science education has not always studied race and ethnicity in the same way. In scholarship immediately following World War II, one mode of studying race asked how science courses might address the polarized public views of race as biological versus social (Parsons, 2011).[104] By the late 1960s, these studies of changing public attitudes about race were "largely displaced by research that examined phenomena with respect to racial group membership" (p. 176). In the decades following Sputnik-inspired reforms and national searches for science talent, as well as school desegregation orders and the Coleman Report, there was an increasing availability of data related to science achievement, coupled with the demand to disaggregate that data to explain and address racial disparities feared to threaten the nation's progress. In this emerging body of research, race operated as a group identifier that could be correlated both to cognitive skills and non-cognitive factors, like curiosity, engagement, self-efficacy, science affect, and attitudes toward science (B. Lewis, 2003; Parsons, 2011). Intervention programs aimed to interest students of color in science by providing enrichment programs to connect science to the local community and to present scientists of color as role models.

Returning to the NGSS case study, the pedagogical salience of "race and ethnicity" is treated as self-evident. As in the case study for girls, the existence of these students as a distinct type of science learner is made visible through the triangulation of demographic data,

[103] The case study uses this phrase interchangeably with "major racial and ethnic groups," "underrepresented groups," "diverse racial and ethnic groups," and "racial minorities" (NGSS Lead States, 2013c, pp. 1-2, 12). The NGSS' equation of "race and ethnicity" with "major racial and ethnic groups" and with "non-White" reflects a broader U.S. discourse wherein race and ethnicity are deployed as markers of Otherness, while whiteness operates as the implicit norm presumed to stand outside of race, ethnicity, or culture.

[104] For instance, by the early 1960s, quasi-experimental studies attempted to "investigate changes in White students' knowledge and attitudes before and after some type of race instruction" (Parsons, 2011, p. 176).

achievement gap data, and a synopsis of research-recommended practices for subgroups described as underserved, underperforming, and underrepresented.[105] The case study cites multicultural education as a resource for identifying "effective strategies for major racial and ethnic groups" that can be adapted for the science classroom: "(1) culturally relevant pedagogy, (2) community involvement and social activism, (3) multiple representation and multimodal experiences, and (4) school support systems including role models and mentors of similar racial or ethnic backgrounds" (p. 12). What brings these four strategies together is an aim of increasing student interest. Stripped of their theoretical frameworks (and arguably, their paradigmatic incommensurabilities), each strategy matters insofar as it: a) "communicates . . . that science is relevant" (p. 12), b) "motivates them to learn science" (p. 12), c) "increase[s] student engagement," (p. 6), and d) serves as a "key factor for students choosing a career in science" (p. 12).

Interest does more than make visible distinct categories of giftedness, gender, and race and ethnicity. It also divides categories of students by whether they are presumed to possess well-developed individual interests in science, or instead require appeals to situational and subgroup-level interests in order to spark an initial interest in science. Individuals marked as gifted and talented are depicted as entering the classroom with fully developed scientific interests: "Jerry's naturalist interests were immediately apparent in the first week of school" (NGSS Lead States, 2013h, p. 2). Throughout the case study, individual children and their interests are specified by name: Jerry possesses an "unusually high interest in nature" (p. 2), Allie and Kate are "passionate about insects" (p. 3), and Bob has a "strong interest in sketching"

[105] This stands in contrast to the case study on gifted and talented students, which as mentioned, offers no demographic or achievement data due to the absence of a consistent definition or methods of identification (NGSS Lead States, 2013h). Instead, it is the combination of a particular U.S. policy and research literature that constitutes the "Context" for this group (p. 8).

and in stop motion photography (p. 4). For those designated as gifted and talented, the teacher is to "encourage autonomy by allowing the student to follow and cultivate her/his interests" (p. 7). This is illustrated in the vignette by devoting time for students to develop individual interest reports on a wide range of topics: "flying critters, pit vipers, rock classification, falcons, robot characteristics, mastodons, zebra mussels, eclipses, and the end of the Earth" (p. 4). The premise here is that the interests of students like Jerry are already aligned with science, a disposition qualifying them to conduct self-directed investigations alongside "like-minded peers in terms of ability and/or interests" (p. 7).

In contrast, for those demarcated as girls or "major racial and ethnic groups," interests are identified not in the singular but in the plural. The argument is that to "enhance girls' engagement in science," it is necessary to "focus on science topics related to the girls' interests" (NGSS Lead States, 2013f, p. 11). Those interests are defined as follows:

> Girls respond well to strategies that integrate *literacy* with science. . . Girls become more motivated toward technology if the curriculum incorporates *design* and stresses *aesthetic aspects* of science. In addition, girls respond to topics in physical and biological sciences that they perceive as addressing issues relevant to the *real world*. (p. 11, emphasis added)

Here, interests from "outside" of science are to be leveraged to remedy girls' purported lack of engagement, motivation, and positive response toward science in general. Additionally, distinctions are made within science (i.e., aesthetic aspects of science) and between disciplines. Elsewhere, the case study recommends using areas of greater progress for women to forge inroads in more male-dominated domains: "*Engineering*, practiced by far fewer females, has a particular appeal for the girls in this vignette because the practices are developed around the core content in *life sciences*, a discipline with which more girls tend to identify" (p. 1, emphasis added). The vignette highlights “early exposure to engineering through a forest restoration project that girls found engaging” (p. 1), and depicts a 3rd grade class designing a solution to the problem of hungry animals in the local woods. These research-based recommendations aim to support teachers to “reach girls more effectively” (p. 11) by emphasizing interests purported to be associated with their gender.

The case study titled “Race and Ethnicity” also recommends using subgroup-level interests to promote engagement and identification with science. The vignette presents an 8th grade unit on the cycling of energy, highlighting “strategies that motivate” a class in an “urban school” where “20 of the 29 students are from major racial or ethnic groups” (NGSS Lead States, 2013c, p. 1). One strategy is connecting science ideas to real world issues, such as “social and environmental impacts of the oil industry on Nigerian ecosystems” (p. 2). Another is to connect science to the students’ daily lives and local community, such as “food items in their homes” (p. 3) and fuel use at the “gas station near the school” (p. 5). These strategies’ rationale rests on a distance assumed between some students’ backgrounds and science: “place-based pedagogy was an effective way to reach [this teacher’s] students since they came from diverse cultural backgrounds” (p. 3).

Whereas the concern for girls is formulated as their engagement and confidence in science, the concern for major racial and ethnic groups is engagement not just in science but in school, and not just the interest in science of the child, but of the family. The case study recommends kinesthetic activities like student movement to “increase student engagement” (p. 6) and the use of an engagement protocols like roll-a-number as “creative ways to foster individual responsibility for learning” (p. 2). Non-dominant groups are said to require strategies that connect science to daily life, such as recording water use in the home, in order to “increase interest among both parents and students" (NGSS Lead States, 2013a, p. 366). The premise is that these students' purported lack of interest in science has roots in the home.[106] Gaining knowledge of these students' prior interests is given as a means to an end—a "bridge for student engagement" (NGSS Lead States, 2013c, p. 8), so that they "embrace and further investigate what they are learning, instead of being resistant to learning science" (NGSS Lead States, 2013a, p. 367). This logic bears a concerning resemblance to arguments made by *GSQ* scholars for appealing to the interests of the masses: "If they are to be elevated, they must first be reached" (Rowell, 1916, p. 55). Interest in science continues to function as a dense transfer point of power, simultaneously monitoring the desires of individual students and holding the family and community responsible for cultivating proper attitudes.

Interest thus generates oppositions between gifted and talented students on the one hand, and girls and major racial and ethnic groups on the other. Since not all students are perceived as possessing interests that are equally scientific, Interest demands dividing students by whether their current interests should be freely encouraged on the one hand, or closely monitored, leveraged, and transformed on the other. Within the logic of the case studies, interests in pit vipers and robots are prototypical of gifted and talented students, interests in feeding animals and aesthetic aspects of science are prototypical of girls, and interests in fuel use at the local gas station or food items in one's home are prototypical of major racial and ethnic groups. A danger is that the vignettes serve as primers. Together with the research they cite and the teacher education programs they inform, these vignettes train the teacher's classificatory eye to read

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[106] This is linked as well to concerns over increasing "parent involvement" (NGSS Lead States, 2013a, p. 366) and "helping non-dominant groups see museums as worthwhile destinations for their families" (p. 367). This is expressed as a call for formal and informal science learning environments to begin taking into account the "interests and concerns of particular cultural groups and communities" (p. 367). However, the logic also makes up these groups as different along a hierarchy of value—as insufficiently involved and as requiring extra help to "appreciate" science museums as worthwhile for their children's science learning.

particular expressions of interest in science as a sign of a certain kind of student—one with greater versus less talent. Historically, a number of practices have generated Interest as an ordering strategy that intertwines hierarchies of reason and desire in order to fabricate "like-minded peers in terms of ability and/or interests" (NGSS Lead States, 2013h, p. 7). These hierarchies serve to devalue the local, real-world issues presumed to interest girls and major racial and ethnic groups as compensatory strategies and as meant to the end of developing the more idiosyncratic and decontextualized interests ascribed to gifted and talented students.

Though certainly not the intention, the effect of the focus on Interest is that racial and gender distinctions are simultaneously reinscribed and transformed. Girls and non-dominant racial and ethnic groups are demarcated as distinct types of science learners that appear to demand different forms—and, given the organization of science curriculum from local to universal, and concrete to abstract (see chapter 4), different tiers—of science education. Not only does the gender and racial segregation of tracked science courses not appear as a key explanation for inequity in the NGSS, these tracking practices are potentially reinforced as a more efficient means to address the divergent interests assigned to each demographic group—what Epstein (2007) calls "niche standardization" (p. xxxv). This risk is underscored by the resemblances between the interests assumed to appeal to the masses in the 1920s and to non-dominant racial and ethnic groups today—their own everyday lives, local communities, and concrete projects—as opposed to the abstract and quantitative knowledge seen as of interest only to the few and the gifted.

This chapter has sought to demonstrate that the danger is not merely gender and racial stereotypes that portray girls and students of color as less engaged or motivated in science. Framing the problem as a deficit view is to suggest that these contaminating biases could be removed through the design of a more objective assessment of interest or attitudes. I have argued that Interest in science, as materialized in *GSQ* and the NGSS, only becomes visible through a comparative mode of analysis. Its historically provisional criteria for perceiving and evaluating human difference constitute what Butler (2011) calls an exclusionary matrix. In reiterating the boundaries around the normative science student, interest in science helps to "produce—demarcate, circulate, differentiate—the bodies it controls" (p. xii). The bright interests of the few only appear against the passing interest of the masses, while the intense interests of the gifted and talented students stand out in contrast to the alienation and resistance ascribed to non-dominant subgroups. The subject who desires science learning, then and now, remains "constituted through the force of exclusion and abjection, one which produces a constitutive outside to the subject" (p. xiii). In this sense, Interest in science resembles positive psychology notions like curiosity and grit. Each depends on a "founding repudiation" (p. xiii) through the production of the less interested, the incurious, and the non-gritty (C. Kirchgasler, 2018). Moreover, the positivity of these constructs results in "normalizing a proximal subset of the Other" (Fifield & Letts, 2014, p. 396)—those who express interest, curiosity, or grit in culturally recognized and officially sanctioned ways.

How to Identify a Depoliticization Reaction

> Depoliticization involves construing inequality, subordination, marginalization, and social conflict, which all require political analysis and political solutions, as personal and individual, on the one hand, or as natural . . . on the other.
>
> —Wendy Brown (2006, p. 15)

> All students can profit from [instruction that builds on prior interest and identity], but the benefits are particularly salient for those who would *feel disenfranchised* or disconnected from science should instruction neglect their personal inclinations.
>
> —*Framework for K-12 Science Education* (NRC, 2012, p. 287, emphasis added)

Interest in science depoliticizes questions of why some students advance in science education and others do not. The call for teachers to know their diverse students' interests elides the fact that both the construct of interest in science and the pre-given categories of diversity have been "socially and historically constituted and are themselves the effect of power" (W. Brown, 2006, p. 16). Instead, different groups with distinct interests and degrees of motivation in science become what teachers are exhorted to see, sort, and act upon in targeted ways. In *GSQ* and the NGSS, the approaches of "knowledge of the pupil" (Quickstad, 1917) and "making diversity visible" (NRC, 2012) conceptualize underlying differences in terms of problems to be solved, gaps to be filled, and deviations to be rectified. The hope is that by seeing these distinctions more precisely, science education can more effectively bring about their improvement. For groups feared to possess subnormal levels of interest, this approach subjects them to attempts to monitor their affect and to shift their identities and attachments toward more socially desirable ones.

The political nature of the processes discussed in this chapter—the production and regulation of gendered and racialized bodies—is disavowed by the fact that Interest in science is treated as natural, individual, and ahistorical. Interest in science operates normatively to produce enthusiastic and apathetic learners, while this normativity is made virtually invisible through scientific techniques. Discussions of ability can be substituted with interest to avoid more politically fraught questions of IQ, for which the history of gender and racial discrimination is more widely known (e.g., Gould, 1996). Analysis of systemic inequities can be replaced with interest, obviating the need to examine these disparities in any detail (see B. Lewis, 2003). Further, as evident in the final epigraph above, disenfranchisement is rendered into a personal feeling that must be managed, rather than a set of political relations. When Interest in science becomes the primary lens for seeing equality and difference, the sociopolitical dilemma of how to redress science education's exclusions is replaced with an agenda of attitudinal change. That agenda—rather than accounting for the ongoing history of marginalization—is targeted at those very groups identified as only "historically" marginalized.

Power relations will not be evacuated from the science classroom, since the stabilization of what counts as school science is already an effect of power. Still, it is important to work to transform those relations by "detaching the power of truth" from the forms of stratification, normalization, and exclusion it currently authorizes (Foucault, 1994b, p. 317). This will require rethinking the premise that making science education more relevant to students' interests will necessarily result in their inclusion and empowerment. It is to recognize the precipitate as strange.

PART III. Needs as an Ordering Strategy

Part II of the study explored how it became possible to order students as having distinct levels of Interest in science. My argument was that the very notion of "Interest in science" as a stable, individual attribute is productive of difference. I traced how the management of students' sentiments toward science became a pedagogical problem through practices stemming from the anthropology of sex differentiation, sociological studies of immigrant attitudes, interest surveys, Likert scales, studies of science talent, regression analyses, and research agendas on underrepresented groups. Historically, these techniques crystallized in varying configurations that have produced different kinds of people. One effect has been to gender and racialize students (and their feelings) as objects of analysis and targets of distinct interventions within science education. For those feared to have grown cold toward science, the hope is to spark an interest by bridging their prior interests to science or by demonstrating the immediate relevance of science. This brings into view another set of distinctions: Who appears to need science instruction made relevant to their everyday lives and local community, and how are those needs or relevance determined?

Part III introduces a third ordering strategy that divides students into potential scientists versus citizens by projecting differences in their needs for science instruction. Analytically, I use Needs (with a capital N) to designate classifying practices that go beyond the individualizing distinctions of cognitive and developmental psychology ("Readiness") and motivational psychology ("Interest"). Under the rubric of Needs, I consider how discourses of anthropology, sociology, and public health intertwine to evaluate whether students' future need for higher education is outweighed by their immediate need for instruction focused on their health or well-being. Needs designates efforts to: a) forecast students' future needs, b) diagnose their immediate needs, and c) prioritize which should override the other as the primary aim of instruction for a particular student or demographic subgroup.

Needs is a biological notion that entered discourses of developmentalism in the late nineteenth century (Baker, 2002a). Traveling across the child study movement, eugenics, psychology, and pedagogy, recapitulation theory operated to map the needs of a child or a racial stock in terms of its upcoming stages of development. As Baker (2002a) contends, talk of needs came to replace talk of values, especially as the curriculum became linked to claims of the child's nature rather than appeals to the inherent worth of classical content:

> The discussion of children's needs, as imagined in regard to racial recapitulation theories, ended up being a convenient one; to talk in terms of needs sounded important, fundamental and basic, pressing, urgent, something that requires immediate fulfillment, and a kind of attention that knows that any action teeters on the line between life and death. (p. 98)

By the early twentieth century, techniques for assessing and addressing needs traveled between U.S. sociology and Americanizing agencies like settlement houses (Lybarger, 1987). Sociological studies of tenements used surveys to record details of everyday life, tabulating findings by nationality and race. The "needs" of each group were those pathological qualities that seemed to separate them from the American ideal, such as the "impulsiveness of the Italian" and the "shiftlessness of the Irish" (Jones, 1904, p. 133). Needs became a new object of knowledge, converting observations of a few families into generalized attributes of racialized populations. As a set of comparative principles, Needs circulated across sociological research, Protestant reform movements, and the educational sciences as a theory of what was and was not desired in the "nature" of the child or the American citizen.

Talk of Needs remains ubiquitous in education today, though certainly much has changed. Across research, policy, and classroom practice, the identification of a particular set of "learning needs" divides children into categories and matches them with distinct services and curricular reforms. The discourse of needs demarcates boundaries of dis/ability in talk of "students with special needs," as well as demographic difference in studies of the "educational needs of refugee students." "High-needs" can refer to a student, a school, a community, or a population. Pre-service teachers are instructed to "develop and apply knowledge of varied students' needs," and to focus on those needs through cycles of planning, instruction, and assessment (SCALE, 2015a, pp. 1-2). To pass the edTPA, candidates must delineate students with "specific needs"—given as "students with IEPs or 504 plans, English language learners, struggling readers, underperforming students or those with gaps in academic knowledge, and/or gifted students" (p. 13)—in order to explain how they plan to adapt instruction or assessments accordingly. Learning to notice and respond to differences in students' needs has become central to the development of a professional teacher, as well as to efforts to promote educational equity.

What tend to escape notice, however, are the principles and practices that make Needs visible along a hierarchy of value. Chapter 7 opens with a vignette of a lower-track science course called Chemistry in the Community, which created equity dilemmas for teachers at Alderwood High School (AHS). On the one hand, Chemistry in the Community was considered better than other science courses, as it was designed to meet students' immediate needs by making science relevant to everyday life. On the other hand, the course disproportionately served students of color and failed to qualify as a legitimate science credit when applying for higher education. This dilemma cuts to the heart of current discourse on equity and diversity: is it more important to respond to the distinct needs of “diverse” groups (i.e., equitable instruction), or to provide the same opportunities for future study (i.e., equal access)?

Rather than seeking to resolve this dilemma directly, I will explore how this debate is formed through a particular set of rules and standards for thinking about differences that make it possible to see “problems” and “solutions.” Both in Chemistry in the Community and across high school science coursework, I analyze how Needs operates as a principle for ordering people and the pedagogical interventions they appear to require. Some students were marked as having “immediate needs” that science instruction must address, while others were understood as having “future needs” related to their anticipated academic trajectory. I then highlight how a similar hierarchy of needs operates in the Next Generation Science Standards (NGSS). Finally, the chapter will make the case for putting the ordering strategy of Needs into historical perspective—a task I begin to undertake in the subsequent chapter.

Chapter 8 will return to the early twentieth century, when various transformations made it possible to think of particular populations as not-yet-prepared for American citizenship, and as such, needing a distinct type of science education. The chapter traces how emerging practices of public health, schooling, and governance came together to project differential needs onto racialized populations within U.S. cities, but also within the nation’s newly acquired colonies like the Philippines. I explore how a set of pedagogical imperatives marked exclusionary boundaries of “biomedical citizenship” (W. Anderson, 2006, p. 3), as assessments of health were reconfigured as indices of civic potential along an evolutionary scale. This scale linked the adoption of culturally specific habits to the development of scientific reasoning and civilizational uplift. Finally, I place these pedagogical imperatives in conversation with recent equity-oriented reforms aiming to use science class to prioritize the health of marginalized groups.

The purpose of pairing the ethnographic analysis in chapter 7 with the historical analysis in chapter 8 is to show how dividing practices of an earlier era may persist today, potentially subverting the good intentions of current reforms to make science education more democratic by responding to the needs of “diverse” groups.

Chapter 7. Science Education for Life: A Hierarchy of Needs to Grow Healthy Citizens

> We're all citizens. All of us. . . . If you are going to go into science, if you are going to take college chemistry, you need something really rigorous. [But] why should we teach everybody a dry science because that's what it is in college—that's not really easily applied to your everyday life?
>
> —AHS science educator (Interview EP, 2015)

> [T]he great mass of the pupils are never going to be scientific specialists. The value of science for them resides in the added meaning it gives to the usual occurrences of their everyday surroundings and occupations. . . . When we do this, . . . we shall have a citizenship of men and women really intelligent in judging the affairs of life.
>
> —Science education scholar (Dewey, 1916, pp. 8-9)

U.S. science education is divided in two. Whether today or a hundred years ago, school science has repeatedly drawn a contrast between specialized rigor and everyday relevance. This opposition makes up different sciences to be learned, but also different kinds of science learners. The first kind has needs in the future tense. These students are the ones predicted to be heading to college today, or to be finishing high school in the early 1900s. They will take further science courses. And eventually, they may go into the sciences as a profession. As potential scientists, they require a dry, rigorous course to anticipate this higher training. The second kind of science learner has immediate needs. While their professional futures may be uncertain, these students are members of local communities and the voting public. As prospective citizens, they require a science course not to prepare for college, but for life. This divide between future scientists and prospective citizens seems like common sense. Of course not all children will go into science as a career—and why should they? Yet this divide deserves further scrutiny, because historically it has enlisted science teachers to carry out two difficult assignments.

The first has been to predict the future. Teachers must forecast who will go into science and who will not. The second has been to diagnose pathology. Teachers are to inspect the everyday lives of those classified as future citizens to identify areas that can be improved by science. Yet how can one accurately predict the future of any one person, let alone dozens of young people at a time? And for those students designated as needing everyday relevance, how can a teacher get to know their out-of-school lives sufficiently to identify students' most pressing needs? Besides these practical difficulties, such assignments are dangerous. They conscript the science teacher to determine which students fall on either side of a consequential divide—a divide that presumes that some of the U.S. citizenry are already "intelligent in judging the affairs of life" (see second epigraph, above), while others must be made so.

The divide between potential scientist and future citizen has a long history in the United States, but has not remained the same. The founders of the U.S. republic were skeptical that the people possessed the ability for cosmopolitan reason, and thus believed they needed to be taught to appreciate it rather than to be cosmopolitan (Wood, 1993; see chapter 6). Their rejection of Old World aristocracy was not a repudiation of the fundamental divide between leaders and led. Rather, the United States aspired to be a "natural aristocracy" (Jefferson, 1813, as cited in Carson, 2007, p. 11), where social advancement would rest not on birth into nobility but on one's merit through the objective recognition of innate talents and virtues presumed to be unequally distributed. This Enlightenment commitment to "reconcile social structure with the dictates of nature" called for education both to identify individuals with superior merit for higher training, and also to "improve the populace and ready it for citizenship" (Carson, 2007, p. 2). While the

Enlightenment elevated science as the apotheosis of reason, the school subjects associated with the scientific disciplines (geography, natural philosophy, astronomy, chemistry, botany) had not yet been positioned as a primary vehicle for enlightening the citizenry at large.[107]

The early twentieth century marked important shifts in the professionalization of the natural and social sciences (including a new field of science education scholarship), and in the rising prominence of science in American life (see also Nye, 1994; Pauly, 2000; Popkewitz, 2008). Science education scholars began to articulate a divide between the aims and methods of science instruction needed to prepare future specialists versus to educate future citizens. Rudolph and Meshoulam (2014) note that as public high school enrollments increased:

> A consensus emerged among educators that the masses of students now populating the schools had decidedly *different educational needs* than their predecessors . . . The majority of students now in attendance increasingly were viewed as *needing more practical and personally relevant instruction* in contrast with the formal disciplinary studies that had been common to that point. (p. 509, emphasis added)

This emphasis on Needs is well established in historiography of U.S. science education. A common narrative holds that the transformation and differentiation of science coursework during the Progressive Era was propelled by the "different educational needs" of the masses entering high school at the time (see also DeBoer, 1991, 2013; chapter 2). But if we instead shift the emphasis to what comes right before the masses and their needs, we can ask exactly how this "consensus emerged" and how people became "viewed as" having distinct sets of needs. That is, what are the presuppositions that not only provided the basis for making a particular needs

[107] Not until the 1880s did public high schools surpass private academies and seminaries, at which point scientific subjects were becoming "firmly established as central components of their curriculum" (Rudolph & Meshoulam, 2014, p. 506). The reach and role of scientific school subjects extended further with compulsory education laws and the rapid expansion of high schools in the early 1900s (Rudolph, 2005a.)

assessment, but also made possible Needs as the question that must be asked and answered by the science teacher? I am interested in what, if any, relation there may be between the early twentieth century divide of science teaching for the few versus the masses, and the early 21st century divide of science teaching for future scientists versus for all citizens.[108] How can history be made "effective" (Foucault, 1977, p. 153) for considering the possible limits of the "two-pronged approach" (NGSS Lead States, 2013a, p. 370, see chapter 1) that is recommended as an equity strategy today?

Many have argued that notions of "relevance" and "scientific literacy" are sliding signifiers (e.g., Aikenhead, 2006; National Academies of Sciences, Engineering, and Medicine [NASEM], 2016). One focus of debates over these terms center on rhetorical rationales. Basile and Lopez (2015), for instance, analyze recent science education policy and argue that the rationales given for improving science instruction for underrepresented groups tend to be framed as economic rather than moral imperatives (see also DeBoer, 2013). Pierce (2012) expresses a related concern, arguing that school science should be fostering democratic citizens rather than neoliberal consumers.[109] While I share many of these concerns, my task here is not to weigh in on the relative merit of various definitions or rationales for scientific literacy (see McEneaney, 2003). Instead, it is to contribute to these debates by drawing attention to how specific formulations of "scientific literacy," "everyday relevance," and the "needs of citizens" are not merely rhetorical, but act in the world with material effects. I hope to demonstrate how these

[108] While I explore those historical questions more fully in the chapter that follows, it is important to clarify here that divides between enlightened experts and their appreciative masses are not preserved in amber. Transformations in the sciences, schooling, and society require careful attention to differences in historical modes of difference-making within science education.

[109] Importantly, as Valero (2017) has discussed in mathematics education, the binary assumed between citizens and workers tends to obscure the intertwining of practices and logics that foster a particular kind of citizen-worker.

ideas become manifested in concrete tools and practices of pedagogy that powerfully shape the differential experiences afforded to students in U.S. schools.

While acknowledging a plurality of notions of scientific literacy and science education for citizenship, one prevailing contemporary vision of science education for citizenship asks teachers to identify problems in those students' homes and neighborhoods that can be easily solved by applying the content of school science.[110] This widely circulating set of theories and practices constitute scientific literacy as: a) a property of individuals, b) one that can be externally assessed, and c) one that serves as a proxy for well-reasoned personal and civic decision-making. One effect of this formulation, regardless of intent, is to ascribe problems that children confront (e.g., disease, poor nutrition, and environmental hazards) to a lack of scientific understanding within their homes or local community. In formulating the problem in this way, the solutions adopted in science class tend to take one of two forms. One approach is to try to make science "accessible" to those students by helping them understand, appreciate, and comply with official guidelines of health and safety. Another is to "empower" them to persuade their parents and neighbors to make more scientifically informed choices about health (e.g., to avoid fast food) or the environment (e.g., to reduce litter or energy waste). For those designated as not-yet-informed citizens, the problem is treated as populations requiring intervention at the level of their daily decision-making—a pedagogical objective that may be given precedence over preparing them for future science coursework and careers.

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[110] The call to make citizens more scientifically literate by diagnosing unscientific habits in their daily lives is certainly not the only available vision of science education for citizenship. Alternative visions have reconsidered what constitutes civic engagement in science education (Rudolph & Horibe, 2016), redefined the notion of the usefulness of science for daily life (Feinstein, 2011), relocated scientific literacy as a property of communities rather than individuals (Roth & Lee, 2004), reconceptualized scientific literacy in relation to biocapitalism (Pierce, 2012), and contrasted the depoliticized model of civic participation with one of dissensus (Bazzul, 2015).

The chapter is organized as follows. First, I present a vignette of a contemporary lower-track science course called Chemistry in the Community, which posed equity dilemmas for teachers at Alderwood High School (AHS). After discussing Chemistry in the Community, I analyze how similar modes of classifying students operated across science coursework at AHS. I then highlight how a similar hierarchy of needs operates in the Next Generation Science Standards (NGSS). Finally, the chapter will make the case for historicizing the ordering strategy of Needs into historical perspective.

Vignette: Chemistry in the Community and a Hierarchy of Needs

Chemistry in the Community (or Chem Com) had a brief but significant life at Alderwood High School (AHS). Reacting to demographic changes in Glacier City, it was adopted to serve "poor, minority, less-achieving kids" (Interview TN, 2015). But less than two decades later, the course was eliminated. The deathblow, it seemed, had been the refusal of Glacier City Technical College and the National Collegiate Athletic Association (NCAA) to accept Chem Com as a legitimate science credit.[111]

Nevertheless, the course lived on as an ideal of what science education could be. In the opening epigraph, an AHS teacher was arguing that Chem Com was better suited to the needs of some students than the higher-level Math Chemistry course. It is worth citing the teacher's argument at length, as it illustrates various modes of classifying students and the science instruction they require:

[111] This concern was evident across the Glacier City School District (GCSD), dating back at least a decade. At a March 2005 meeting of the Parent Teacher Student Organization at another high school in GCSD, the science department chair reassured a parent that despite a shift toward teaching a core curriculum for other subjects, "they would not eliminate the regular Chemistry class because the lack of math content/rigor in Chem Comm [sic] ("Chemistry in the Community") would leave [their] graduates unprepared for chemistry at the U[State] and other universities.)" (Meeting minutes archive, 2005). As one AHS administrator put it, "They went away from Chem Com because GCTC [Glacier City Technical College] won't even accept Chem Com for nursing" (Meeting fieldnotes, 2014).

> We're all citizens. All of us. . . . When I taught Chem Com, we focused it on kids who were maybe interested in science but didn't want to do it as a career. I really liked Chem Com. We did some really fun stuff. . . . It's much less abstract. I thought it was a much better course than the typical Math Chem to tell you the truth. . . . If you are going to go into science, if you are going to take college chemistry, you need something really rigorous. [But] why should we teach everybody a dry science because that's what it is in college—that's not really easily applied to your everyday life? And Chem Com is. . . . It's how do we use chemistry, and how can we use it to make your life better and understand the world around you. As opposed to stoichiometry, which is silver nitrate, sodium chloride, add them together, and what do you get. . . . It's a level of prestige thing. That's what kids see, because that's what colleges want to see, but in real life, Chem Com is a lot more—I think it's a lot better course for preparing you for life. (Interview EP, 2015)

The statement contains expressions of unity, egalitarianism, and humanitarianism: all citizens, all of us, everybody, make your life better, and understand the world around you. These expressions are linked to a critique of traditional science education as pedagogically unsound, elitist, and reinforcing the artificial prestige of gatekeeping content in college admissions.[112]

The statement also displays several ways of seeing and sorting difference, which create divisions within these expressions of unity. Each contributed to the sense that it was crucial to have two different chemistry courses. First, the argument endorses Chem Com as "much less abstract" than the "really rigorous" Math Chem. As discussed in chapter 3, the dividing practices of Readiness rate whether a student's mind is ready and able to tackle decontextualized

[112] Similar critiques of traditional science education appear in Aikenhead (2006).

calculations, given here as “silver nitrate, sodium chloride, add them together, and what do you get.” For those positioned at a lower developmental stage, it appeared self-evident to match them with applied science rather than pure stoichiometry.

Second, Chem Com is lauded here for not being a “dry science” like Math Chem. As discussed in chapter 5, the ordering strategy of Interest rates whether students are sufficiently motivated to study abstract science. Interest makes it possible to distinguish some as having the drive to make it through Math Chem, whether because they’re “going to go into science,” or because they recognize its prestige and want “what colleges want to see.” In contrast, other students are marked as only “maybe interested” in science. For those students, it seemed important to make Chem Com “really fun” by exploring how chemistry is used in daily life. Together, Readiness and Interest worked to divide the student population in two: concrete thinkers who were less motivated to learn science, versus abstract thinkers who were self-driven science learners. These distinct types of minds and attitudes were taken as pre-existing conditions, to which tracking appeared a logical response.

It did not escape notice, however, that such typologies tended to cut along racialized lines. According to one teacher, the adoption of Chem Com in response to the district’s shifting demographics could be understood as “a basic disrespect” to Black students (Interview TN, 2015):

> It’s called *Chemistry in the Community,* and I just have a real strong bias against that whole idea, where there’s two chemistries . . . [as in] “You don’t have enough wherewithal to learn real chemistry, so we’re going to teach about things that matter to you about water quality and some other watered down concepts” . . . [as if] that’s what Black people would be interested in. . . . It was brought in as a response to the

demographic change, and I think, personally, it's a disservice to that demographic. (Interview TN, 2015)

A second teacher seemed to disagree, bringing up—but immediately ruling out—the possibility that Chem Com's adoption had something to do with racism:

> I would doubt that it was racially or ethnically motivated. I think it was just looking at students in general who were not that motivated in science, and saying, "Let's try to make this more applicable to your everyday life," which is a very logical thing to try to do. . . instead of looking at this theoretical stuff. (Interview NM, 2015)

One way to approach these statements would be to set up a contrast between the two teachers by inferring differences in their underlying beliefs or conceptions. However, as I argued in chapter 2, such an approach might mistakenly suggest that the problem originated within these individuals. Rather than create an opposition between the teachers, it is possible to read both statements as indicative of the modes of reasoning about difference available in educational spaces today (see appendix G).

The task is not to presume a totalizing ideology or deterministic structure, but to analyze the shifting rules, principles, and practices that make "these diverse responses simultaneously possible" (Rabinow, 2003, p. 46). Both statements, for instance, attest to the clear expectation that teachers were responsible for classifying students by: a) Readiness, by identifying those who don't have the "wherewithal" to learn "theoretical stuff," and b) Interest, by figuring out who is "not that motivated in science" and what "matter[s]" to them instead.[113] These logics, as I've argued in parts I and II, are not an invention of individual teachers or even a misuse of research-based reforms. In fact, the designers of the *Chemistry in the Community* textbook (a reform from

[113] Notably, the statements concur that, regardless of whether disrespect were intended by adopting Chem Com, there were racializing effects.

the American Chemistry Society first released in 1988) had found it equally logical to design the curriculum to target those "with minimal interest in the quantitative aspects of the subject," and then to pilot test it on students in "inner-city" schools (Sutman & Bruce, 1992, pp. 564-565).[114]

The previous chapters began to explore how such divisions came to appear logical. It is not merely that negative stereotypes misrepresent Black students as less ready or interested to study science. Rather, these ordering strategies carry selective principles that make people up as racialized populations (e.g., producing whiteness and blackness), at the same moment as they make up the interior spaces of the mind (e.g., as having measurable degrees of reasoning or motivation) and the exterior spaces of the science curriculum (e.g., as composed of abstract theories versus concrete facts). Readiness and Interest, as I have argued, are not merely racializing in a binary way, but productive of a wide range of hierarchical differences through which racializing, gendering, ableizing, and other modes of Othering become possible. They comprise principles that compare, classify, and order along a continuum of differences, such that those at the lower end of this spectrum are subjected to biopolitical mechanisms of regulation and "the conduct of conducts" (Foucault, 1994a, p. 138). In this way, the practices of educational research mutually fabricate distinct types of learners and the levels of school science they seem to demand.

Yet Readiness and Interest were not the only ordering strategies that made Chem Com appear necessary. Even when it was assumed that each student possessed the same readiness and interest in science, distinctions were still made based on perceptions of which form of school science would best serve students' present and future lives. I turn next to this third ordering strategy of Needs. It is perhaps more dangerous than the other two, precisely because it appears

[114] The AHS Chem Com course had been using the fourth edition of the official *Chemistry in the Community* textbook. Despite the dissolution of Chemistry in the Community prior to 2013, the textbook remained in use for some sections of the renamed General Chemistry course.

to move judgment away from students' interior qualities and onto the external reality (e.g., social, economic, and health conditions) that they must—for their own good—be prepared to face.

According to the teacher's argument above, what made Chem Com a better course was that it was easily applied to daily life. But because the demands of college were different from those of real life, it was not a better course for everyone. Clearly acknowledged was that those wanting access to college science did not need everyday relevance but the rigor of Math Chem. Therein lay a dilemma: while it was unfortunate that colleges gave less prestige to Chem Com, wasn't it still more important to offer a science education that would prepare students for life? Chem Com emerged as the better option only for those with less need for "rigorous" science, and greater need for science "to make your life better and understand the world around you." This logic differentiated potential scientists from prospective citizens: even if not all students were headed toward scientific careers, "we're all citizens. All of us."

As with Readiness and Interest, the ordering strategy of Needs did not originate at AHS. The *Chemistry in the Community* textbook was "designed for high school students who may or may not be college bound," but who, as the "'nonscience major' component of our citizenry," would benefit from applying science to "significant issues facing them personally and that face the nation" (Sutman & Bruce, 1992, p. 564). My question, then, is: How did it become reasonable for both textbook designers and teachers to distinguish between the needs of a selective cohort of future scientists versus those of a not-yet-scientific component of our citizenry? This is a historical question.

In the 1920s, the general science course was promoted as better than the existing physics and chemistry courses, which were dismissed as "fundamentally unpedagogical" (Barber, 1917,

p. 111), “too technical,” and trying to “cover too much material” (Berninghausen, 1917, p. 165). Science education scholars also called into question the “practical value” of physics and chemistry, asking “whether this is not a sort of college-made mold into which we propose to fit all students regardless of whether they are to go to college” (Caldwell, 1904, p. 18). Yet, those critiquing physics and chemistry as unpedagogical for the masses did not want to wish these courses away. They acknowledged that these courses, now referred to as “specialized subjects,” were “found advantageous for mature students of science” (Caldwell, 1917, p. 135). The problem, according to a school superintendent, was that their aim was “not broad enough, not big enough to meet our present need” (Berninghausen, 1917, p. 166). The question here is how “our present need” became formulated as the necessity to divide and order pupils and pedagogies along a hierarchy from practical to technical and from general to specialized. Echoing Dewey’s division (see second epigraph, above), the superintendent went on to explain: “We do not wish to make specialists and experts out of the majority of high school people, but we do wish to fit them as best can be for all the issues of life” (p. 166). Before delving further into the past and exploring its resemblances and ruptures with the present, I want to examine how Needs not only compelled the adoption of Chem Com, but also the maintenance of a hierarchical organization of science courses at AHS.

A Hierarchy of Needs at Alderwood High School

Talk of needs was ubiquitous at AHS. In debates over tracked courses, everyone agreed that the most important goal was meeting students’ needs, but disagreed on what those needs entailed. This section draws from classroom observations, teacher interviews, meeting artifacts, and the school’s curriculum guide to analyze how Needs were identified and correlated with demographic distinctions in the daily details of science teaching.

While the term functioned in myriad ways, here I am interested in how Needs worked to index two interrelated distinctions.[115] The first was differences in what students needed for their *future academic or career trajectories*—i.e., "they won't need X (e.g., stoichiometry) for technical college." The second was differences in students' *immediate lives and home conditions*—i.e., "we need to provide Y (e.g., nutritional guidance) because their single parents can't." This distinction between future and immediate needs provided a basis for stratifying science classes. Higher-level courses aimed at preparing those with future needs for college science. Lower-level courses often focused on meeting students' immediate needs by applying science to issues of health, safety, and civic decision-making.

In determining which needs to prioritize for a given student at AHS, there were two halves of the equation. The first half—future needs—was to weigh how much the student needed higher-level science. While some students "need all those AP [Advanced Placement] classes," others appeared to just "need science credits" to graduate high school (Interview TN, 2014). Standardized test data provided one resource for making this determination. As discussed in chapter 3, students in the lower-track Biology 2 course were said to have EPAS scores ranging from 16 to 19, placing them below the benchmark of 22 and well below the score of 27 assumed necessary to "have a shot of getting in" to the state university (Interview KC, 2014). Distinctions in future needs were also inferred based on perceptions of students' families. "Honors kids" were ascribed more needs in the future tense due to presumed differences in parental involvement: "It literally is just a different population of students: ones whose parents have pushed them" (Interview GA, 2015). In contrast, those in lower-level courses were assumed not to face the same academic pressure from home; college was imagined as unfeasible for families who might

[115] At AHS, "needs" sometimes referred to "special needs" or the "learning needs" of an individual child's mind. Because these uses of the word "needs" produce distinctions in cognitive or developmental terms, I do not consider these examples here.

be unable to afford rising tuitions (Interview JH, 2015), or ineligible for financial aid due to their presumptive immigration status (Interview SF, 2014). Based on these logics—which circulate in research and policy as well—it seemed unnecessary to subject everyone to the dry rigor and breakneck pace demanded by the honors curriculum or AP exam if some were unlikely to attend a four-year college or university.

The logic of predicting future needs did not go unquestioned. The prospect of advising students on their science course selection made one teacher uncomfortable, because "you can't even identify who the future scientists are going to be" (Interview PB, 2015). To mitigate this uncertainty, one recommended approach was advising students based on the specificity of their future plans. Another teacher discussed feeling uneasy with this informal protocol for guiding students in their course selection:

> I *should* ask, "What do you want to do? What do you want to do when you get to college?" And if they say, "I want to be a doctor," then I'm supposed to say, "Then go to Math Chem." [But] then if they say, "Well, I don't know. I think I want to go to GCTC [Glacier City Technical College]," then, "Hey! This is a great class for you—you should be in Gen Chem." . . . I really think we could do a better service to the chemistry student population here if we took the Math Chem and Gen Chem and turned it into just one chemistry class. (Interview TN, 2014).

In spite of these concerns over the inadequacy of predictive heuristics, it remained commonsense that not all students required the same level of preparation. It appeared to many as though students already had different future needs, because regrettably, they were already moving on trajectories that were separate and unequal; it seemed too late to change the future that had yet to transpire.[116]

The second half of the Needs equation—immediate needs—involved determining which students had more pressing needs to address in their everyday lives. While higher-level courses could afford to focus on future preparation, lower-level courses sought to promote science literacy for the here and now. The department had laid out a clear sequence of course goals: from "Science Literacy" at the bottom to "Preparation for a college major" at the top (Meeting artifact, 2014). Likewise, the AHS curriculum guide positioned science literacy as the primary goal of lower-level courses, such as ESL Science Fundamentals (AHS Curriculum Guide, 2013-14). Where Chemistry Honors was to prepare students for the AP test with topics like "formula writing," Physical Science was to address "food chemistry" and other topics "as they apply to real, everyday situations" (p. 51). Within this logic, students going into science would benefit from learning stoichiometry, but others had more pressing needs:

> It's worrying about being fed and where you're going to sleep at night. . . . If your main concern is more of a survival mindset than looking to the future, what-can-I-do-with-my-life mindset, then you're going to be a step behind everyone else. (Interview GA, 2015)

Whether perceived as academically behind, less interested in science, or coming from less stable home lives, the priority established for those students was learning to apply science to daily decision-making. The most urgent concern was reaching "at-risk students" who "don't do any

[116] The educational commonsense that high school is "too late" to change a child's academic trajectory was expressed by one teacher as follows: "If you're coming into kindergarten a year or so behind—and that's why they're really pushing for 4K [preschool]—then by third grade, you're not ready to read to learn in the classes. You're completely behind [and] by this time, they've been in school for ten years. What can I do in one semester to outweigh a ten-year thing?" (Interview EP, 2015). This logic resembles (and may draw upon) long-circulating educational theories like the Matthew Effect in learning to read (e.g., Stanovich, 1986), or recent studies claiming that racial gaps in science learning start *before* kindergarten and only grow with time (e.g., Morgan, Farkas, Hillemeier, & Maczuga, 2016). Later, I discuss the productive power of theories in shaping what seems both feasible and important in practice.

science in their lives" (Interview EP, 2013). This urgency stemmed from the worry that each course could be the last science they would ever take (Interview GA, 2015).

Teachers assigned to lower-level courses—e.g., Physical Science, ESL Science Fundamentals, Biology 2, and formerly Chemistry in the Community—expressed a responsibility to help their students become "better citizens and have a better life" (Interview EP, 2013). These courses tackled topics like safe driving, hand washing, nutrition, daily habits of water conservation, and "why we don't put out grease fires with water" (Interview JN, 2015). The logic of immediate needs implicated the family, because the school was understood as taking on the responsibility to foster safe and healthy living *in loco parentis*. The Biology 2 course, for instance, adopted a focus on human health and disease. The hope was that because "kids are innately interested in their own health and wellbeing," science class could inoculate them against the fears and misconceptions held by their family members, such as vaccines making you sick (Interview KC, 2014; see also chapter 5). The corresponding fear was that without explicit training in the science of daily living, some children and families would pose a threat to themselves and to the body politic. Making better citizens, then, operates as a moral imperative, linking efforts to confront scientific misconceptions to a broader mission promoting better-reasoned decisions in the home, doctor's office, and voting booth.

What requires further inspection is how it became self-evident to divide individuals—and demographic groups—by their relative need for stoichiometry versus something akin to survival. In the next section, I examine how the divide between the needs of future scientists and not-yet-informed citizens is formulated in recent policy.

A Hierarchy of Needs in the Next Generation Science Standards

The U.S. NGSS call for adapting instruction to meet "the learning needs of the nation's increasingly diverse student population" (NGSS Lead States, 2013a, p. 359). This section draws on the NGSS and their accompanying *Framework* to analyze how the problem of distinguishing students' needs is formulated as a demographic concern.

Key to the NGSS' treatment of equity is the concern for how to prepare a more "diverse" population for informed citizenship. The NGSS' *Framework* introduces its chapter on equity and diversity by citing the "democratic ideal" of ensuring that "all of the nation's people" acquire a baseline of scientific literacy needed to make decisions, such as those concerning human health (NRC, 2012, pp. 277-8). As mentioned, the NGSS Appendix on equity and diversity outlines a two-pronged approach: "to elevate the achievement of low-performing at-risk groups while simultaneously lifting the ceiling of achievement for our future innovators" (NGSS Lead States, 2013a, p. 370). Delineated here are two types of science learners matched with distinct needs. While "our future innovators" need opportunities for advanced study, "at-risk groups" need first to be elevated to a baseline of scientific literacy for their own benefit. The resulting dichotomy takes for granted that these subgroups exist, that they can be clearly identified, and that they do not overlap.[117]

The ordering strategy of Needs is hard to disentangle from those of Readiness and Interest. Metrics of science achievement serve as proxy measures of the scientific understanding needed for daily life and responsible citizenship (see chapter 4).[118] Because achievement data are said to "measure how well students were able to reason through complex problems and apply science to real-life situations" (NGSS Lead States, 2013a, p. 370), science achievement gaps are

[117] Such premises reinforce the standards' broader presumption that "gifted and talented students" and "major racial and ethnic groups" are mutually exclusive, given the distinct (and in some cases, opposed) pedagogical strategies recommended for each group (see chapters 4 and 6).

[118] While researchers continue to work on developing a direct measure of scientific literacy (e.g., Fives, Huebner, Birnbaum, & Nicolich, 2014), standardized tests of science achievement often fill in as indicators of scientific literacy, such as the National Assessment of Educational Progress (NAEP) cited in the NGSS.

constituted as a national crisis not only in terms of the external ranking of countries, but also the internal functioning of the democratic state. The urgency of addressing equity and diversity in U.S. science education has been asserted through appeals to real-world issues, especially related to health and the environment:

> Systematic reduction of greenhouse gases, controlling the spread of pandemic viral infection, and combating the obesity epidemic in the U.S. are just three examples of critical social issues that can only be addressed by a scientifically literate public. . . . Persistent achievement gaps, however, imply that non-mainstream students will be increasingly disadvantaged in both job markets and civic decision-making. (O. Lee & Buxton, 2010, pp. 3, 9)

The hope is that differentiating science education by demographic group can remedy these disadvantages and better prepare students for real-life challenges. But that hope is again accompanied by a fear: that those issues will only worsen if the country fails to close achievement gaps and improve the scientific literacy of “non-mainstream” populations.

Needs is also intertwined with distinctions in Interest. The focus on immediate needs, such as personal and family health, promises to “awaken an interest in science” (e.g., Kyburz-Graber, 2012, p. 34). This is deemed especially important among populations perceived as otherwise less motivated (see chapter 6). In the NGSS case study for “students from major racial and ethnic groups” (NGSS Lead States, 2013c), the teacher brings in chips for students to eat in part to “motivate” student participation in an energy unit (p. 1), and in part to spark a discussion of how high fructose corn syrup is “unhealthy” (p. 3). The logic is that the same students who struggle with Interest also have more immediate Needs for a science applied to their daily lives.

Across the NGSS, everyday relevance is given as a particularly effective strategy for "non-dominant groups," who otherwise "do not see science as being relevant to their lives or future" (NGSS Lead States, 2013a, p. 363). Relevance, here, depends on the identification of a need to which the science content or pedagogy can be made relevant or applicable. For instance, the case study on major racial and ethnic groups depicts 8th grade students in an urban school focused on the scientific literacy required of lay citizens, such as nutritional choices and a local vote on biofuels (NGSS Lead States, 2013c). Meanwhile, the case study on gifted and talented students portrays a suburban classroom of 4th grade students who "became scientists" by developing expertise on topics at a distance from day-to-day application, like mastodons and the end of the Earth (NGSS Lead States, 2013h, p. 3). The only physiological concerns addressed in this case study were gifted and talented students' investigations into the daily growth and health of praying mantises as their class pet (p. 3). A troubling premise is that racial and ethnic groups correspond to distinct kinds of bodies with differing needs for instruction focused on "real-world" concerns of healthy habits and well-reasoned civic participation.

What emerges, both in practice (AHS) and in policy (NGSS), is a sort of hierarchy of needs. Reminiscent of Maslow's (1943) hierarchy, the most basic needs are given as physiological: the health and safety of the human body. At first glance, this seems natural. Why shouldn't a society prioritize ensuring that all citizens achieve a baseline of scientific literacy? If a student learns nothing else in their science education, surely it should be how to make good decisions on matters of life and death—whether to reduce the danger of grease fires through a working knowledge of combustion, or to lower the risk of diabetes by avoiding high fructose corn syrup. Certainly, one could argue that better individual decisions would improve public health (e.g., vaccination) as well as the health of the democratic process. Within this logic, only after addressing fundamental needs of survival and societal responsibility would it make sense to work on less immediate needs, like self-actualization or training future scientists. It would appear self-evident to order immediate needs before future ones, relevance before rigor, and citizenship preparation before specialized training.

Importantly, though, that hierarchy does not always operate as a temporal sequence (i.e., *first* teach all students relevance, and *then* teach them all rigor), but as a spatial mapping (i.e., teach *these* students relevance, and *those* students rigor). In the tracked courses of AHS, those who take Chem Com do not later take Math Chem. Likewise, the NGSS *Framework* differentiates two goals for K-12 science education: one for all, and the second for "scientists of the future"—for whom higher-level coursework is recommended (NRC, 2012, p. 10).[119] This is not to say that everyday relevance and future-oriented rigor are necessarily opposed, only that they have been widely formulated as such in research and policy. At issue is how immediate versus future needs have become projected as belonging to distinct human kinds—categories imbricated with (and productive of) distinctions in race, ethnicity, class, and culture—such that the tracking of science courses comes to appear as a reasonable response to those populations' differing needs.

Before Maslow: Why Historicize the Hierarchy of Needs

The first half of the Needs equation—i.e., sorting which students have future needs as potential scientists—has already come under substantial critique. Previous studies of tracking have argued that predictions of students' academic trajectories tend to reproduce the unequal distribution of high-status knowledge along socioeconomic and racial lines (see Gillborn & Youdell, 2000; Oakes, 1985/2005; Tate, 2001). A similarly robust literature has examined how

[119] While the NGSS (2013a) articulate the baseline of what all citizens needs to know, the *Framework* maintains that "course options, including Advanced Placement (AP) or honors courses, should be provided" (p. 10), in order to meet the needs of those classified as future scientists.

deficit thinking and the construction of blackness as inferior shape judgments of who is perceived as a potential scientist, and which academic or career goals appear “realistic” for a given student (see Mutegi, 2013; Ong, 2005; Valencia, 1997). Much less scrutiny, however, has been given to the second half of the Needs equation: sorting which students have immediate needs as prospective citizens. In fact, as I explore in chapter 8, the demand to prioritize the health-related needs of marginalized groups within their K-12 science instruction has become a key part of reforms aimed at promoting equity and cultural relevance.

Making visible the underlying logics and potential limits of such reforms requires a different analytics of power. Research on tracking has tended to analyze power in terms of dominant groups denying educational opportunity to non-dominant groups. This is described as rationing access to courses that transmit high-status knowledge (Gillborn & Youdell, 2000), such as Math Chem. However, this analytical approach neglects to explain how curricular reforms, such as *Chemistry in the Community,* become understood as more equitable, and as better serving the everyday, health-related needs of marginalized groups. This study has argued that rather than merely seeing power as repressive, it is crucial to analyze how power also functions productively by making new typologies of people, alongside new theories and tools to diagnose and address their everyday needs. As Foucault (1992), Stoler (2009), and W. Anderson (2006) have discussed, the making of racialized hierarchies, while evident in anthropological theorizing, may be most explicitly rendered and materialized in the everyday practices of governance—whether judicial, medical, or pedagogical. It is in these administrative practices that cultural norms and racializing processes tend to operate unbarred. This is precisely because their technical details (while perfectly visible at the surface of discourse) tend to fall below the radar of politics, and as such, may have even more potent political effects (Latour, 1983).

As one example of the productive power of theories, consider Maslow's hierarchy of needs. Circulating across educational studies today, Maslow's hierarchy has helped to define social justice in education, where the first two levels—physiological and safety needs—have been designated as the minimum rights of citizenship (Schulz, 2007). The hierarchy also serves as a heuristic for teachers, who are advised to get to know their learners by locating each student's level on Maslow's scale: "By doing this, you will be in a better position to help learners move up the hierarchy" (Burleson & Thoron, 2014, p. 3). These examples illustrate how theories do not remain insulated from the social world, but insert themselves as integral to projects as varied as (in the sources cited here) a tutoring program for Hmong refugees and a logic model for training agricultural educators. A psychological theory first proposed by Maslow in 1943 continues to travel, assembling with wide-ranging political theories and administrative techniques to give shape to specific reforms.

I want to consider whether Maslow's hierarchy may have had a particular resonance within science education, given that the lowest-level needs are cast in biological terms. For instance, Maslow's hierarchy has provided a framework for prioritizing the goals of science teaching: "At the lowest level are physiological needs such as food, water, and air. These are the human needs that, for example, are usually discussed relative to majorities in underdeveloped countries and minorities in developed countries" (Bybee, 1979, p. 251). Here, the invocation of survival-related needs predates the distinction of survival versus stoichiometry at AHS, and the association of survival needs with "minorities" and "underdeveloped countries" authorizes the mapping of racialized and geographic categories along Maslow's scale. If such associations persist today, is it possible they silently bear on what appear like natural pairings of demographic groups with particular aims and methods of science education?

Of course, hierarchies of need did not begin with the 1943 publication of Maslow's theory. Several decades earlier, U.S. science education scholars insisted that the key to good teaching was to design projects to solve students' immediate needs—for "only through solving present needs can future needs be met" (Moore, 1916, p. 15). The general science course (see chapter 1) would follow this hierarchy, being "adapted to the conditions in which the learner is found" and "taught for the sole purpose of their usefulness to the students' immediate needs and not to prepare a student for some future subject" (Elhuff, 1916b, pp. 18, 20).[120] Within the overall aim to teach pupils "how to live" (Elhuff, 1916a, p. 2), general science textbooks would begin with the most basic physiological goals, such as remaining "free from disease and avoid[ing] the use of stimulants and narcotics," and conclude with higher goals like building "self-confidence" (p. iii). By starting with health, the hope was that the masses would "form proper hygienic habits" (Elhuff, 1916a, p. iv), even if they never made it to physics or chemistry.

What this brief history suggests is that health has often been a primary goal of school science for those marked as outside of mainstream society—whether the hygienic habits of the "urban masses" (1910s), the physiological needs of "underdeveloped" countries and "minorities" (1980s), or the healthy decision-making of "non-dominant groups" (2010s). Attempts to democratize science education have repeatedly targeted subpopulations by designing curricula around problems assumed to exist in their home lives in efforts to improve their daily decision-making through science.[121]

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[120] The general science course actually embodied two nested hierarchies. First was the relative positioning of general science as preceding specialized science courses. This organization followed the developmental scale outlined in chapter 4—from health at the bottom (as the focus of general science), up to knowledge of the disciplinary sciences at the top (e.g., physics and chemistry courses). Second was that the content of the general science course could be similarly sequenced, opening with a chapter on health. As the textbook author explained, "the material which touches upon the pupils' personal habits is placed as early as possible in this course, so that they can use it at the beginning" (Elhuff, 1916b, p. iv).

[121] Here, it is useful to remember that the predecessor of the social sciences was called moral sciences and directed toward addressing deviancy and vices thought to threaten the republic (Hacking, 1990). The moral sciences

The next chapter further examines how it became possible to differentiate some students as having future needs, and others as having more pressing needs to apply science to everyday life. I explore how this divide became entangled with cultural norms and racialized judgments regarding healthy lifestyle choices and informed civic participation. At stake is whether reforms intending to respond to the needs of "diverse groups" inadvertently produce new distinctions, as certain groups must exhibit particular health habits to prove their scientific literacy and civic responsibility.

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brought together the celestial mechanics of Newton with Locke's investigation of human reason to offer "a rational theory of individuals and society" (p. 38). Recall as well that the Marquis de Condorcet—a "preeminent spokesman of the moral sciences" (p. 38)—articulated a fundamental divide in the purpose of science education. This entailed bringing the masses to a basic level of enlightenment through which they could distinguish scientific expertise from charlatans and from superstition, while still offering talented individuals the opportunity to develop their abilities in order to direct humanity's progress (Broman, 2012). My interest is in how a biological register of Needs came to reinscribe this divide, while effacing the moralizing principles and governing techniques that demarcate some as having everyday problems and diagnose those problems as stemming from their lack of a proper, healthy attitude toward expertise.

Chapter 8. Moving the Lab into the Field: The Making of Pathologized (Non)Citizens with Differing "Needs"

Education for citizenship is frequently invoked as a democratic ideal, contrasted with instrumental aims like improving economic competitiveness. Within science education, preparing future citizens is upheld as a "more inclusive" alternative to the canonical model of training scientists (e.g., OECD, 2016, p. 4). Debates in the field revolve around the question: What counts as scientific literacy, and how can we prepare all students for informed citizenship? (Linder et al., 2011; NASEM, 2016). But of course, the category of citizen is not universally inclusive. Throughout U.S. history, citizenship has operated as a differentiating hierarchy, distinguishing the archetypical citizen "whose civil rights are never placed in question" from those "having to wage struggles for the right to be regarded as citizens" (Davis, 2012, p. 182). The citizen takes on an additional valence in science education as a non-expert layperson versus a scientist (see chapter 1). Schools have long been enlisted to evaluate, segregate, or remediate those suspected as ill-prepared for civic life. Rather than how to develop future citizens, I want to ask: How has science education already participated in the making and unmaking of citizenship in uneven ways?

Teachers at Alderwood High School (AHS) were expected to differentiate the future needs of potential scientists from the immediate needs of prospective citizens (see chapter 7). Teaching science for citizenship meant improving students' science literacy—a primary objective of lower-track courses. What made this civic aim appear more inclusive was that, even if not all students were regarded as future scientists, "We're all citizens. All of us" (Interview EP, 2015). "Citizen," then, does more than designate "all." It creates a bounded space that encloses some as the "'nonscience major' component of our citizenry" (Sutman & Bruce, 1992,

p. 564) and ascribes to them distinct pedagogical and real-world needs. A durable premise—which this chapter seeks to place in historical perspective—is that some populations come to school equipped with the reasoning needed for personal and civic decision-making, but others do not.

In the next section, I introduce a set of recent reforms, which aim to use public health concerns to make science instruction more inclusive and relevant for students from marginalized groups. I am interested in the practices of science and schooling that make this a reasonable solution to a taken-for-granted problem. Tracing the history of those practices requires traversing disciplinary boundaries and national borders. I will consider how pedagogies of everyday relevance bear indelible marks of their journey across public health campaigns, sociological studies, immigrant settlement houses, and colonial medical interventions at the turn of the twentieth century. The chapter reconsiders current logics of diversity and inclusion by investigating how the hierarchical tracking of science courses came to appear as a necessary and even equitable response to the health needs of "diverse" groups.

The Hope of Making Healthier Citizens: An Entangled History

Recent policy reports propose health literacy as a "prescription to end confusion" (Institute of Medicine, 2004) and as integral to the scientific reasoning needed by all citizens (NASEM, 2016). Prioritizing health concerns in K-12 science education is outlined as a win-win situation: health would enter the core curriculum, while science education could gain everyday relevance (Zeyer & Kyburz-Graber, 2012; see also J. Brown, 2017; Roth, 2014). This win-win is considered even more powerful for demographic groups confronting both science achievement gaps and health disparities. For such groups, the inclusion of health topics promises to make school science more motivating and applicable to daily life. The hope is that science education can foster healthier citizens by getting outside the lab to bring science to bear on the well-being of local communities. This is not a new hope.

A century earlier, U.S. science education scholars designed a general science course to democratize science by focusing on the health needs of everyday citizens (Elhuff, 1916b). General science advocates dismissed the abstract exercises of the physics lab, arguing that the "grandest laboratory" is "the community in which that High School is located" (p. 18). The aim was to "get back nearer to the world in which the pupil lives, and away from a world which exists only for the scientist" (Dewey, 1916, p. 5). This legacy is invoked today whenever efforts to renew a civic purpose for science education locate their roots in a Progressive Era vision of science for everyday life (e.g., Aikenhead, 2006). Here, I want to direct attention to a dimension of that history that has received less scrutiny in critical studies of science education.

That is, I want to consider how early twentieth-century science pedagogies sought to improve public health in part by bettering the health of those cast as not belonging to that public. A progressive thesis of the time was that it was both possible and essential to rescue populations regarded as not-yet-American. Rescue meant moving them up an evolutionary trajectory to become "worthy citizen[s] of the nation" (Whitman, 1920a, p. 31). This scale linked the development of scientific reasoning to bodily hygiene, moral uplift, and civic duty. For some, recognition as part of the body politic would demand displaying a capacity for self-discipline through observable habits of hygiene. Science classrooms emerged as a key site for this transformation. Perhaps the best place to observe this strategy of Americanization is not in the United States at all, but in the U.S.-occupied Philippine Islands at the turn of the twentieth century.

The colonial Philippines have been studied as exemplifying the ambiguities and contradictions of U.S. citizenship (Aguilar, 2010). In the decades between annexation and independence (1898–1946), the political status of those living in the archipelago was open to intense debate in the U.S. Congress and courts.[122] A key element of this debate turned on the alleged ill health and unsanitary habits of the "Filipino" body, cited as evidence of a presumed incapacity for reason or self-governance.[123] Meanwhile, under the policy known as "benevolent assimilation," U.S. colonial administrators described the Philippines as a laboratory of hygienic modernity—a testing ground for military, scientific, medical, and pedagogical reforms to improve "natives'" everyday habits (e.g., Heiser, 1910).

While historians of science have examined how interventions designed in the colonial Philippines would later be deployed by public health departments across the U.S. mainland (W. Anderson, 2006; McElhinny, 2005), comparatively little attention has been paid to colonial interventions in the history of U.S. education (cf. Coloma, 2009). This chapter charts the circulation of science pedagogies between colonial schools in the U.S.-occupied Philippines and public schools in the continental U.S. to raise the following questions. First, what pedagogies developed under the auspices of preparing Filipino "natives" for modern hygienic citizenship? Second, how did these colonial pedagogies compare with general science pedagogies designed to Americanize the "unassimilated" masses across the U.S.? And finally, how do these histories bear on recent efforts to make science relevant to the immediate needs of "non-dominant racial

[122] A central question was whether the Fourteenth Amendment (granting citizenship rights and equal protection under the law) applied to the inhabitants of the Philippines, whether they fell under the exception for "uncivilized tribes," or whether the precedent of *Dred Scott v. Sandford* made it possible to conceptualize them as non-citizen nationals (e.g., McGovney, 1934; see Aguilar, 2010).

[123] My use of the term "Filipino" is to track the precise discourses of historical actors as a means to examine and denaturalize the historical construction of racialized categories.

groups," such as the focus on health concerns in the NGSS case studies and in lower-track courses at AHS?

The analysis examines how pedagogical efforts to prepare healthy citizens did not merely transmit science knowledge. They also marked exclusionary boundaries of "biomedical citizenship" (W. Anderson, 2006, p. 3), as assessments of hygiene were reconfigured as indices of scientific reasoning and civic potential. I will argue that the pedagogies contributed to "making up" different kinds of people (Hacking, 2007) in a double sense (Popkewitz, 2008).[124] The aim is to understand how the knowledge and practices organizing science education contain normative principles that mark some as pre-qualified citizens, and others as needing intervention to be recognized as fully responsible human agents.

This chapter pays special attention to the transnational entanglements explicitly discussed by historical actors, but which typically go unnoticed under historiographical conventions of methodological nationalism and disciplinary isolationism (Sobe, 2013). The analysis also probes transnational relations that are less explicit, such as the circulation of theories and techniques that delimit what appears as a problem or a reasonable course of action. Specifically, I am interested in how theories of racial hygiene came together with medical statistics, sociological surveys, and project-based instruction to yield a new pedagogical apparatus, which sought to address health problems ascribed to a lack of scientific reasoning.

My analysis relies on a variety of sources. I examine colonial pedagogies in the U.S.-occupied Philippines by analyzing education reports, scientific journals, and teachers' manuals from 1906 to 1928.[125] I investigate how comparable pedagogies emerged in the U.S. general

[124] That is, typologies of students and their "needs" were *made up* as historically contingent categories, but also *made into* reality through their material effects.

[125] These dates span from the first issue of the *Philippine Journal of Science* in 1906 to the joint publication of teachers' manuals by the Bureau of Education and the Philippine Health Service in 1928.

science course through analysis of the journal *General Science Quarterly* (1916–1929), along with contemporaneous textbooks and education reports.[126] Importantly, pedagogies to foster healthy citizenship were never deterministic, and they changed as they traveled between colonial and metropolitan schools. Rather than presume a unidirectional transfer of education reforms, I want to draw attention to their "partial reinscriptions, modified displacements, and amplified recuperations" (Stoler, 2016, p. 27). Highlighting how pedagogies changed in space is one way to sharpen attention to how they may also be changing in time.

The argument is organized as follows. I first outline a shift in the model citizen that gave rise to new types of power relations. Second, I describe a pedagogical apparatus that took shape in the U.S.-occupied Philippines. This apparatus sought to foster hygienic citizenship by moving the scientific laboratory into the "field" of the school, home, and community. Third, I explore the transnational circulation of biomedical and pedagogical expertise, and consider how key elements of the U.S. general science course emerged through these imperial circuits. Finally, I conclude by discussing how this historically comparative approach provides leverage to unsettle what appear today as equitable ways of dividing people in the name of their health, science literacy, and empowerment.

A New Order of Things: Making the Biomedical Citizen and its Others

> [I]n 1898, a new order of things was established. The microscope supplanted the sword, the martial spirit gave place to the research habit, and the status of social and political prominence, to . . . the sacred privilege of helping [one's] fellow man.

[126] As discussed in chapter 1, I approach these sources not as origins of self-evident meaning or individual authors' intentions, but as an archive that can be studied for the principles that made it possible to classify difference, diagnose pathology, and prescribe solutions in historically particular ways. While my focus is on mapping these official techniques, it is important to recognize that such attempts to classify and normalize pupils' everyday lives were always partial and insecure. The very non-fixity of the boundaries and trajectories they projected provided some of their regulatory force, as well as openings for what Butler (1995) calls a plurality of resistances and resignifications. See Aguilar (2010) and Mendoza (2015) for studies exploring various modes of resistance in the U.S.-occupied Philippines and among Philippine nationals living in the United States.

—Director of the Philippine Health Service (Heiser, 1906, p. 245)

One challenge of considering how colonial histories matter today, as Stoler (2016) suggests, is the premise than past racisms and strategies of governance were always much fiercer than those of the present (p. 6). Certainly, links between military violence and early twentieth-century hygiene campaigns have been well documented (W. Anderson, 2006; Rogaski, 2004). Yet there is also a need to account for what was declared as a “new order of things” (see epigraph), wherein the ferocity of the sword would be replaced by the scientist’s research habit and by the physician’s commitment to help one’s fellow man. This section considers how boundaries of citizenship became entangled with scientific and medical distinctions and productive of new relations of power. Understanding this shift is crucial for attending to colonial residues (C. Kirchgasler, 2017a) in science education today, since the microscope is less easily relegated to a distant imperial past than the sword.

The notion of the ideal citizen as possessing scientific reasoning is usually traced to the eighteenth-century European Enlightenment (e.g., Cassirer, 1932/1951). That Enlightenment citizen was already an exclusionary category, deemed uniquely capable of the independent thinking necessary to administer the public interest. As Scott (1996) has argued, this notion depended on classifying others as undifferentiated, unreasoning masses against which the individuality of the citizen and “his” mind could appear. What initially distinguished the citizen, then, were qualities of mind and moral character, discussed as talents and virtues (Carson, 2007).

However, by the early twentieth century, changes in social science, medicine, and governance permitted new metrics of civic potential. Evolutionary and social science theories gave rise to a new model of man as a natural organism. Individual merit became calculable as a mental trait (i.e., IQ), assumed to correlate with classifications of sex and racial stock.

Concurrently, germ theories were altering the conditions of pathology and its modes of expert verification (Tomes, 1998). Microscopes could now discover microbes in blood, urine, and feces, while sociological inspections of the home could identify disease-spreading habits amongst seemingly healthy persons.

A new form of power emerged that sought to enhance life by inducing subjects to live in particular ways (Foucault, 1990). Biopower reconfigured but did not replace existing power relations, as the physical and mental fitness of the individual became linked to that of the population and nation-state.[127] Medical inspections became legal grounds for deportation (Yew, 1980); health statistics were deployed in campaigns to segregate, restrict, and repatriate populations of immigrants and non-citizen nationals (Abel, 2004); and public health departments employed measures of hygiene as “yardsticks of Americanization” (Molina, 2006, p. 45). Habits of personal cleanliness (e.g., refraining from spitting) had long operated as markers of gentility (Tomes, 1998); now brought together with theories of heredity and contagion, these social manners came to double as evidence to array populations on an evolutionary scale of racial hygiene.

So far, I have argued that the Enlightenment citizen, already an exclusionary category based on presumed differences in reasoning, was reconfigured through biomedical distinctions. As the microbe emerged as a scientific object, it offered a new foundation to understand the health of the individual as consequential to the nation. Bodily health could now serve as an outward sign of reason and morality, while scientific instruments like the microscope could arbitrate responsible citizenship versus societal risk.

[127] See Bazzul and Carter (2017) for a recent synthesis of Foucauldian analyses in science education, including several examining biopower. For studies of how biopower techniques traveled and gave distinct contours to how populations were pathologized and regulated within educational projects, see Gastaldo, 2006; Nieves, 2014; and Tunc, 2017.

Alongside those transformations, U.S. officials in the Philippines engaged in what they understood as an experiment to speed the evolution of the "Filipino native" toward modern standards of hygiene and democratic participation. Next, I analyze pedagogies designed with these ends in mind to consider how schools became sites for the making and unmaking of biomedical citizenship.

Colonial Pedagogies and the Making of (Non)Citizens

> The Filipino people may need economic development and modern education, but as foundation to these they need to be freed from the bacteria and parasites that wage continual warfare upon them. . . . This hope can be realized only as a scientific study and campaign of health education is carried on through the schools.
>
> —The Board of Educational Survey (1925, p. 479)

If the microscope did supplant the sword, as was announced in 1906, then the bacteria it displayed would provide an empirical grounding to unleash a war by other means. According to U.S. colonial bureaucrats (see epigraph above), health education was tantamount to an emancipatory campaign—in 1898, the American army had "freed" the Filipino people from their Spanish colonizers, and by 1925, colonial authorities remained to liberate them from the invisible onslaught of microbes that allegedly impeded their development. To better understand how public health and science education became entangled as colonial governing techniques, this section outlines a coordinated set of practices that sought to remake the U.S.-occupied Philippines as a laboratory of hygienic modernity. These included: 1) a medical survey to assess local needs; 2) a health index to move the scientific laboratory into pupils' everyday lives; and 3) the project method to enlist pupils as health reformers and future citizens—even if the latter status was—as W. Anderson (2006) notes—perpetually deferred.

1. Assess local needs. The first step toward moving the Filipino people up a trajectory of hygiene and civic duty was to assess local community problems. Laboratory practices promised to bring order to a tropical milieu that had until recently been conceptualized as inherently hazardous to white Americans (W. Anderson, 2006). These practices did not simply discover a pre-existing set of "needs," but contributed to making up their objects of study through a series of displacements (Latour, 1983). Consider the 1909 Medical Survey of the Town of Taytay, which became a model for assessing health concerns across the colony. Its aim was to "obtain exact and comprehensive knowledge of conditions as they actually existed in a typical Filipino town" (Strong et al., 1909, p. 289). By coordinating clinical records, house-to-house inspections, and laboratory analyses, they aspired to inscribe the "average native of Taytay" (p. 248) in terms of exact calories, intestinal parasites, and daily habits.

Investigators isolated samples of Taytay life within petri dishes and data tables, bringing the messiness of the "field" into the abstracted space of the laboratory. There, it could be compared against standardized reference material. According to the Taytay survey, the average native ate "a high percentage of fruits"—e.g., guava, pomegranate, and watermelon—which when "judged from the European or American standpoint, are decidedly inferior," since they were scarcely "utilized by others than the natives" (p. 221). What became worthy of notice "from the standpoint of health" was anything deemed a "principal defect," such as the presence of sympathizing neighbors around the sick, the "excessive" nursing of infants, and the preference for "herb doctors" over the drug store (pp. 253-254). This comparative mode of reasoning coded difference from the investigator as deficiency. The differences displayed were at the same time brought into existence by laboratory practices and their embedded categories and standpoints of comparison.

The Taytay survey was only pedagogical in a broad sense, as it offered an empirical basis to justify and guide American "tutelage" of Filipinos—already caricatured in the U.S. media of the time as a "child-like race" (see Coloma, 2009). The survey results were taken to confirm that the diseased bodies of "native races" resulted from their "immature" and "uncivilized" habits, such as spitting, eating with the fingers, and leaving windows closed (Heiser, 1910). Epidemiological and ethnological discourses made it seem logical to use the Taytay data to estimate infection rates in the Philippine population as a whole (Strong et al., 1909, p. 257), and to generalize from the town of Taytay to the "entire Tagalog race," whose habits were surmised to be "practically identical" (p. 269). Such conclusions made economic and environmental investments—such as increasing wages, or repairing infrastructure destroyed during U.S. occupation—appear unnecessary until the "natives'" daily habits could be better monitored and regulated (Ventura, 2015). The scientific gaze, a first step in fostering biomedical citizenship, set a baseline of pathology for designing subsequent interventions.

2. Move the lab into the field. Efforts to know the colony's problems scientifically were met with another anxiety of governance—namely, that those governed did not necessarily share the same view of their problems and solutions. In response, a second pedagogical imperative was to extend the reach of colonial laboratories by enlisting schoolteachers. Science education in Philippine schools centered on concrete health habits rather than abstract physics (The Board of Educational Survey, 1925). What made the instruction concrete was the use of measurement and inscription practices to produce systematic data about the Filipino body, its pathology, and its pathway to remediation. By recruiting teachers to conduct standardized health assessments and prioritize instruction accordingly, the aim was to export the research habit of the American scientist into the minds of Filipino pupils.

The official teachers' manual provided a health index to guide daily observations of pupils (Bureau of Education and the Philippine Health Service, 1928; see Figure 8.1). The right side of Figure 8.1 illustrates the proper use of a wooden triangle to determine the pupil's exact height, which could be compared on weight-height-age tables by race to reveal the child's over- or under-development. Health criteria also included: posture, inattention, delinquency in studies, nasal voice, skin diseases, offensive breath, uncleanliness, vicious personal habits, bodily pains, and defective speech (p. 32). Evident here is the intermingling of physical, moral, linguistic, and aesthetic standards of normalcy. Teachers were obligated to report any abnormalities to health inspectors. As W. Anderson (2006) notes, this collusion of pedagogy and policing was also evident in teachers' role to accompany police in conducting home inspections. Such practices transgressed traditional private/public divides, producing intimate administrative knowledge of bodies and homes.

The increasing role of public schooling in the Philippines marked a shift in U.S. colonial governance, as education came to appear more effective than top-down enforcement. New pedagogies drew on psychological techniques to cultivate a desire for health (The Board of Educational Survey, 1925), as evident in this directive from the teachers' manual:

> Secure effort and habit by daily record on charts of essential health habits, such as cleaning the teeth, general cleanliness, etc. Place a star or appropriate mark after the child's name for each daily performance. Individual and class graphs should be used also. This may be made a competition in the entire school. (p. 478)

Compared with the health index, these daily records and graphs were to shift the investigative role onto pupils, even though teachers would verify the standards externally. Once pupils learned to self-assess according to the essential health habits, later grades could focus on developing

HEALTH INDEX OF PUPILS

1. Posture
   a. Sitting
   b. Standing
2. Emaciation
3. Color, pallor or flush
4. Unusual dullness or sleepiness
5. Activity, physical
6. Teeth, malposed or diseased
7. Mouth breathing
8. Frequent absences
9. Bad behavior
10. Inattention
11. Delinquency in studies
12. Defective vision, eye symptoms
13. Defective hearing
14. Nasal voice
15. Discharging eyes, nose or ears
16. Skin diseases or pimples
17. Over development, physical
18. Under development, physical
19. Twitching of eyes, face, or any part
20. Offensive breath
21. Sore throat
22. Cough
23. Enlarged glands, front or side of neck
24. Uncleanliness
25. Scratching of any part of body
26. Frequent requests to go out
27. Vicious personal habits
28. Headaches
29. Other bodily pains
30. Limping, or deformity
31. Stuttering, or defective speech

Figure 8.1. A health index and measuring guide for teachers in the U.S. colonial Philippines (Bureau of Education and the Philippine Health Service, 1928, pp. 32, 37).

scientific attitudes using general science textbooks adapted from the United States. This too was understood as a form of "benevolent assimilation," since the "more scientific knowledge one has, the less superstitious he becomes" (p. 245). Officials estimated that the Filipino pupil could eventually develop the scientific attitude presumed necessary for self-governance, but only after years of practicing these prescribed habits of health and record keeping.

3. Enlist future citizens. Teaching pupils to self-evaluate and internalize scientific criteria of healthy living came to appear necessary but insufficient, given that not all of those governed would attend colonial schools. The third pedagogical imperative, then, was to enlist pupils as future citizens through concrete sanitary improvement projects and community outreach. Part of what it meant to become reformed was to become a hygiene reformer.

The daily records of sanitary habits (as discussed above) were taken as revealing ways to tailor curricular projects to local needs. Students in grade 7, for instance, were to build a toilet in their own home or that of a neighbor (Bureau of Education and the Philippine Health Service, 1928, p. 49). Another common project was asking pupils to create "posters on food, posture, sleeping, exercise, and similar health subjects" (The Board of Educational Survey, 1925, p. 479). Such educational practices, which deputized children as health inspectors and pedagogues, can be understood as furthering infantilizing their parents. Contrasted with the malleability of children, adult Filipinos were routinely depicted by colonial authorities as too ignorant, superstitious, or resistant to be fully reformed (W. Anderson, 2006). By targeting schoolchildren, health instruction sought to "improve the individual and community of the future; to insure a better second generation and a still better third generation, a healthier and fitter nation and race" (Bureau of Education and the Philippine Health Service, 1928, p. 7). In a sort of reversal, pupils gained recognition as responsible future citizens at the expense of their parents, undermining Filipino adults' claims for immediate rights and independence.

Across this set of three devices—the Taytay survey, the health index, and the projects of toilet building and poster making—it is clear that health was not just absence of illness, nor education the mere presence of knowledge. Practices from the medical and social sciences embodied normative principles, which generated certain bodily conditions as indices of racial development and the mental maturity to qualify for full citizenship. Moreover, these scientific and schooling practices indicate the need for analyses of power that do not rely on a linear ideological spectrum. To understand how the sciences act on society, as Latour (1983) suggests, it is insufficient to look for unconscious ideologies or political motives. Rather, we must find ways of accounting for power relations instantiated by the expertise to speak on behalf of microbes—or in this case, the calories, habits, and attitudes required for healthy citizenship. Consider education scholar George Counts (1925), whose report for the Philippine Educational Survey Commission rejected the "prejudice" of others who presumed "the inferior capacity of the Filipino" (p. 99). At the same time, the report insisted on the importance of adapting pedagogies in the modes outlined above:

> At present there is great need in the Philippines for the rapid dissemination of elementary concepts drawn from the fields of natural and social science and applied to the improvement of health, industry, and citizenship. In his effort thus to utilize the experience of Western civilization the pupil is undoubtedly greatly handicapped at present. (p. 102)

The report asserts universal problems of health as revealed by natural science, and problems of industry and citizenship as revealed by social science. Within this universalized grid of theories and techniques, it appeared intolerable to not facilitate the rapid dissemination of "Western civilization," since this would leave the Filipino people "greatly handicapped" as laboring bodies and as a body politic. What appeared as technical assessments of a community's greatest needs demarcated people as different from a norm defined explicitly here as Western.

Besides being envisioned as a laboratory to investigate and improve the native population, the U.S. colonial Philippines also served as a testing ground for the United States—offering lessons for how to scientifically manage new crises of public health, urbanization, and immigration feared to threaten the stability and progress of American democracy. President W. H. Taft (1912), in his address to the International Hygiene Conference, would credit the Philippines intervention and its demonstration of "successful sanitation under the most burdensome conditions" for "making clear the need of an additional branch of general education in the matter of the hygiene of the home and of the individual" (p. 505). The next section shifts focus to the U.S. mainland to explore how colonial pedagogies became reconfigured in U.S. schools as strategies to differentiate populations and the types of science instruction they most urgently required.

General Science and the Making of Not-Yet-Citizens

> In the Orient everywhere one goes he hears of movements to improve and increase science instruction. It is a world movement, the whole civilized world realizing that the achievements and method of thought of modern science must be possessed by those who would aspire to progress.
>
> —*General Science Quarterly* (Caldwell, 1925, p. 155)

Historiographical conventions often constrain educational histories to developments within the boundaries of a single subject area or nation-state. Under these conventions, U.S.

science education has often been portrayed as a self-contained domain, sealed off from societal concerns or imperial pursuits. Yet early twentieth-century science education scholars traveled extensively, visiting Egypt, China, and a range of schools in other British and U.S. colonies.[128] Through what Pratt (2007) has termed "imperial eyes," these transnational journeys made it possible for U.S. scholars to see themselves as part of a world movement to extend "modern science" from the "civilized world" to "those who would aspire to progress." This notion of science had little to do with the disciplinary sciences or their inquiries at the time into special relativity, marine embryology, or radiometric dating. Instead, U.S. science education took on an explicitly cultural purpose to spread what was stabilized as the "achievements and method of thought of modern science" (see epigraph, above). First among those achievements were the hygienic habits and the method of thought presumed to distinguish American civilization.

Recalling Morrison's (1992) provocation (see chapter 2), I want to ask whether characteristics of U.S. science education that might seem to emanate from a particular Americanness—its goal of fostering independent thought and individual agency through scientific methods, its egalitarian emphasis on making science relevant to populations' varied needs, and its pragmatic focus on designing solutions to local community problems—may in fact have relied on a fabricated Africanist—or in the case of the epigraph above, Orientalist—presence. To what extent did the pedagogical experiments underway in the colonial Philippines provide a model for U.S. science education? This section will compare specific pedagogical

[128] Authors in *GSQ* described travel to British colonies, where General Science was elevated as the "great New Bible" for teaching the "scientific bases and authority for temperance and chastity" (Johnston, 1919, pp. 226, 227). A scholar's trip to British mission schools in China outlined the challenge of adapting instruction to the native environment of the Chinese students (Whitman, 1926). Another's trip to Egypt attested to the difference between "theory-loving" Europeans and "practical" natives who remained "unchanged from the time of Tut-enkh-amen" (Hopkins, 1925, pp. 311, 314).

imperatives, but first I draw on journals of public health and science education to consider how health problems and their pedagogical solutions traveled along imperial circuits.

Transnational circulation of biomedical and educational expertise. Theories of racial hygiene circulated amongst medical researchers in the Philippines and the United States in the early 1900s. In the U.S., notions of the "health menace of alien races" (Nesbitt, 1913, p. 74) posited both biological and anthropological mechanisms for the spread of disease. Just as the body of the Filipino "native" was conceived as an arsenal of parasites, U.S. physicians held that the African origin of hookworm meant that "Negroes" were natural carriers of this "germ of laziness" (see Ettling, 1981). And like concerns over inherited customs in the Philippines, U.S. public health officials articulated fears that "Oriental gardeners everywhere" grew edible plants for public markets in soil mixed with their own excreta, spreading new diseases to "our white population" (Nesbitt, 1913, p. 76). In this new paradigm of pathology, microbes could be translated as universal vectors of disease (e.g., hookworm), while their human carriers were differentially arrayed along developmental trajectories of racial hygiene.

Intertwined with medical diagnoses, pedagogical solutions also circulated transnationally. Previous scholarship has explored how the racialized category of "Negro"—as a type of body and mind cast as requiring white tutelage—produced spaces of equivalence for the spread of U.S. educational expertise, with elements of Negro Industrial Education traveling as templates for schooling in the U.S. colonial Philippines (Coloma, 2009) and in British colonial East Africa (C. Kirchgasler, 2016). Similarly, universalized categories of microbiology (e.g., tuberculosis) gave rise to new spaces of sameness and difference that facilitated movements of biomedical and pedagogical expertise.

One way these circuits have been visualized is through W. Anderson's (2006) analysis of the career pathways of colonial bureaucrats, such as Dr. Allan McLaughlin, who moved from studying the health habits of Italian immigrants in the U.S., to serving as deputy director of health in the Philippines, to become the Massachusetts commissioner of health in 1914. In this new role, McLaughlin's colonial experience indicated the need to survey the physical and mental health of every schoolchild in the state, and to "carry sanitary instruction into the home, especially those of immigrants and minorities" (p. 230).[129] McLaughlin's work as part of a growing school hygiene movement reflected new relations of power and knowledge, where practices for investigating and intervening on the health of the "masses" relied on the production of unhygienic Others as portents of disease, targets of rescue, and object lessons for the curative powers of modern science.

Alongside the school hygiene movement, the new general science course sought to bring a cultural purpose to science education (Massachusetts State Committee on General Science, 1916). Scientific progress, construed as an American cultural inheritance, was perceived as under threat by the nation's other exceptional feature: democratic freedom. Even though in "civilized countries," "we know enough to ban all contagious disease" (Downing, 1925, p. 69), the United States' "gigantic experiment in democracy" appeared to be compromised by the "infusion into our body politic . . . [and] into our public schools of several hundreds of thousands of children possessed of different ideals, different traditions and different inheritance" (Averill, 1918, p. 38). As one scholar explained: "[T]he need of Americanization is not alone confined to the mental attitude of the foreigner, that inasmuch as sound mind accompanies sound body, a large

[129] McLaughlin's career path also demonstrates the circulation of particular practices, where his experiences "at home" and "abroad" emerge as effects of historical modes of reasoning that made the colonial intelligible, while also providing a way to see difference in the United States based on "experience" of the problems of colonial administration.

proportion of Americans are in need of physical and perhaps mental Americanization" (Grier, 1920, p. 47). Instead of fixed boundaries, this statement indicates a somewhat flexible trajectory of Americanization imposed not only on the "foreigner," but also on those already considered "American." Next, I highlight three general science pedagogies that were comparable but not identical to those of the colonial Philippines, and that were articulated as necessary to improve the health of the body politic.

1. Assess local needs. The first priority for general science teachers was to acquire "knowledge of the pupil" by assessing their needs (Quickstad, 1917, p. 159). The demand arose to find an objective basis for selecting and ordering the curriculum. New agencies like the U.S. Public Health Service and state-level Board of Health compiled statistics (e.g., top ten causes of child death), such that by 1913, school medical inspections had gathered an "immense mass of data regarding the defects of school children" (Downing, 1925, p. 93). To make use of this data and collect their own, the "teacher must be a student of Sociology as well as Psychology and Pedagogy" (Elhuff, 1916b, p. 19). Such training would authorize them to conduct "repeated investigations until we can make fairly sure of what are the community needs in science teaching" (Downing, 1925, p. 95).

Techniques like those of the Taytay survey were employed to identify the needs of immigrant groups in U.S. cities. The principles of Chicago School Sociology held that national health data would be insufficient to adapt the curriculum, since each "community" had a distinct set of needs. The sociologist's role was to produce detailed classifications of families by "ethnic-race and nationality" (Jones, 1904, p. 23) in order to identify the "needs" that separated each from the "Anglo-Saxon ideal" (p. 133). Bodily needs ascribed to Italians, for instance, included a "diet too exclusively vegetable to supply necessary nutrition" (p. 72), and difficulty bringing their “muscular systems under discipline,” as when learning to march in kindergarten (p. 89). These examples attest to the cultural peculiarity of what became constituted as “health needs.” Pathology did not inhere within the individual body but was produced by social science techniques. As Rose (1985) points out, the validity of those techniques depended on designating as abnormal those bodies already cast as not fitting within the customs and expectations of societal institutions (e.g., American dietary guidelines emphasizing beef, and school routines like kindergarten marching).

2. Move the lab into the field. A central argument of general science scholars was that the formal laboratories of physics and chemistry were ill-adapted for the urban masses entering high schools. As such, they would need to move the laboratory into homes and communities (Elhuff, 1916b). This extension of the “laboratory” into the “field” drew on discourses of progressive evolutionism (Pauly, 2000), where pupils had become adapted to unhygienic, irrational home environments rather than to standards of American civilization. The home survey, also called a pupil’s score card, became a staple of general science pedagogy to distinguish the needs of each class. It offered a means to collect data on family meals, home conditions, and health habits (Bayer & Clark, 1920; Massachusetts State Committee on General Science, 1917). Each day for a month, students recorded their hygienic routines and home conditions (see Figure 8.2). This was one strategy to foster in each pupil a “tendency to turn his crude experiences over into a more scientific form” (Dewey, 1916, p. 9). In graphing individual and class data, students were to compare their personal habits with statistical averages and scientific norms (e.g., 9 hours of sleep, 1 teeth cleaning per day).

Like the Philippine health index, the score card’s categories were informed by what had already been determined as those defects, traditions, and vices unbefitting of the future citizen. In

Figure 8.2, the “Bad Health Habits” chart demonstrates the merging of medical recommendations, moral judgment, and markers of racial distinction, such as “spitting” and “licking fingers while eating” (habits previously targeted by colonial authorities as “uncivilized” native customs). Likewise, the habit of “sleeping with closed windows” (a concern for tuberculosis) was taken as deriving from an irrational fear of the night air, and was ascribed to both Filipino natives and recent immigrant groups in the United States. Through discourses linking the evolution of civilizations to a scale of racial hygiene, those behaviors and beliefs theorized as standing in the way of “Filipino natives’” proper development could simultaneously function to policy internal boundaries of American civility, rationality, and whiteness.

The pupil’s score card shares common features with the Philippine health index, in that both employ standardized categories of health that also embodied racialized distinctions and cultural values. However, a comparison of these tools also reveals key differences. Where Filipino pupils were assumed to require a more direct teacher’s hand in health inspection (see Figure 8.1), pupils in U.S. comprehensive schools were to engage in more “self-evaluation” through the disembodied categories of the score card (see Figure 8.2). Filling out the card was hoped to offer daily reminders of pupils’ “defects and backslidings” (Bayer & Clark, 1920, p. 420), while seeing the gaps between their own data and the scientific norms was to incite a desire to adopt modern American ways: “When the pupil sees how he looks on paper, a picture not presented by the mirror—this visual presentation carries greater conviction than class room [sic] drill. The mathematical evaluation further speaks with definite and uncompromising forcefulness” (p. 422). The score card and accompanying graphs stabilized certain practices as civilized, scientific, and healthy by projecting others as primitive, superstitious, and dangerous. Yet these culturally laden

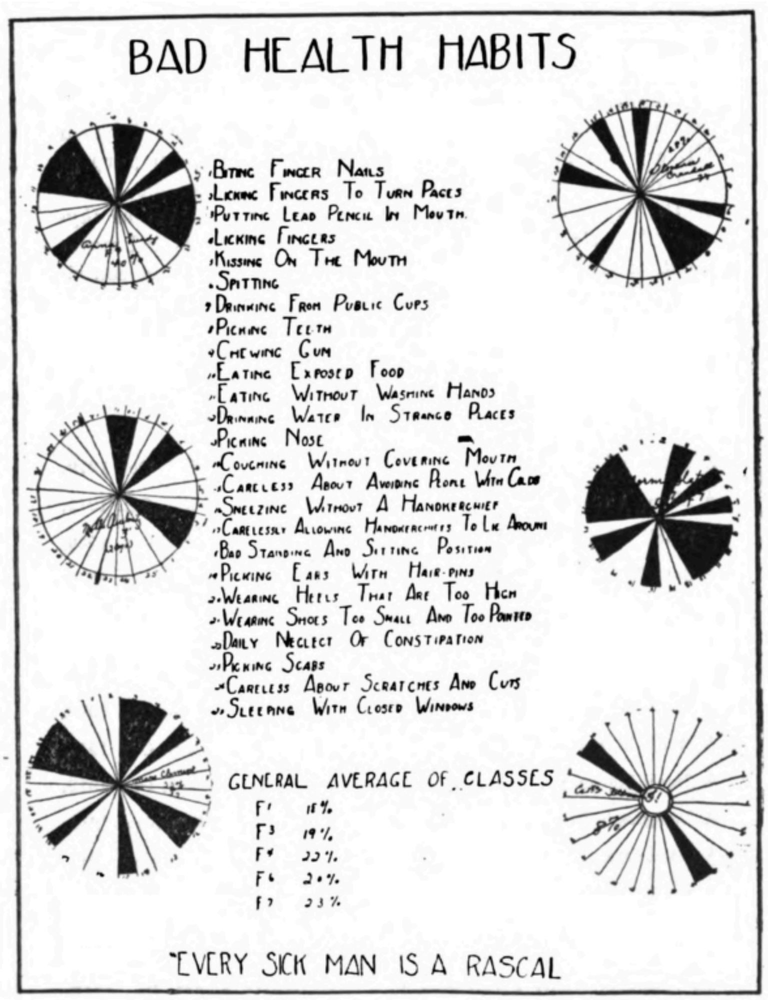
Figure 8.2. A home survey with graphs of class data used in the U.S. general science course (Bayer & Clark, 1920, pp. 419, 426).

CHART I. **Pupil's Score Card.**

Name .... **Date** .... **Age** ....
HEIGHT .... **Normal weight for age** .... **Normal height for weight** ....
WEIGHT .... **Normal height for age** .... **Normal weight for height** ....

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Hrs. *sleep* per day																												
Min. *outdoor exercise*																												
No. of regular *meals*																												
No. of times *teeth* are *cleaned*																												
							1st. wk.							2nd. wk.							3rd. wk.							4th. wk.

BATHS: **No. of sponge or tub baths per week** ....
TEETH appearance; **excellent**.......... **good** .... **fair** .... **poor** ....
Postion of visible cavities ....
Date of last visit to dentist ....; **date of filling of cavities** ....:
HAIR appearance ....; **frequency of washing per year** ....
NAILS. Evidence of biting........; **times cleaned per week**........; **how cleaned**.........................
SLEEPING QUARTERS. No. of windows in room........; **arrangement at night**.............................



judgments were effaced by scientific techniques that presented data as the unmediated speech of mathematics, and as a mirror to directly reflect one's need for reform.

3. Enlist future citizens. The third pedagogical imperative was to instill in future citizens a self-mastery of personal health, along with a duty to enlighten others. Since hygienic habits were acquired in the home, families were held responsible for children's poor health and assumed to require pedagogical intervention as well: "The parents must be taught through the children as far as possible" (Whitman, 1920a, p. 26). Similar to the Philippines, one strategy to reach the parents was engaging pupils in the project method. The pupil's score card would offer teachers a "fund of knowledge" (Brownell, 1917, p. 142) to tailor applied science projects to the pupils' greatest defects. Projects included creating a sanitary survey of their ward, inspecting grocery stores and meat shops, and testing for the presence of germs: "Is it not necessary to plant and grow bacteria and count the increasing colonies in order to really understand why the hands should be washed before eating or why spitting is dangerous?" (Bayer & Clark, 1920, p. 424). Like the toilet-building project, these general science projects sought to stimulate interest by demonstrating the applied nature of science to the family as well as the child. Children could also contribute by creating health posters, posting health slogans on mileposts, and enrolling in clubs like Modern Health Crusaders (Andress & Evans, 1925, pp. 317-322).

To inspire acts of health service, textbooks introduced pupils to a pantheon of "America's noblest citizens" (Andress & Evans, 1925, p. 4). Portraits of scientists (e.g., Dr. Pasteur, Dr. Lister) sat alongside those of colonial medical officers (e.g., General Gorgas, Major Reed), whose victories in saving Havana and Panama from malaria were espoused across general science textbooks as proof of American modernity and enlightened rule (p. 304; see also Elhuff, 1916a; Brownell, 1918). Juxtaposed against these "American health heroes" were their subhuman foes: the "criminal" mosquito from Panama (Andress & Evans, 1925, p. 300), the rat "native of China" that brought the plague to San Francisco (Brownell, 1918, p. 400), and the hookworm living inside poor Southerners who "lack[ed] ambition" to practice healthy habits (p. 402). As these textbooks exhibit, learning science was not just to improve one's knowledge, reasoning, or personal habits. It was also an exercise in what Stoler (2009) terms the "proper distribution of sentiments" (p. 69) toward self and Other—in this case, an admiring identification with U.S. reformers, and a healthy fear and pity toward foreign bodies that must either be contained or cured. These science curricula projected the American citizen as a model of fitness, rationality, self-restraint, and benevolence—notions that relied on what Morrison (1992) calls the "fabricated presence" (p. 3) of pathologized Others in need of diagnosis, tutelage, and rescue.

Importantly, pedagogical imperatives and techniques were not simply transferred between colonial and metropolitan schools, but recalibrated and differentiated along a developmental scale. Those cast as "unassimilated" (Hunter, 1922, p. 526) or not-yet-citizens, such as immigrants from southern and eastern Europe, were matched with pedagogies that began with concrete health habits and eventually built toward developing a scientific attitude and interest in abstract scientific disciplines. Higher up the scale were those projected as already-prepared citizens—"the original stock of the nation" (p. 526). These pupils were still expected to adopt hygienic habits, but such habits were presumed as a natural part of growing up within "careful homes" (Andress & Evans, 1925, p. 248). As such, they were deemed fully capable of self-assessment and pedagogical efforts focused on inspiring a duty to engage in health service toward others, whether in the local county or a far-off colony.[130]

[130] Importantly, articles in *General Science Quarterly* tended to discuss "comprehensive schools" without referring to the existence of segregated institutions such as "Negro Industrial Education" and "Indian Schools." While an analysis of science pedagogies in these schools is beyond the scope of the dissertation, contemporaneous U.S. reports on Negro and Indian education called for modes of external surveillance and enforcement of hygiene

Whether in the colonial Philippines or in general science classrooms, producing germ-free citizens was a civilizing project that made particular cultural norms into signs of mental maturity and prerequisites for self-government. These normative principles differentiated geographical and cultural spaces. In the transnational circulation of pedagogy, some places and peoples "emerge[d] as sites suited for liberal, democratic, participatory politics; others emerge[d] as more appropriately governed through force, authority and the inculcation of habit" (Sobe, 2013, p. 98). The intertwining of bodily disease, scientific attitudes, and civilizational progress would demand that educational intervention go beyond previous boundaries between school and home. Daily life was becoming a site of surveillance, most intensively for those being pathologized and racialized as outside threats to the American public.

Science Literacy and the Making of Not-Yet-Informed Citizens

> An understanding of science, and of science-based technology, is necessary not only for those whose careers depend on it directly, but also for any citizen who wishes to make informed decisions . . . such as maintaining a healthy diet.
>
> —*PISA 2015 Results: Equity and Excellence in Education* (OECD, 2016, p. 2)

In our current moment of real-time data and unremitting health disparities, it may seem untimely to look at the past. Yet historical analysis can offer a useful distance from the present. While notions of health and citizenship have changed substantially in one hundred years, the stakes of their entanglement remain clear in ongoing health care and immigration debates over which bodies deserve public protection and which pose a burden to the country's resources.

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habits that more closely resembled the military-medical interventions in the colonial Philippines. According to one report, health officers in Indian schools were given "large authority to direct and control the sanitary conditions on their respective reservations" (Reel, 1908, p. 24). Teachers were urged to "make frequent visits to homes of pupils, gain the confidence of their parents, [and] impress upon them the importance of observing the laws of hygiene and sanitation" in hopes of "civilizing the adult Indian who has never attended school" (p. 139). Likewise, in Negro Industrial Schools, school nurses were charged with visiting the community to teach "simple lessons of hygiene to all" (Jones, 1917, p. 484), since such top-down inspection and control were seen as necessary "for the better protection of both races" (p. 25).

Certainly, official policy today is unlikely to articulate the problem as a threat from unhygienic foreign races.[131] Nevertheless, as evident in the epigraph, habits of bodily health (e.g., diet) continue to function as indicators of scientific reasoning and informed citizenship.

One important change is that the call to distinguish the needs of various populations is now formulated using concepts that were unavailable in the early twentieth century, such as equity for and inclusion of underrepresented groups. Leveraging science instruction to address public health concerns is now outlined as a strategy to foster a more equitable and inclusive education for students from underrepresented backgrounds (e.g., OECD, 2016). Distinctions in needs are no longer articulated as natural or hereditary, but as by-products of social marginalization, which educators must recognize and redress. Paradigmatic is the recommendation that teachers use obesity and type 2 diabetes as topics to make science instruction more culturally relevant for students of color (for a review, see J. Brown, 2017). The aspiration is that merging science and health education for these underrepresented groups can close achievement gaps, address health disparities, and empower students as change agents in their families and communities.

Rather than question the intentions behind that aspiration, I want to stay at its surface to examine the scientific and administrative practices that make it both thinkable as a problem-solving strategy and actionable as classroom pedagogy. Such practices tend to operate without debate, precisely because they constitute the technical details of what it means to teach science and to differentiate instruction. This section juxtaposes past and present to draw attention to those technical details of pedagogy. I draw examples from recent science education policy

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[131] Cf., see Horton and Barker (2009) for an ethnographic study of how oral-hygiene campaigns targeting a Mexican migrant farmworking community in California's Central Valley function to racialize Mexican immigrant parents and shape the substance of their citizenship. Their analysis suggests that "the recent concern with Mexican immigrant children's oral health blends classic eugenic concerns in public health with neoliberal concerns regarding different immigrant groups' capacity for self-governance" (p. 784).

(NGSS) and classroom practice (AHS) into conversation with the pedagogies already outlined from the early 1900s colonial Philippines and general science course. The purpose is to spark dialogue about a different layer of politics than is typically discussed. This layer of politics, separate from ideology or intent, rests in the tools by which students' needs are visualized, filtered, and prioritized in the name of public health and citizenship.

1. Assess local, immediate needs. The first pedagogical imperative—to assess local needs—is considered especially important today for non-dominant racial and ethnic groups, for whom traditional school science is characterized as too decontextualized. As a first step to make science relevant to these groups, the NGSS' Framework (NRC, 2012) recommends studying "local community health practices" (p. 285). Connecting science to everyday concerns—e.g., discussing the health dangers of high fructose corn syrup—appears as a strategy to "motivate" non-dominant racial and ethnic groups (NGSS Lead States, 2013c, p. 1). In these ways, the standards encourage teachers and researchers to make diversity visible through a specific assembly of practices to differentiate instruction for non-dominant groups by using ethnographic and public health data to identify problems (often health-related) that science learning could potentially solve.

Likewise, the tracked science courses at AHS generate a demand for teachers to divide students by those needing preparation for higher education versus for health and everyday citizenship. As discussed in chapter 7, a hierarchy of needs orders immediate needs as a prerequisite for future needs, but also as characterizing distinct types of students. Part of what constitutes professional expertise—not just at AHS, but in the broader "culture" of U.S. education—is learning the rules to assess where a student falls on this hierarchy. That expertise was called upon to guide AHS students in "self-selecting" which science course would best meet their needs.[132] In deciding which students required higher-level courses, it appeared necessary to predict which were future scientists, or at least headed to a four-year college or university.[133] For students identified as college-bound, the needs assessment could end there, as the rigidity of the curriculum obviated any further inquiry into those students' homes or communities.[134]

But for others, regarded as less likely to pursue science in the future, the focus could shift to improving students' present lives. As one teacher described, "It's using the curriculum to do something significant versus just teaching content, which is to a great degree what we as science teachers have done" (Interview KC, 2014). Following the principles of learner-centered pedagogy, this shift could be understood as progressive, both in the sense that it represented progress over past methods of instruction (i.e., "just teaching content"), and in the sense of fostering meaningful progress in students' out-of-school lives (i.e., "to do something significant"). These principles prescribed distinct modes of action and reflection for lower-level courses, altering the criteria by which one could recognize oneself as properly pedagogical in those spaces. Demonstrating knowledge of student diversity and skill in curricular differentiation meant assessing students' homes and communities. Teachers of lower-level courses described a responsibility to continually research topics to demonstrate how science related to local concerns. The point was to identify what was significant from the standpoint of improving their

[132] AHS teachers were expected to provide guidance during the course selection process even if the district no longer permitted these recommendations to serve as gatekeepers. Nevertheless, administrative practices made it possible to "re-route" students to a more suitable course level after they had submitted their course requests, as well as to assist students who seemed to be "misplaced" to change to a different course during the semester (see chapter 5).

[133] As discussed in chapter 7, such predictions were informed by asking directly about students' career plans, or inferring based on their standardized test scores and perceptions of their life situation (e.g., parental expectations, financial resources, or immigration status).

[134] As discussed in chapter 7, higher-level courses were considered either constrained by external demands (e.g., the contents of the Advanced Placement test), or, in a more positive light, committed to maintaining the "integrity" of the subject matter as a rigorous body of organized knowledge and skills. The organization of that subject matter was not only a subset of logically organized disciplinary knowledge. Even the subject matter upheld as more "abstract" relied on psychological and pedagogical theories of the ideal child and citizen that were not reducible to the disciplinary sciences.

science literacy, health, or "community-readiness."[135] Many resources were available to guide this needs assessment, including conversations with students (e.g., an offhand question about marijuana's side effects), curricular reforms (e.g., the textbook *Chemistry in the Community*), and public health data (e.g., vaccination rates by demographic group).[136] Any of these resources might reveal topics, especially in the realms of health and safety, which could satisfy criteria of scientific relevance, everyday significance, and actionability.

This chapter has argued that the demand to assess students along a hierarchy of needs is not an invention of NGSS authors or AHS educators. Moreover, the early 1900s uses of the Taytay survey, sociological studies, and public health statistics highlight the politics of knowledge at stake whenever data appear as objective indicators of health risks for differentiating instruction by demographic group. Even if theories of disease-carrying racial stocks have been long since rejected, recent scholarship highlights the danger of race becoming re-biologized today as a statistically useful indicator of health risks (Epstein, 2007; Hacking, 2005; Roberts, 2011). Those classified as "low-performing at-risk groups" (NGSS Lead States, 2013a, p. 370) are positioned as doubly at-risk—in danger not only of falling beyond benchmarks of science literacy, but also of making poor health choices that might endanger the public and themselves. This trend is evident in pedagogical reforms ascribing the obesity epidemic to the "lifestyle choices" of racialized groups, rather than to environmental racism or unequal access to quality health care (Wright & Harwood, 2009; see also Krieger & Bassett,

[135] As discussed in chapter 3, a stated mission at AHS was ensuring that all students became college-, career-, and community-ready, but these aims were not evenly distributed, but ordered along a hierarchy that corresponded with the science course organization: from community-readiness and scientific literacy up to college-readiness and advanced science coursework.

[136] Importantly, the resources and data became assembled within an existing organization of hierarchical tracks. Even when public health data indicated that the vaccination rate might be equally problematic among the very "educated" and the "extremely poor," the aims of improving students' scientific literacy and making families better informed only seemed to match the overarching objectives of the lower-level Biology 2 course, and not the higher-level Anatomy & Physiology course (Meeting fieldnotes, 2013).

1993). The imperative to identify science-related problems in an actionable way—i.e., such that learning science in school could feasibly solve them—may exacerbate the tendency to impute health disparities to ill-informed choices and individualized responsibility. The category of "needs" continues to be treated as a neutral descriptor of biomedical and educational science, rather than a porous container of cultural theses regarding who is assumed capable of making their own decisions, versus who requires explicit instruction in everyday matters.

2. Move the lab into some homes and neighborhoods. The second pedagogical imperative—to move the lab into the field—is now discussed as a commitment to redress unequal cultural representation by treating the lives of marginalized groups as worthy of scientific inquiry. However, as Epstein (2007) has observed, the 1980s movement to include women and communities of color in biomedical research rested on the assertion that prior research had left those groups underrepresented by predominantly studying the white, college-aged male. What this narrative misses, Epstein argues, is a long history of biomedical research investigating and experimenting on the bodies of women and of enslaved and colonized peoples. Likewise, this chapter's analysis suggests that the move to extend the laboratory into the everyday lives of pupils as sites of inquiry, data collection, and curricular projects emerged within settings where target populations were projected as furthest from norms of science, medicine, and civility, and thus as in greater need of surveillance.

The NGSS recommend pedagogies of self-documentation to bridge home and school for non-dominant racial and ethnic groups. These include a "nonevaluative home survey related to science content" (NGSS Lead States, 2013a, p. 366), outlined as part of an effort to value the daily practices and cultural knowledge of non-dominant groups. For instance, the case study for "race/ethnicity" gives the example of asking students to "generate a list of food items in their homes that had corn as one of the ingredients" (NGSS Lead States 2013c, p. 3). Devices like the home survey are to help teachers filter students' "funds of knowledge" for "connections and disconnections between home/community and classroom/school" (NGSS Lead States, 2013a, p. 364):

> By bringing the neighborhood and community into the science classroom, students learn that science is not only applicable to events in the classroom, but it also extends to what they experience in their homes and what they observe in their communities. (p. 367)

However, the logic of this statement bears little resemblance to a bridge between two equally valued ways of knowing, or to Moll and colleagues' (1992) notion of funds of knowledge as "intellectual resources" to learn from families (p. 132). The logic more closely resembles Latour's (1983) account of scientists bringing raw material from the field into the lab to demonstrate to a suspicious population that the intellectual findings of the lab extend to the field as well. While the NGSS explicitly reject older deficit and essentializing approaches to culture, the teleology remains unidirectional, with the goal of helping students "transition from their naïve conceptions of the world to more scientifically based conceptions" (NGSS Lead States, 2013a, p. 363).

Similarly, lower-level science courses at AHS employed pedagogies of self-documentation to demonstrate the applicability of science to problems of daily life. Take, for instance, the *Chemistry in the Community* textbook that features units on water, industry, and food (American Chemical Society, 2002). Narratives of hypothetical municipalities are interwoven with "Making Decisions" activities—personalized tasks asking students to keep daily records and recruit family members to complete home surveys for analysis in class. The Food unit, for instance, instructs students to inspect ingredients from "several food packages in your home" (p. 519), and compare a "three-day food inventory to the recommended servings indicated in the Food Guide Pyramid" (p. 488). These activities seek to motivate students to gain the chemistry background needed to "make good dietary choices" and understand "how decisions about eating can affect body weight" (p. 488). The goal is not only to improve students' scientific literacy for personal use, but also as prospective citizens: "As a future voter, you can bring your chemical knowledge to decisions that require it" (p. iii). The personalized, applied approach of *Chemistry in the Community* stands in stark contrast to that of the textbook used in the higher-level chemistry course.[137]

Whereas *Chemistry in the Community* offers molecular modeling as a special feature (e.g., a box on Kinetic Molecular Theory (p. 269)), *Chemistry: Principles and Reactions* offers "Beyond the Classroom" as its special feature, pulled out from the rest of the text (Masterson, Hurley, & Neth, 2012). The purpose of going "Beyond the Classroom" is narrowly circumscribed:

> It is a self-contained essay that illustrates a current example either of chemistry in use in the world or an area of chemical research. It does not intrude into the explanation of the concepts, so it won't distract you. But we promise that those essays—if you read them—will make you more scientifically literate. (p. xxiii)

For students in this higher-level chemistry course, consideration of how science applies beyond the classroom is the exception to the rule—a self-contained feature and a potential distraction from the core principles of chemistry. The aim of becoming "more scientifically literate" is not a

[137] Again, significant here is that both textbook designers of *Chemistry in the Community* reform and AHS teachers discuss this contrast as a good thing. The argument is that applying science to everyday life is a more progressive form of pedagogy than the older methods of content transmission that tend to characterize higher-level courses. Importantly, however, this pedagogy is not considered better for all students, but only for those with less "future needs" and greater "immediate needs" (see chapter 7). *Chemistry in the Community*, recall, was designed for the "'nonscience major' component of our citizenry" (Sutman & Bruce, 1992, p. 564). Its goodness, then, was conceptualized in the matching of pedagogical aims to the distinct needs, interests, and readiness ascribed to a particular population of students.

priority for the textbook's target audience (i.e., "if" they read those sections). There is no corresponding effort to have those in higher-level courses record their daily nutrition, or involve their parents in home surveys to identify areas where they could make more educated decisions.

The early 1900s health index and pupil's score card underscore the politics of visibility. What could be most easily noticed in the home were those practices already theorized as different from a cultural norm and exigent from the standpoint of health. What became visible in daily records was not the children's knowledge or the family's intellectual resources, but ratings of the degree to which pupils and their parents carried out prescribed duties of health and home. When theories of cultural competence (Ladson-Billings, 2014) travel into science education, a danger is that the competence of families' cultural practices will continue to be held up to scrutiny against school science standards and official health guidelines—themselves assumed to have transcended culture. Counter to the aims of culturally sustaining pedagogy (Paris & Alim, 2014), what may appear most readily as relevant in the science classroom are precisely those practices deemed too risky to sustain (e.g., fast food consumption), as universalized health norms trump efforts to value cultural pluralism.

3. Empower youth as change agents in their families and communities. The third pedagogical imperative—to enlist future citizens—is outlined today as the need to empower youth as change agents in their families and communities. For non-dominant racial and ethnic groups, the NGSS (2013a) recommend project-based science learning to "engage students in defining problems and designing solutions of community projects in their neighborhoods (typically engineering)" (p. 366). The aim is that through these projects, students who have traditionally been alienated from science can "develop agency in science" (p. 366). The NGSS also suggest giving students from non-dominant groups "homework assignments that invite joint participation of the child and parent" in order to "increase interest among both parents and students" (p. 366). A concern is that these modes of empowering the child simultaneously implicate the family as not instilling sufficient interest or agency in science. Likewise, they position certain communities as having problems that could have been solved, provided that residents were to engage in a logical problem-solving approach like the engineering design process.

Likewise, at AHS, lower-level courses were more likely to engage students in projects applying science to their home lives. As discussed in chapter 5, one strategy for making science relevant in Biology 2 was to ask students to persuade their family about the importance of vaccination. The unit's essential question was, "What would you say to a family member to convince them that getting vaccinated was a good idea if they were resistant to the idea? Use data from the CDC" (Classroom fieldnotes, 2014). This driving question made sense within a grid of pedagogical principles. For students who were below benchmark on standardized tests, analyzing vaccination graphs provided an opportunity to "catch kids up, support their skills, . . . [and] focus more on data and science process from a simplistic point of view" (Interview KC, 2014). Part of what made this activity make sense, then, was the ordering strategy of Readiness: it matched what the standardized test data indicated about the class, that "here's what most of them can handle" (Interview KC, 2014).

Not only did the Biology 2 activity "personalize the task," which "makes it a little easier for them to write about," it also focused on an issue of "social drama" as "a way to motivate them. You know, it's like, 'They shouldn't make you get a shot!' You know, but why would they want to? And then examine the reasoning and then look at data that seem to support that" (Interview KC, 2014). Another advantage of this activity, then, relied on distinctions produced by the ordering strategy of Interest in science. The social drama—which in the higher-level textbook cited above would have been considered a "distraction" from the scientific concepts—was here deemed necessary in order to pull students into an examination of data and reasoning about health presumed as unfamiliar in their households.

Early 1900s pedagogies illustrate the politics and ethics of subjectification, as becoming recognized as a modern, enlightened subject required subjecting oneself to routines of self-assessment and self-discipline. Through building toilets, counting bacterial colonies, and creating nutritional posters, children and their families were differentially compelled to prove their capacity for scientific reasoning via compliance with, and advocacy of, culturally peculiar habits of health. In today's efforts to empower marginalized groups and transform local communities, what new responsibilities are levied as criteria for demonstrating one's scientific literacy and civic potential? As health topics gain traction as a way to make science education more culturally relevant, new modes of analysis will be required to account for multiple, overlapping forms of power—including biopower. In well-intentioned efforts to respond to the needs of "diverse groups," the question is whether and how such reforms may inadvertently rely on pre-existing practices like those studied here, which produce difference by mapping populations along trajectories of biomedical citizenship.

Chapter 9. Turning the Current Model of Student Diversity into a Matter of Concern

> We try to address [diversity] with as much data as possible, so that we are not basing whatever decisions we make on made-up things. I think we're trying to find something we can stand on. . . . We can try things that we can measure against that and see if they work or not. But if we can't find any point that is solid, a single fact that we can base things off of, anything that we try, we won't have anything to compare it to.
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> —AHS science educator (Interview IY, 2015)

> When someone asks me [which course to sign up for], I can see that you're a white girl, and I answer the way I've answered to plenty of white girls in my past. I can't completely be unbiased, as much as I try, and I'm sure that creeps in. . . . It's also kind of a hot-button question—that if someone comes to me and says, you know, you're racist, then I'm suddenly defensive. But I have to admit that I must be. We all are. We all see the other person and we make some subliminal judgments about them. We're not computers. . . . But then the scientist in us wants to be like, okay, so then what's the answer? . . . Because here they're trying to make a mathematical model out of something that might not be able to be modeled in that manner. There's data we can react to. But how would a scientist relate to this—and should we be relating to it like a scientist would?
>
> —AHS science educator (Interview TN, 2015)

Two approaches to addressing racial disparities in education are usually positioned as opposites: objective data to confront personal bias, or teacher reflexivity to confront biased data. The first approach demands objectivity through data-driven decision making. Accountability policies call for statistical disaggregation of outcomes on externally validated metrics to override individual bias and inform instruction. The teacher must learn to seek data in an effort to "find something we can stand on" (see first epigraph, above). Numbers verify comparisons of past versus present (e.g., calculating pre-test/post-test), teacher versus teacher (i.e., rating educator effectiveness), and subgroup versus subgroup (i.e., closing gaps). In this formulation, the issue of diversity in education demands mechanical objectivity (Porter, 1995), and "as much data as possible."

The second approach demands instead an explicit focus on the subjectivity of the teacher. Efforts to turn diversity into a "mathematical model" are rendered suspect if the human beings generating and reacting to that data are making "subliminal judgments" (see second epigraph, above). The teacher must learn to recognize and confess their racial and gender biases as a deeply ingrained human failing: "We're not computers."[138] This formulation rejects the positivism of mechanical objectivity, and instead aims to unearth, interpret, and transform teachers' preconceived notions and defensive attitudes. Nevertheless, both approaches inscribe a divide between computers and humans, between data and "made-up things." Data use technologies are either promoted or rejected as Other to the teacher.

The danger of this dichotomy is that it misses the ways the teacher (and no less, the policymaker or the researcher) is already cyborg (e.g., Haraway, 1991). Public discourse and scholarly debate focus on what appears timely, like online testing or galvanic skin response detectors for measuring student engagement. Meanwhile, other technologies go undetected and unremarked. These include: psychological constructs of engagement and motivation; standardized instruments of science achievement; curricular standards, developmental stage theories, and hierarchies of need. Put another way, only certain technologies rise to the level of visible and remarkable newness, while others are already so integrated into the making of the teacher that they do not appear as theoretical lenses or technologies at all, but as the pragmatic

[138] For a discussion of teacher evaluation rubrics as a Foucauldian confessional, see Popkewitz and C. Kirchgasler (2014).

problems of teaching (see chapter 1). To borrow from Hayles (1999), we have "already become posthuman" (p. xiv).[139]

Advocates and critics alike characterize data-driven decision making as a new arrival into education. For those emphasizing the promise of data-driven reforms, the narrative that the technologies and routines came out of the rapidly evolving business world is a boon for an outdated educational bureaucracy (e.g., Piety, 2013). For those concerned with the explosion of private interests in school reforms, the corporate origin story of data-driven reforms confirms their contaminating threat to the humanist legacy of public education (e.g., Sleeter, 2007). Rather than contrasting objective data with biased teachers (e.g., the need for teacher data literacy in Mandinach & Gummer, 2016), or conversely, teachers' professional expertise with biased test data (e.g., weapons of math destruction in O'Neil, 2016), this study has sought to account for the rules of perception that govern both instruments and teachers' experience, and the ways that each has informed the other. The analysis reminds us that practices of educational data use and accompanying calls to turn education into a science have, in some form, been part of the infrastructure of U.S. schooling for at least a century.

Untimely Questions and the Historical Fabrication of Researcher/Teacher

The conventional rules of educational scholarship treat research and teaching asymmetrically. The words of researchers appear as citations in literature reviews, or in discussion sections testifying to the validity or significance of the author's argument. In contrast, teachers' words, confined to the findings section, testify for or against them as individuals.

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[139] Hayles (1999) explains:

> If "human essence is freedom from the wills of others," the posthuman is "post" not because it is necessarily unfree but because there is no *a priori* way to identify a self-will that can be clearly distinguished from an other-will. . . . [I]t is important to recognize that the construction of the posthuman does not require the subject to be a literal cyborg. Whether or not interventions have been made on the body, new models of subjectivity emerging from such fields as cognitive science and artificial life imply that even a biologically unaltered *Homo sapiens* counts as posthuman. The defining characteristics involve the construction of subjectivity, not the presence of nonbiological components. (p. 4).

Teachers' words become evidence of their own beliefs and biographies, revealing one's level of appreciation for research-based practice or one's degree of agency in contesting an inequitable system (see appendix G). This study has attempted to treat the statements of researchers, policymakers, and teachers in a more symmetrical fashion by foregrounding the fact that, regardless of one's professional title, the conditions that make a statement possible to think and say are historical in nature.

The previous chapters have examined some of the rules for saying what is good, true, or practical. These rules govern how people can generate statements that "make sense" in their time and place. It would sound equally unintelligible for a teacher, psychologist, or educational scholar in 1916 to call for closing achievement gaps or fostering STEM-engaged citizens to compete in the global economy. Likewise, it would be equally bizarre to hear a researcher or science teacher today calling for dissolving the evils of modern civilization by teaching science for purity, self-restraint, and race preservation. The rules for seeing and sorting difference precede the entrance of individual actors—and in fact, provide the means for making oneself into a certain kind of person—and yet do not remain the same.

The study contributes to a wider literature seeking to bring into view the historical fabrication of the teacher as a kind of person (Popkewitz, Diaz, & C. Kirchgasler, 2017). This literature includes the making of: the post-WWII U.S. progressive educator (Lesko & Niccolini, 2016), the urban/rural teacher in Teach for America that is not exclusive to that program (Popkewitz, 1998/2017), the African American male teacher as role model (A. Brown, 2012), the reform U.S. math teacher (Diaz, 2017), the up-lifting environmental educator in Sweden (Ideland, 2017), the Chinese teacher with Confucian *shide* and competitive expertise (Zhao, 2017), and the teacher as researcher in Finland (Sitomaniemi-San, 2015). I have argued that ordering strategies of Readiness, Interest, and Needs have been integral to the making of the good, modern U.S. science teacher of the 1920s, as well as the equitable, data-driven U.S. science teacher today. This approach prompts an inversion—from studying which subjects produce difference (e.g., teachers, administrators, test designers), to examining how difference from sameness produces subjects (e.g., principles and practices making up different kinds of teachers and students as ways of being and being seen).

The difficulty in apprehending how one's vision and experiences are historically mediated demands an approach that Paul Rabinow (2009) has called *untimely*: ill-timed, unreasonable, and inopportune. The study interrupts the typical chronology of science education research making incremental progress in discovering how students learn science (differently), and how to redress the dis/parities identified in their minds, attitudes, and home lives. This approach may be read as unreasonable, failing to oblige the limits of what may be questioned and what must be conserved. It risks appearing inopportune in a funding climate that demands scalability, or a political climate that insists on clear binaries of identity and representation. The point of investigating how ordering strategies came to appear reasonable is to suggest a release from these obligations and an opening for new ways of exploring pressing ethicopolitical concerns.

Recognizing Indeterminacy and Resuspending Made-Up Things

If I return to the fear of basing human sorting decisions on "made-up things" (see first epigraph, above), this notion of "made-up" presumes a clear divide between fact and fiction, reality and illusion. Such a distinction is invoked when educators contrast a course placement decision that is "racially or ethnically motivated" versus one that is "just looking at students in general who were not that motivated in science" (Interview NM, 2015). Similarly, curricular standards reject "biased stereotypes" about the interests of demographic groups, but insist that teachers should keep in mind "factors that may motivate or fail to motivate students from particular demographic groups" (NGSS Lead States, 2013a, p. 279). These statements illustrate a logic that underscores the social construction of race and ethnicity as "made-up things," such that curricular differentiation should not be based on these fictional stereotypes but instead on "real" differences in how students learn: cognitive development, math readiness, interest, motivation, learning style, needs, and so on. While inscribed at the level of the individual mind, these distinctions are permitted to correlate statistically (e.g., "in general" or "factors") with demographic categories acknowledged as made-up.

The issue here is that student diversity has become formulated as a problem of *epistemological uncertainty* rather than *ontological indeterminacy* (Schrader, 2010). Epistemological uncertainty suggests that we do not know yet. The absence of consensus in the field is attributed to gaps in scientific knowledge of how different students learn. The NGSS biomedicalize student diversity as composed of different treatment groups. The model of epistemological uncertainty presupposes the existence of different kinds of learners who should be matched with distinct effective practices. This approach demands finer and finer distinctions through research and development (R&D) on what precise factors can predict which teaching practices will be most effective.[140] As Schrader notes, "the very idea of an epistemological

[140] In the NGSS, race and ethnicity are discussed as sociopolitical rather than biological categories (e.g., "non-dominant" groups), and the dangers of essentializing are acknowledged. The ideal, comparable to personalized medicine, is given as individualized instruction. In a phenomenon Epstein (2007) calls "niche standardization," since R&D has not yet evolved to being able to identify and match each individual's biomedical (or in this case, pedagogical) needs, socially salient categories like race and gender are positioned as useful mid-points on a trajectory from universalism to personalization. Specifically, the NGSS adopt a biomedical model of disability as paradigmatic of how to specify further distinctions within racial and ethnic groups. The standards draw an analogy between subgroups of "Mexican Americans, Puerto Ricans, and Cuban Americans" within "Hispanic," to the relationship between lumping "learning disabled" and "emotionally disturbed" within "students with disabilities" (NGSS Lead States, 2013a, p. 370). Further inquiry could explore the genealogy of how the biomedical model of

uncertainty presupposes an *a priori* separation of the epistemological question 'how we know' from the ontological status of 'what we know,' where only the former, that is, our knowledge, is allowed to vary" (p. 277). The notion of uncertainty obscures how attempts to produce knowledge about those presupposed as different *act* on both knowers and known, generating new ways of being and being seen as a teacher or student.

In contrast, Schrader (2010) proposes recognizing *ontological indeterminacy*—how the "means of science affect that which it studies" (p. 279). Ontological indeterminacy "challenges conventional notions of causality that seek to establish a connection between independent events in linear time" (p. 275). This resonates with Hacking's (2007) notion of looping effects. Those diagnosed as distinct kinds of human beings become moving targets as efforts to know and administer their difference have material impacts on those individuals and the ways they are seen and treated. The advantage of being in the middle of things (Rabinow, 2008) at AHS was to note the ways in which "kinds" of science learners never achieved a stable identity but emerged through entangled ordering strategies and a play of differences within indeterminate situations. "Phy-Sci kids," "Math Physics Kids," "Bio 2 kids," and "AP kids" manifest themselves as fabrications (Popkewitz, 2008): *made up*, fictions imposed on the world, but simultaneously *made into* reality.

I can also think of the made-up-ness of each element in what Horn (2007) terms the Mismatch Problem. This includes the made-up-ness (or alchemy) of science as a school subject, but also the populational reasoning that makes up demographic categories, and of the U.S. social and biomedical sciences that generate objects (e.g., interest, cognition, health literacy) with which to classify and administer human kinds. The study has argued that school science—as

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disability entered science education as an assembly of theories and techniques for formulating the pedagogical "problem" of student diversity in cultural, linguistic, racial, and ethnic terms.

stabilized in curricular standards, learning progressions, and standardized test data—should not be conflated with the work of research scientists. Because of the transformations taking place in the pedagogical editing room (see chapter 1), the act of making diversity visible is never neutral.

As ordering strategies, Readiness, Interest, and Needs work together to foreclose deliberation about the relationship between science, culture, schooling, power, and injustice. Who would advocate that students receive a developmentally inappropriate curriculum? Who would want to decrease students' interest in science? Who would advocate for dismissing what a student needs, or giving them a needless, irrelevant education? It appears fundamentally inequitable to not attempt to redress a difference so construed: to be an underperforming, low-interest, or high-needs student is to be in trouble—a status that troubles the professional educator to act.

What has often been left unscrutinized is how these categories retain many of their earlier design features. Readiness, Interest, and Needs remain individualizing attributes that vary in degree and are unevenly distributed. The past is not repeated, but partial reiterations appear at the level of the practices that enclose and order populations by differences located in the child's mind, attitude, bodily health, and home. Despite key shifts over the past century, tools to classify learners as distinct types retain norms and principles that gender and racialize some people as less "scientific" than others, and as requiring surveillance, intervention, and transformation. Efforts to promote inclusion, equality, and justice are undermined by historically available theories and techniques that classify some backgrounds and experiences as further from the norms given as universal skills, scientific practices, and objective methods of reasoning for daily life.

What then to do with Readiness, Interest, and Needs? If I think of them as having precipitated out of a confluence of historical conditions (see chapter 6), then can these strange precipitates be recrystallized to remove biases and obtain more objective measures? I have argued that these constructs do not correspond to timeless traits of human nature. Because each materializes as an object of research and reform, attempts to measure “it” will inevitably rely upon historically available theories and techniques that help produce the distinctions they purport to discover (Danziger, 1997). Drawing on Barad’s (1998) notion of intra/activity, they can be thought of as agential cuts, producing a variety of non-neutral effects, making up both observer and observed. Historical assumptions of human difference are not contaminants that can be simply scrubbed away—either in efforts to remove biased test items or to retrain biased teachers. They are principles organizing both institutional practices and pedagogical imperatives of differentiation.

Another possible response might to add Readiness, Interest, and Needs to a list of hazardous research products, alongside IQ or cultural deprivation, that should be removed from educational discourse. Yet, the problem is not in the words themselves. Consider how the NGSS embrace a shift from a deficit- to an asset-based approach (NGSS Lead States, 2013a, p. 366), and never use the term unmotivated. Nevertheless, the logic remains that certain subgroups require strategies to motivate them. The problem, then, is not with each term itself, but with the ordering strategies that have made “it” appear, differentiating kinds of children and curricula. Even if one “dangerous” term were removed (e.g., ability), other classifications persist and new modes of difference-making continue to precipitate out of solution: achievement, worldview, metacognitive behavior, disciplinary dispositions, science-related identities, modeling performances, critical science or mathematical agency, creative literacy, and so on.

This study builds on a wide range of perspectives from outside the field (see chapter 2) to ask how the theories and instruments we inherit have social and political histories of their own that may subvert the intentions we bring to their use. There is a need to better understand the power relations that create what Butler (2011) calls an "exclusionary matrix by which subjects are formed [that] requires the simultaneous production of a domain of abject beings" (p. 3). This is to examine the "grid of discourses and distinctions through which students are seen and are asked to see themselves" (Popkewitz, 1998/2017, p. 31), and onto which students are projected and asked to "self"-determine where they belong. A complex solution of categories and distinctions diffuse across high school classrooms, teacher education, policy, and research, which cannot be reduced to deficit thinking. The concern for deficit thinking focuses on negative labels affixed to stable demographic categories, but this misses how difference is ordered in comparative terms through normalizing distinctions, sliding scales, universalized standards, humanitarian imperatives, and perpetual deferments.

The point of historicizing the making of difference in science education is to "refuse prescriptive closures" (Chen, 2012, p. 237), opening space for new questions and possibilities. What else can be imagined as good, valuable, or just in science education? Adopting a deciphering approach to the making of difference is to refuse *a priori* ontologies of race and gender. These ontologies continue to be reinscribed, correlated with psychological and sociological distinctions, and marginalized as student-level variables that must be accommodated within a system that still imagines itself as natural, normal, and neutral. This is not a call to abandon all identity categories, educational theories, or research methods. It is to ask what each of these moves—which establishes foundations for thinking, speaking, and acting—"*authorizes*, and what precisely it excludes or forecloses" (Butler, 1993, p. 7). In *Bodies that Matter,* Butler

(2011) clarifies that her argument is not against using terms like woman or queer, but to insist on an "inquiry into their formation" (p. 174). In the case of ordering strategies like Readiness, Interest, and Needs, my study suggests that we treat these tools of research and pedagogy not as natural givens but as products of human history. This demands care in considering the "exclusionary operations of their own production" (p. 174). It also requires vigilance toward their continual reinvention and toward the protean nature of social hierarchies that make up racialized, gendered, and ableized human kinds.

Questioning the grounds on which the dividing practices of school science stand may produce discomfort and uncertainty. Becoming a teacher or educational researcher today is to be disciplined in what is reasonable and valid to see, say, and do. Part of this discipline is learning to demand objective data and prescriptive solutions that can offer a sense of moral assurance and professional expertise: "to find something we can stand on" (see first epigraph, above). Opening up the black boxes (see chapter 1) is to demonstrate how the ground on which our ordering strategies stand is already unstable. This study has attempted to "wear away certain self-evidences," and "to bring it about, along with many others, that certain phrases cannot be spoken so lightly, certain acts no longer, or at least no longer so unhesitatingly, performed" (Foucault, 1991, p. 83). There is a difference between uncertainty and stasis. Destabilizing the common sense does not paralyze the practitioner (Foucault, 1991).[141] On the contrary, it provokes the

[141] Consider excerpts from one interview, where an AHS teacher is grappling with what counts as data, how coursework is divided, whether the NGSS can provide guidance about closing achievement gaps, and what counts as science in international comparisons:

> This is all numerical data. It's all numerical. And what is the significance of the 6-point increase in graduation? I don't know. I feel like I'm saying it, just like, "Oh it's significant! A 6 point increase." . . . Even just thinking about like, should you have homework in school? I don't know. It's something I think about. Or chatting with other teachers, like honors-level homework loads versus non-honors-level homework loads. And I'm like, what is the deal with that? . . . And just thinking about, what's the difference between Biology and Biology Honors? [The levels] don't make sense to me. I don't know what the meaning of the differences are. . . . I don't know why we need Honors. And I've always been confused about General Physics versus Math Physics. Because all of physics involves math. So I don't know what Math Physics is. Physical Science is at least gone now. That's

political and ethical deliberation that tends to be anesthetized by treating equity as a technical problem.

This is to take what has been formulated as a matter of fact, and turn it back into a matter of concern (Latour, 2004). One concern, for instance, is how the demarcation of local contexts and social activism as compensatory strategies for non-dominant groups (Feinstein & K. Kirchgasler, 2015) leaves so-called "mainstream" students to receive a reductive view of the sociopolitical implications of science. In the demand to stratify science coursework to meet the needs of two allegedly distinct populations, what alternatives have been foreclosed by having to maintain a distance between the study of "abstract" principles and "real-world" applications?

The act of resuspending the presuppositions of Readiness, Interest, and Needs does not yield clear answers or practical solutions. But it does work toward freeing up ethicopolitical dilemmas as more than technical matters of effective practices, and as exceeding the jurisdiction of a few scientists and educational scholars. On what grounds should it be decided what type of science education a person or group of people requires or deserves? What problems are worth discussing in science class? What counts as knowledge? What or whom is schooling for? What is democratic, inclusive, or just?

> Earth Science now. But apparently, Earth Science is turning into the new Physical Science from what I hear . . . I need more data. Why are they ending up there – is that equitable? . . . I don't know who decides what bucket kids get put in. . . . That's what I like about Next Gen Science Standards. It's all research based. Like they have the data and show the gaps. But if I knew about strategies to use! . . . I don't even know what test that we take that they're using to compare different countries' math and science scores and we're always way down here, and other countries are way up there. And why? What are they doing differently? And what's this even testing? What are they doing better at? Is it real science, or is it taking this one science test that means nothing? . . . I always leave with more questions than I had before. . . . It's good to think about. Teaching is a difficult job to begin with. . . . It should be difficult if you're trying to do it right. (Interview PB, 2015)

A growing literature assumes that teachers require professional learning opportunities to engage in more productive sense-making using data to inform instructional improvements and promote educational equity. The questions raised here, though, suggest a value in non-sense-making, or what Baker (2008) calls "apophatic strategies that attempt to unsay the sayable" (p. 479). What would it mean if current ordering strategies no longer make as much sense? To not know what to say or do is not the same as not being able to do or say anything.

Disputing the Boundary Work of U.S. Science Education

The study has aimed to place curricular reforms to foster science-minded, STEM-engaged, and healthy citizens into historical perspective. By restoring a few of the tethers linking U.S. science education to early twentieth-century social science, immigration debates, public health interventions, and colonial projects, I propose that greater attention must be paid to the politics of boundary work (Gieryn, 1999) in five respects.

The first boundaries that must be challenged are those insulating Science (and school science) from culture and power. The formulation of socio-environmental crises at a global scale—such as the obesity epidemic, the integration of refugees, and climate change—has placed STEM education at the center of planning initiatives (Zheng, 2018). Precisely because spaces of nature, health, science, and mathematics seem to stand outside of culture, they appear key to solving problems attributed to the "increasing cultural diversity" of a globalizing world. In many such reforms, cultural diversity does more than denote the presence of variation, often serving as a marker of relative distance from norms of scientific reasoning.[142] Where once culture was elevated as the unique property of "civilized" societies (versus "primitive" groups cast as closer to nature), today culture tends to label groups positioned as yet to enter the global knowledge economy. This dangerous logic presumes that while the cosmopolitan "we" may have culture, culture *has* "them" (W. Brown, 2006, p. 151). As this study has explored, universalized notions of nature, science, and health are not neutral, but contain normative principles about the desired student and future citizen that marginalize those classified as outside these cultural norms.

Second, the study suggests the need to dispute boundaries claiming to separate educational theory from classroom practice, as if the former were sealed inside an Ivory Tower.

[142] Recent frameworks of scientific and health literacy, for instance, locate cultural background as a factor mediating one's capacity to acquire the knowledge, skills, and dispositions needed for civic decision-making (e.g., Institute of Medicine, 2004).

In early 1900s U.S. colonial and metropolitan schools, theories of progressive evolutionism, racial hygiene, motivational psychology, and sociological needs did not remain in a realm of ideas, but materialized in daily health inspections targeting particular bodies and homes. These theories, embedded in the comparative categories of classroom practices and curricular standards, made up students as objects of scientific study and as distinct types of people. Children and families were racialized on a trajectory of deferred citizenship via criteria that projected specific social manners, dietary preferences, and living conditions as universal indicators of health/pathology, reason/superstition, and responsibility/risk. If the citizen is not born but made (Popkewitz, 2008), then a closer analysis is required of those historical theories that organize the making and unmaking of citizenship through daily practices of science teaching and learning.

The third boundaries that should be called into question are those that chart pedagogies at either end of a linear ideological spectrum. Educational research is replete with dichotomies, such as standardization versus local responsiveness, abstraction versus everyday relevance, and content transmission versus civic empowerment. Such binaries tend to treat the latter terms—local responsiveness, everyday relevance, and civic empowerment—as inherently more equitable. This precludes consideration of how the pedagogies associated with Progressivism have their own social, political, and even colonial histories. This is not to underestimate the importance of prior critiques of educational research and pedagogy for their universalism, positivism, or deficit orientations. It is rather to extend such scrutiny to pedagogies that explicitly identify as democratic, value cultural diversity, and acknowledge the sociopolitical dimensions of schooling. These too must be interrogated for their assumptions of what counts as human agency, scientific reasoning, community well-being, and social transformation.

Fourth, I have argued for questioning the boundary between machine and human, conceptualized as cold data versus warm affect. Tracking, curricular differentiation, and other mechanisms for sorting students have been critiqued as part of the cold rationalization of schooling.[143] Implicit in these critiques is a concern for what gets downplayed and excluded in such calculations: students' interests and emotions, as well as teachers' intuitive understanding, ethical concerns, and professional discretion. Yet, the conventional divide between warm affect and cold data obscures the promiscuous relations between them. As explored, U.S. psychology has long sought to turn pupils' emotional attitudes into scientific objects, including more recent effort to turn affect into data.[144] As modes of data use expand to encompass student affect and teacher dispositions, further inspection is needed to understand how new metrics reconfigure older moral imperatives. How does the making of students as differentially vulnerable, apathetic, or alienated from science become linked to the making of different ways of being a good teacher—all under an aegis of care?

Finally, the study has put in question the boundaries that cut off the study of education from its dense web of historical, transnational, and cross-disciplinary relations. To delineate a study's focal area as U.S. science education risks reinforcing the assumed separation between nations (U.S.), subject areas (science), and academic disciplines (education). Rather than treat these as self-evident entities, the analysis has raised the question of whether the history of U.S. science education can be understood without a more robust consideration of its imperial

[143] These critiques highlight how tracking relies on impersonal data from external exams, and is buttressed by economistic calculations of rationing, triage, and the zero-sum game of opportunity hoarding (Gillborn & Youdell, 2000; Horn, 2013; A. Lewis & Diamond, 2015).

[144] Recent research aims to measure affective engagement using biometric sensors to detect students' galvanic skin response (e.g., Ghali, Ouellet, & Frasson, 2016), and to map the neurological basis of interest in science in the reward circuitry of the brain (e.g., Hidi, 2006). Besides these efforts to turn affect into data, Friedrich and colleagues (2015) have explored how "contemporary technologies of quantification and data management have complicated the relationship between data and affect" (p. 11). When teachers describe feeling pain in the face of poor student achievement data, or evidence of low student engagement (see chapter 5), what blocs of historical affect (Lesko & Niccolini, 2016) make these experiences sensible?

entanglements, such as how the science-minded American citizen became defined in opposition to excluded groups exterior and interior to the nation's contested borders. Further inquiry is needed to better understand: What of the past has been fully abandoned, and what may persist as what Stoler (2016) calls imperial durabilities in our times?

Returning to Morrison's (1992) inquiry in *Playing in the Dark*, this study has argued that major characteristics of U.S. science education—such as its persistent tension between rigor and relevance and its competing visions of preparing scientists versus citizens—must be understood, at least in part, as responses to the fabricated presence of a racialized Other. In equity-oriented science education scholarship, the near exclusive focus on non-dominant groups, while understandable, has allowed for little systematic attention to the making of difference in relational terms: not just the making of the Other, but also of the self. That is, the theories and techniques that divide and order students have not merely produced the underrepresented. They have also been productive of the potential scientist, the gifted, and the unmarked norm: students for whom no pedagogical adaptation is deemed necessary. Efforts to reorganize and reform science education, I suspect, cannot be understood separately from the question of different "kinds" of students.

My hope is to provoke further inquiry into how the making of difference has profoundly affected not only those marginalized in U.S. science education, but also what appears as its normative center. What did notions of the "foreign masses," "Negro," "primitive Indian," or "Filipino native" do to American science education, and what it meant to understand oneself as scientific or American? How might science education have looked differently without the demand to differentiate and assimilate a pathologized Other, cast as unfit to study the specialized sciences, and yet requiring the application of science to become fit for American society? What other purposes might animate a science education freed from the injunction to respond to presumed differences in students' readiness, interests, and needs?

The dissertation makes visible how difference is not simply the recognition of representational categories of people; rather, central characteristics of U.S. science education—its goal of fostering independent thought and individual agency through scientific methods, its egalitarian emphasis on making science relevant to populations' varied needs, and its pragmatic focus on designing solutions to local community problems—emerged in relation to concerns about the nature of the child, reason, and democracy that were entangled historically with racialized, gendered, and colonial distinctions. This calls attention to the limits of current discourses of "making diversity visible" in understanding the paradoxes of inclusion and exclusion in schooling today.

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APPENDIX A: OVERVIEW OF SOURCES

In order to identify ordering strategies (see chapters 1 and 2), the study assembled the following three archives, which were then historicized by tracing their theories and techniques both within and outside of science education.

Site 1: Research in *General Science Quarterly*

The following documents constitute the archive of statements concerning how difference is seen and sorted in early twentieth-century U.S. science education:

- *General Science Quarterly* (*GSQ*) journal articles for its entire publication period from 1916 to 1929 (when it was renamed *Science Education*);
- Books and articles cited in *GSQ* (e.g., Dewey, 1910), or published by authors of articles in *GSQ* (e.g., Woodhull, 1918);
- General science and health education textbooks for U.S. schools (e.g., Elhuff, 1916a; Brownell, 1918; Andress & Evans, 1925); and
- Teachers' manuals, reports, and other artifacts related to science and health education in the U.S.-occupied Philippines (e.g., The Board of Educational Survey, 1925; Bureau of Education and the Philippine Health Service, 1928; Counts, 1925)

Based on statements in these sources, I identified principles and practices used to order children and curricula, and consulted histories of curriculum (e.g., Popkewitz, 2008), science education (e.g., Rudolph, 2005a), science (e.g., Broman, 2012), the social sciences of race and sex (e.g., Somerville, 2000), and public health (e.g., W. Anderson, 2006) in order to examine their conditions of possibility. I also drew on primary sources from earlier time points (e.g., Mann, 1867a) in order to illustrate key shifts preceding the early twentieth century.

Site 2: Policy Documents from the Next Generation Science Standards

The following documents constitute the archive of statements concerning how difference is seen and sorted in early 21st-century U.S. science education policy:

- The U.S. Next Generation Science Standards (NGSS), along with their appendices (NGSS Lead States, 2013a);
- The NGSS Appendix D Case Studies, released as an online supplement to the standards (NGSS Lead States, 2013b, 2013c, 2013d, 2013e, 2013f, 2013g, 2013h);
- The *Framework for K-12 Science Education,* on which the NGSS were based (NRC, 2012); and
- Books, articles, and policy documents cited by the NGSS, their case studies, and the *Framework* (e.g., O. Lee & Buxton, 2010).

Based on statements in these sources, I identified principles and practices used to order children and curricula, and compared and contrasted these with those in site 1 (*GSQ*). This led to the identification of historical continuities and discontinuities, which demanded targeted analysis of the period in between the 1920s and 2010s to examine changing formulations of difference and disparities within science education (e.g., Crowley, 1977). I also drew extensively on historical studies of shifts in social science theories and techniques (e.g., Danziger, 1997), and in the study of underrepresented groups within science education (e.g., B. Lewis, 2003).

Site 3: Educator Interviews, Classroom and Meeting Fieldnotes, and Artifacts at Alderwood High School

The following documents constitute the archive of statements and practices about how difference is seen and sorted at Alderwood High School (AHS):

- Interview transcripts from 103 debrief interviews with 13 high school science teachers and 3 student teachers over two years;
- Interview transcripts from 42 formal interviews with 13 high school science teachers, 1 guidance counselor, 1 student teacher, 1 bilingual resource specialist and 1 special educator who supported science courses, and 2 minority services staff members who co-facilitated an after-school club for Black students in advanced science courses;
- Fieldnotes from 160 hours of meetings where the science teachers were in attendance, including professional learning communities, science department meetings, ESL and AVID department meetings, and all-school meetings;
- Fieldnotes from 162 classroom observations across all science courses offered by the school; and
- Artifacts from these meetings (e.g., data displays), classroom observations (e.g., chemistry textbooks), and media (e.g., newspaper articles, newsletters, school and district websites) concerning the school or district.

Based on statements in these sources, I identified principles and practices used to order children and curricula, and compared and contrasted these with those in sites 1 (*GSQ*) and 2 (NGSS). In order to historicize specific practices in these sources, I investigated the history of related research (e.g., Maslow, 1943), policy (White House Office of the Press Secretary, 2015), and curricular reforms (e.g., Sutman & Bruce, 1992).

APPENDIX B: HIGH SCHOOL SETTING AND PARTICIPANTS

While my analysis does not focus on the demographic characteristics of either students or teachers, this appendix contains data about the setting and participants of my study of the high school in accordance with how schools, students and teachers are typically classified in educational policy and research (see chapter 2). All names and initials are pseudonyms, and all numbers have been rounded for confidentiality.

Table B1. AHS School Information (2013-2014)

This table displays school-wide data from the school’s 2013-2014 state report card.

Grades	9-12
School Type	Public High School
Enrollment	1,500

Table B2. AHS Student Demographic Information (2013-2014)

This table displays student data from the school’s 2013-2014 state report card.

Race/Ethnicity	
American Indian or Alaska Native	1%
Asian or Pacific Islander	9%
Black not Hispanic	30%
Hispanic	20%
White not Hispanic	40%
Student Groups	
Students with Disabilities	20%
Economically Disadvantaged	55%
Limited English Proficient	15%

Table B3. Participating AHS Science Teachers (2013-2015)

This table displays science teachers at AHS who participated in classroom observations, meeting observations, debrief and formal interviews. All science teachers at AHS chose to participate during both years of the study. In the second year, two teachers left the school, and the teachers replacing their positions also chose to participate. Science teacher participation included:

- Meeting fieldnotes (all-school, department, and subject-specific meetings);
- Classroom observations, debrief interviews (monthly rotation in year 1, 3 consecutive days of shadowing in year 2); and
- Formal interviews (one at the end of year 1, and two at the end of year 2).

Pseudonym Initials	*Primary Subject Area*
DI	Biology
EP	Biology
GA	Biology
HD	Biology
IY	Biology
KC	Biology
LC	Physics
MS	Physics
NM	Physics
PB	Biology
RL	Chemistry
SF	Biology
TN	Chemistry

Table B4. Other Participating AHS Educators (2013-2015)

This table displays other AHS faculty, staff members, and student teachers who were frequently present at science department meetings or provided support within science classrooms, and the extent of their participation in the study.

Pseudonym Initials	*Position at AHS*	*Study Participation*
AC	Student Teacher	Meeting fieldnotes, classroom observations, debrief interviews
AD	Minority Services Staff Member	Meeting fieldnotes, year 2 final interview
DH	Administrator	Meeting fieldnotes, year 2 final interview
EU	Administrator	Meeting fieldnotes
HJ	Student Teacher	Classroom observations, debrief interviews, year 2 final interview
JH	Support Team Member	Meeting fieldnotes, classroom observations, year 2 final interview
MR	Support Team Member	Classroom observations, year 2 final interview
TS	Minority Services Staff Member	Meeting fieldnotes, year 2 final interview

APPENDIX C: HIGH SCHOOL COURSE MAPS

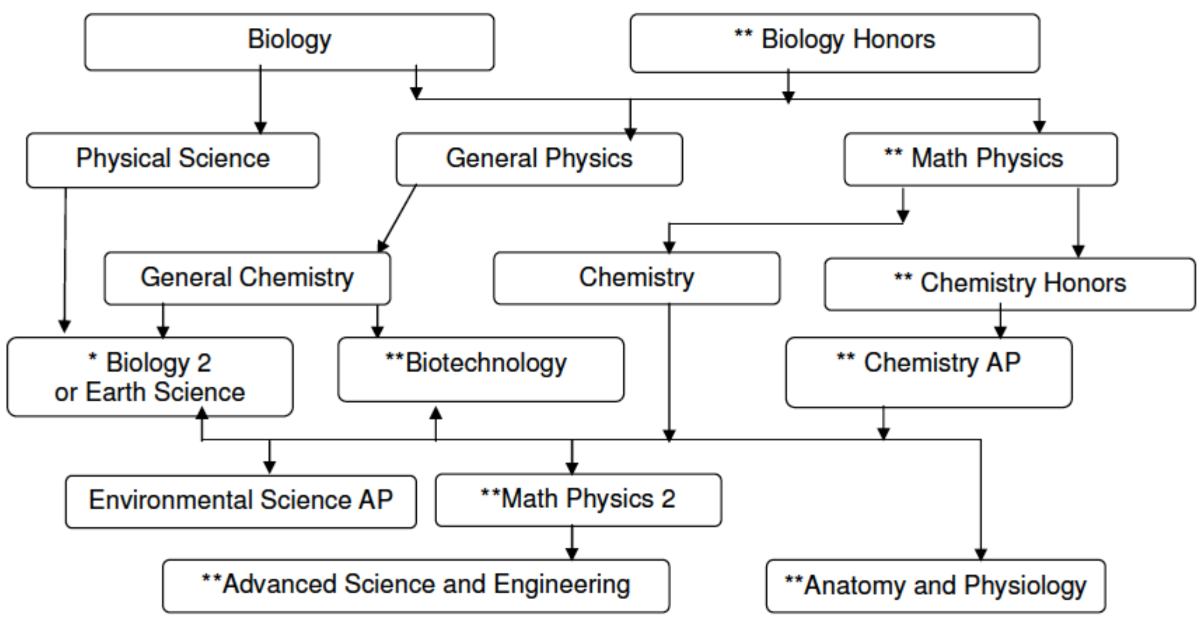
In the first year of the study (2013-2014), Alderwood High School (AHS) offered sixteen courses in the science department (see Figure C1). Half way through the second year (2014-2015), Physical Science was eliminated. A revised course map, adopted for 2015-2016, eliminated both Physical Science and General Chemistry (see Figure C2).

Figure C1. Science Course Map in AHS Curriculum Guide (2013-2014)

SCIENCE

To help you in planning your high school science courses, the following sequences are recommended to provide a balanced science program. If you are not sure which pathway to follow or what science course to take, see your science teacher or counselor.

RECOMMENDED SCIENCE COURSE SEQUENCES



*** Does not eliminate the requirement for a physical science course.**

Honors or Advanced Science Courses(**): These courses are designed for the serious student who plans to pursue a science related career or wants in-depth knowledge of a science area. Students should expect a challenging course with significant outside assignments.

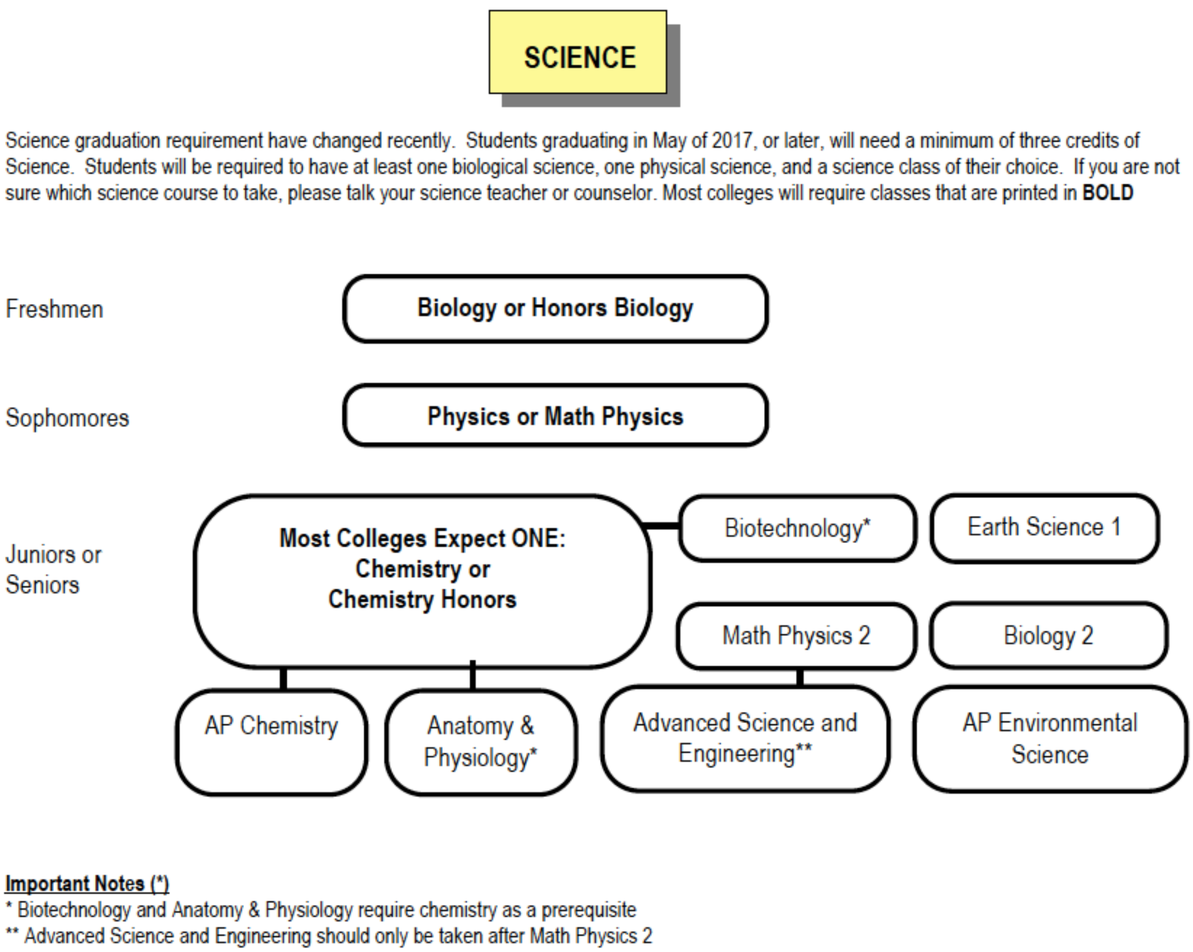
Calculators: **A scientific calculator** is required for Physics, all Chemistry classes, and Advanced Science courses.

Goggles: Chemistry goggles are required for **all Chemistry Classes.**

Recommendations: **Please note before taking science courses you must have successfully completed the course or courses listed.**

Not included on the map above are two science courses listed only within the English as a Second Language (ESL) department: Science Fundamentals and Biology (p. 31). The ESL department also lists Physical Science (which does appear on the course map above) as a science course that "will support students beginning to learn English" (p. 32). Some sections of Physical Science were team-taught with an ESL science teacher.

Figure C2. Revised Science Course Map in AHS Curriculum Guide (2015-2016)



Not included on the map above are two science courses listed only within the ESL department: Science Fundamentals and Biology (p. 31). Because Physical Science was eliminated, it is no longer listed as a course in the ESL section of the curriculum guide. In the spring of 2015, a section of General Physics was team-taught with an ESL teacher, but unlike Physical Science, this course was not officially listed as supporting students learning English.

APPENDIX D: DEBRIEF AND FORMAL INTERVIEW PROTOCOLS

This appendix contains excerpts from interview protocols used with Alderwood High School (AHS) science teachers. All interviews were semi-structured and included probing questions. Debriefs followed each classroom visit, while formal interviews took place at the end of each year. Sections marked with an asterisk were designed by Melissa Braaten for use in the *Evidence in the Classroom* study.

Debrief Interview*

1. What was something that you were trying today that you thought was successful?
2. Was there something that you were hoping would happen today, but it didn't happen?
3. How did you decide what you were going to do and what you were going to ask today?
4. What did you hear or see from your students today? What do you think they might be thinking about based on what you heard or saw?
5. Are there any students who you are particularly concerned about right now? Are there any students who you are particularly excited about right now?

Formal Interview—Data Use*

1. Can you tell me about some of the ways that you have been encouraged to look at "data" and use "data" this year?
2. What do you see as the purposes for looking at or using these data?
3. Are most people in agreement about which data to use and how, or do you see some areas of disagreement?
4. How you do find out things about your students that might be important for working with them?

5. Once you have found out more about students in your class, how do you use that information in your teaching?

Formal Interview—Curricular Differentiation

1. Can you tell me about some of the ways that students end up in one science course rather than another? (*If teacher recommendation is mentioned:* how do you go about figuring out which course(s) to recommend for each student?)
2. What do you see as the purposes for offering these different science courses?
3. Are most people in agreement about the different science courses offered by the school, or do you see some areas of disagreement?
4. How do you figure out what the aims or goals are for each course that you teach?
5. What is your sense of the relationship between these courses? How are they similar, and how are they different?

Formal Interview—Classification

1. Can you tell me about some of the ways you have been encouraged to pay attention to particular categories or focal groups of students in your classroom or the school?
2. What do you see as the purposes for thinking or talking about students in terms of different subgroups or categories?
3. Are most people in agreement about how these categories are talked about and used in the school, or do you see some areas of disagreement?
4. How do you figure out which of your students belong in which category?

APPENDIX E: FINAL INTERVIEW PROTOCOL

This appendix contains excerpts from the final interview, which followed the formal interview at the end of year 2. The interview was conducted with Alderwood High School (AHS) science teachers, as well as six additional educators involved in science courses. The protocol was semi-structured and included probing questions to follow up on anything relevant to the research questions. Each section centered on artifacts (Figures E1-E4) from earlier points in the study.

Interview Preface

My research is about how U.S. science education as a whole decides which students need which kinds of science teaching. Part of my research is historical: I'm tracing how U.S. high schools first started dividing kids into different levels of science courses. The other part of my research is about dilemmas that come up today when data use reforms intersect with an already complex system of tiered science courses. In this interview, we'll talk about how you see data use affecting issues of equity and diversity, starting with when school data are disaggregated, then thinking about how decisions are made about which courses to offer, and finally about when teachers are asked to adapt their instruction for different groups of students.

Part 1: Data Use and Equity in Education

Theme: How data use affects equity, effects when school data are disaggregated

Artifacts: Figure E1 and E2

Timing: 20 minutes

1. In all-staff meetings, there has been a big emphasis on the fact that "disparity exists." This is often shown through bar graphs. (*Show Figure E1.*)
    a. What do you make of these data? If you had to interpret or explain them, what would you say?

   b. What do you see as the reasons for presenting the data in this way?
   c. Do these data inform your teaching, or how you interact with students?
   d. What do you think you're supposed to do with these data?
   e. When do you think it is important or helpful to disaggregate data in this way?
   f. What do you see as the tradeoffs or potential problems with disaggregating data like this?
2. When these graphs appear in meetings, it seems like they are shown pretty quickly before moving on to the next slide.
   a. Do you get any chances to discuss these data with your colleagues or with leaders? If so, when? If not, why not?
   b. Are there other conversations you'd want to have around these data?
3. It seems like with the same bar graph, you could have several different interpretations, depending on where the cause of the problem is located, or what sort of context is given.
   a. What's your sense of what sort of context these graphs are presented in? What sort of interpretations are on the table?
   b. Why do you think that's the case?
   c. Is there ever any talk about race or ethnicity, and how we think it might matter for these trends?
4. When these graphs are shown, one message I've heard is a call to close these gaps between groups. I've also heard that the data show what's "attainable" or "realistic" for each group. (*Show Figure E2.)*
   a. Do you hear those messages also? What do you think?

   b. Do you get the sense that these data shape how adults talk about students, or how students talk about themselves?

5. At the national level, there's a message now that using data will solve the problem of inequity in education by revealing disparities and helping to close those gaps.
   a. What do you think policymakers and leaders mean when they talk about inequity or disparities in education?
   b. Which parts of the message that "using data will solve inequity" make sense to you? Can you tell me more about that?
   c. Which parts of the message that "using data will solve inequity" message *don't* make any sense to you? Can you tell me more?
   d. Do you see any consequences of the focus on data use for issues of equity? For instance, do you see data use promoting equity? Are there ways you see data use making inequities worse?
   e. Do you have any concerns about "disparities," "inequities," or students being excluded or marginalized – either at this school or in science education more broadly?
6. One question I'm wondering about is how data affect which students get focused on. Ever since No Child Left Behind, there's been research on how kids get assigned to color-coded levels of proficiency, like red, yellow, and green. This research has found a pattern called "educational triage" where schools experience pressure to direct more resources toward the kids in the yellow who are close to the benchmark, and away from those who are either in the red, seen as lost causes, or who don't count towards the school's accountability plan.
   a. Does this pattern resonate at all with your experience?

b. Are there ways you've been encouraged to direct your focus on some students rather than others?

c. *If so*, what sort of trade-offs or dilemmas does this raise for you?

7. At all-staff meetings, there's often talk of the "changing population."

    a. What's your sense of this?

    b. Has this had any implications for your teaching?

    c. Are there things you've felt compelled to change in response?

    d. Are there things you've felt compelled to keep constant in your teaching?

    e. What sort of clues have you noticed that the population is or is not changing in a way that matters for your science teaching?

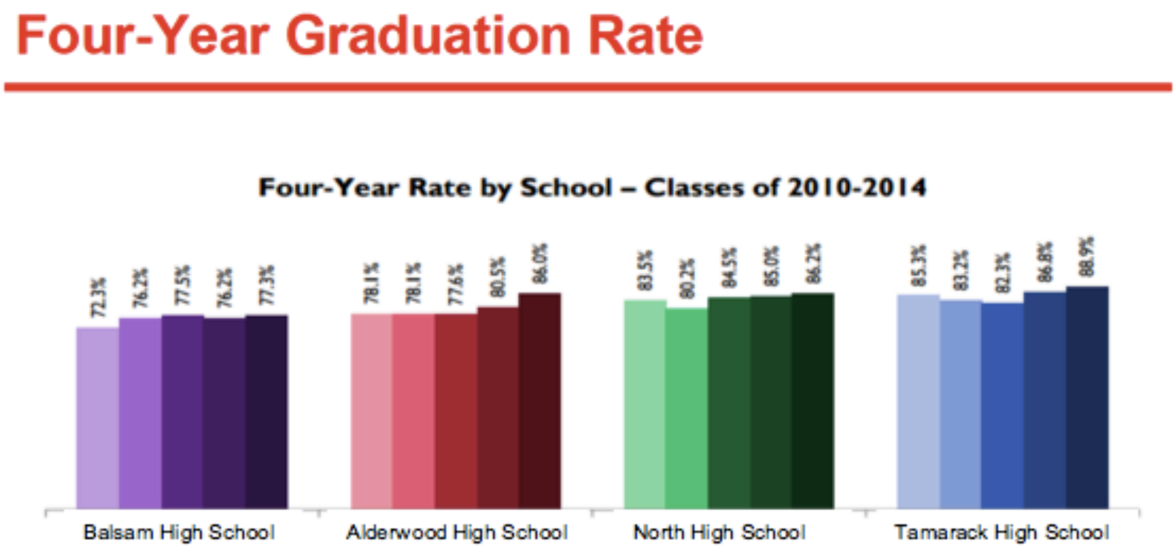
    f. One question I'm wondering is whether the "disengaged kids" and the "disenfranchised kids" are referring to the same students?

8. My sense is that in general, race mainly comes up in all-staff meetings as the label on the bar graph. I'd say one exception might be the PD day after the Freddie Rice (pseudonym) protests, when there was talk of "our disenfranchised kids" and stories of what it's like to be a person of color in the U.S. today. Is this the sense you get as well?

    a. Is race or ethnicity something you would like to hear talked about more or less, or in a different way?

Figure E1. Graduation Rates Comparing Alderwood to Other High Schools in the District

(Meeting artifact, 2014)



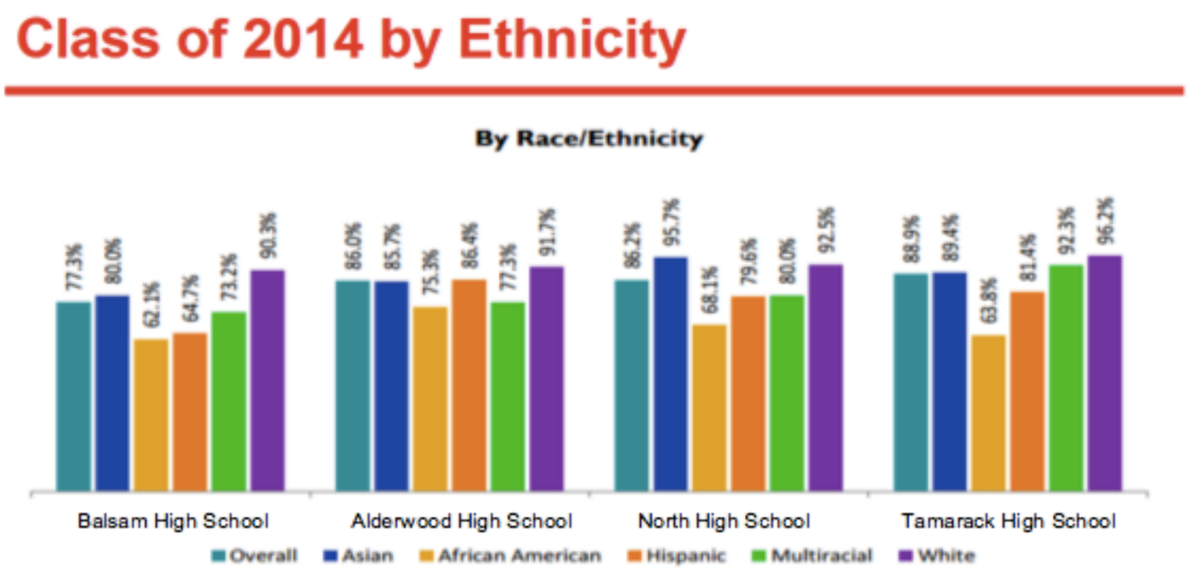


Figure E2. Grade Distribution of AHS Students in Each Science Course. Comparing the grades (A = purple, F = red) of all students with School Improvement Plan focus groups (African American Students and Students with Individualized Education Plans) (Meeting artifact, 2015)

Part 2: Course Levels

Theme: How data affect decisions about which courses to offer, and how to place students

Artifacts: Figure E3

Timing: 20 minutes

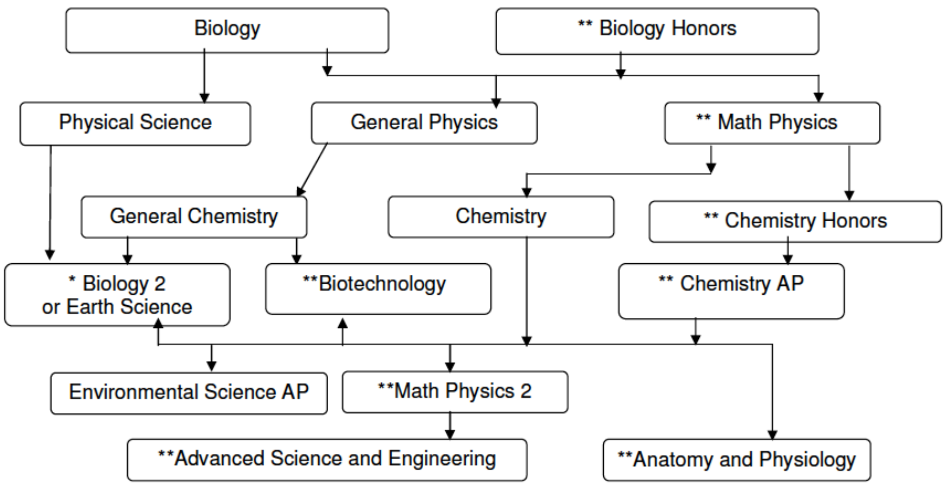
1. Okay, let's change gears. There's been a lot of discussion about the science course levels offered at the school. (*Show Figure E3.)* I'm wondering if you can talk me through these diagrams from the past two years.
   a. What do you see as the big changes that are happening?
   b. What do you see as some of the reasons for these changes?
      i. Why do you think Physical Science was eliminated?
      ii. What's your sense about how things have gone since? Are there other changes this has prompted?
      iii. What concerns or conundrums come up as a result?
   c. Which parts of these diagrams make sense to you?
   d. Which parts don't make sense?
   e. Are there other dilemmas that come up?
2. What do you see as the point of having different levels of science courses?
   a. What does success look like in the different levels?
   b. Are they trying to accomplish the same thing, or prepare kids for the same futures?
   c. How are decisions made which kids need which form of science teaching and why?
   d. How would you know if a student were misplaced? Can you give me an example?
3. What's your sense of where these course levels came from?
   a. Would you call these "tracks"? Why or why not?

   b. What's your sense of the history of tracking in the school or district?

4. There seems to be a push towards common assessments. Are these for [*science subject]* overall, or are there different common assessments for [*General X]* versus [*Math or Honors X]*?
   a. Why do you think that is?
5. One reason given for general-level courses seems to be for students to get caught up because they're not ready yet for the higher course.
   a. Is it possible for them to get caught up once they're in a lower-level class?
   b. Do you see the lower-level course as a preparation for the higher-level course, or are they two distinct pathways with different goals?
6. If you and your colleagues could re-design what science education looks like at the school, how would you re-design things?
   a. What changes would you make, and why?
   b. How would you decide who needs what kind of science education, and for what purpose?
   c. What data or evidence would you use in those decisions?
7. What if there were no levels?
   a. What if it was just one biology, chemistry, physics, and Earth science course each that all students were signed up for randomly?
   b. What would that be like? What tradeoffs would you face?
   c. How do you think your teaching would change?
   d. Do you think that it's possible to do that anywhere? Here?

Figure E3. AHS Course Maps from Curriculum Guides (2013-2014, 2015-2016) (See appendix C for larger maps)

RECOMMENDED SCIENCE COURSE SEQUENCES



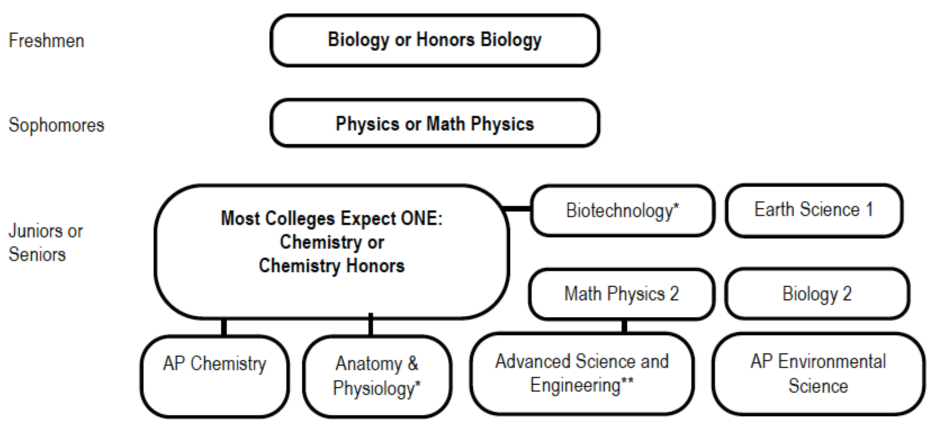
*** Does not eliminate the requirement for a physical science course.**

<u>Honors or Advanced Science Courses</u>(**): These courses are designed for the serious student who plans to pursue a science related career or wants in-depth knowledge of a science area. Students should expect a challenging course with significant outside assignments.

<u>Calculators:</u> A scientific calculator is required for Physics, <u>all</u> Chemistry classes, and Advanced Science courses.

<u>Goggles:</u> Chemistry goggles are required for **<u>all</u> Chemistry Classes.**

<u>Recommendations</u>: Please note before taking science courses you must have successfully completed the course or courses listed.



<u>Important Notes (*)</u>
* Biotechnology and Anatomy & Physiology require chemistry as a prerequisite
** Advanced Science and Engineering should only be taken after Math Physics 2

Part 3: Responding to Different "Kinds"

Theme: How to understand national-scale messages about equity and diversity in science education, whether and how big picture ways of classifying students play out in day-to-day teaching, and how data affect when teachers are asked to adapt instruction to different categories.

Artifacts: Figure E4

Timing: 20 minutes

1. Finally, I'm wondering how science teachers navigate what seem to be conflicting demands – to treat all kids the same, and to treat them all differently. It seems like you're asked to get all students to the same place, but also to differentiate your teaching by meeting them where they're at and taking them where they want to go.
   a. Do you see this as a tension in your work?
   b. Which parts of these demands make sense to you? Which don't?
   c. Which differences do you feel compelled to pay attention to in your teaching?
   d. How do you know that? What helps you see that?
2. I'm trying to understand which differences between students are taken as important for deciding what sort of science teaching they need. For instance, at the back of the NGSS, there is an appendix on equity and diversity. It claims that science education should be for all, but that not all students are the same. The NGSS argue that science teachers need to respond to different subgroups, which have different learning needs in science. (*Show Figure E4.)* Here are the effective strategies they give for each subgroup - can you talk me through what you're seeing and thinking?
   a. What do you make of these categories? Why do you think the authors of the NGSS decided to focus on these subgroups?

b. Which parts of this make sense to you and match up with your experience?

  i. Are you getting messages to focus on any of these groups?

  ii. Do you find any of the categories helpful to think about in your teaching?

  iii. What are possible benefits of classifying students in these ways?

c. Which parts don't make sense and don't match up with your experience?

  i. What dilemmas stand out to you in terms of which differences to pay attention to in your teaching?

  ii. What do you see as the possible tradeoffs or unintended consequences of classifying students in these ways?

d. If you had a class that all fell into one of these categories, would that change how you taught science? Would it change the course goals, the curriculum, or something else?

3. Are there other important groupings that shape how teachers see students or how students see themselves? For instance, I've noticed school-wide talk of "AVID kids," "high flyers," "kids with behavior problems," and "honors kids."

   a. What do you think makes these groupings? What makes "X" different from others?

   b. How do you know that, or what helps you see that? What sort of clues do you pick up on that tells you that this kid is a "X"? If a student is an honors kid, do they ever stop being that? Could there be an honors kid in a general level class?

   c. What do you use them for? Once you notice these things, do you find that you do anything different in your teaching in response to that?

Figure E4. Excerpt from Next Generation Science Standards Case Studies (2013a).

Recommendations of effective practices for making the standards accessible to each group.

Published on *Next Generation Science Standards* (http://www.nextgenscience.org)

Home > Appendix D Case Studies

Appendix D Case Studies

1. Economically disadvantaged students

- connecting science education to students' sense of "place" as physical, historical, and sociocultural dimensions,
- applying students' funds of knowledge and cultural practices,
- using project-based science learning as a form of connected science, and
- providing school resources and funding for science instruction.

2. Students from major racial and ethnic groups

- culturally relevant pedagogy,
- community involvement and social activism,
- multiple representation and multimodal experiences, and
- school support systems including role models and mentors of similar racial or ethnic backgrounds.

3. Students with disabilities

- differentiated instruction, and
- Universal Design for Learning.

4. Students with limited English proficiency

- literacy strategies for all students,
- language support strategies with ELLs,
- discourse strategies with ELLs,
- home language support, and
- home culture connections.

5. Girls

- instructional strategies to increase girls' science achievement and their intentions to continue studies in science,
- curricula to improve girls' achievement and confidence in science by promoting images of successful females in science, and
- classrooms' and schools' organizational structure in ways that benefit girls in science (e.g., after school clubs, summer camps, and mentoring programs)

6. Students in alternative education programs

- structured after-school opportunities,
- family outreach,
- life skills training,
- safe learning environment, and
- individualized academic support.

7. Gifted and talented students

- fast pacing,
- level of challenge (including differentiation of content),
- opportunities for self-direction, and
- strategic grouping.

Excerpted from NGSS Appendix D (NGSS Lead States, 2013a, p. 365)

APPENDIX F: DATA ANALYSIS SAMPLE

This appendix contains a sample of an intermediate stage of data analysis (see chapter 2). In earlier stages of coding, three ordering strategies appeared across all three sites (AHS, NGSS, and *GSQ*): Readiness, Interest, and Needs. In the next round of coding, I used the italicized questions below as analytical tools to ask how each ordering strategy distinguished students as belonging to separate categories, how each these distinctions were seen or known, and what curriculum prescriptions followed. Below is a brief sample of statements (spoken or written) and practices (observed or described in writing) associated with the code of "Interest" for each site.

	General Science Quarterly (U.S. science education journal, 1916-1929)	**Next Generation Science Standards** (U.S. science education standards, 2013)	**Alderwood High School** (U.S. science department meetings and classroom practice, 2013-2015)
Interest *What categorical distinctions are made?*	• Only the few from intelligent families have special interests in physics and chemistry. • The masses are not interested in quantitative abstractions.	• Gifted and talented students already have intense interests and motivation in science. • Non-dominant groups need strategies to motivate and increase students' and parents' interest.	• Honors students are already interested in quantitative and abstract science topics. • Students in lower-level courses need more hands-on, fun activities to spark an interest.

	General Science Quarterly (U.S. science education journal, 1916-1929)	**Next Generation Science Standards** (U.S. science education standards, 2013)	**Alderwood High School** (U.S. science department meetings and classroom practice, 2013-2015)
Interest *How are distinctions seen or known?*	• By using evolutionary theories to infer differences in the natural interests of boys versus girls, and more versus less advanced "racial stocks."	• By referring to research findings that use self-report instruments to assess interest in science and attitudes toward science, and disaggregate by gender and race/ethnicity.	• Surveys of science or medical career interests in Anatomy & Physiology, and Advanced Science & Engineering. • Also by inferring from attendance, course selection, classroom participation, body language, homework quality.
Interest *How are curricula ordered based on these distinctions?*	• The few should be given pure science. • The masses need science applied to their everyday lives to elevate their interests (e.g., home surveys, community projects, domestic science for girls, agricultural science for country boys, industrial science for city boys).	• Gifted and talented students should be given opportunities to follow their interests in science (e.g., independent research projects). • Non-dominant groups need instruction that connects science to their everyday lives (e.g., home surveys, engineering problems in local community).	• In higher-level courses, interest is assumed, allowing for focus on rigor and college preparation. • Lower-level courses need strategies to spark an interest in science (e.g., everyday relevance, home surveys, *Chemistry in the Community*).

APPENDIX G: METHODOLOGICAL DISCUSSION

This appendix elaborates on my approach to data analysis for the high school site, as the study differs from typical approaches of ethnographic data analysis. First, I offer a brief synopsis of how I analyzed the interview transcripts and fieldnotes from Alderwood High School (AHS). Second, I explain why this methodological approach was important given the aims of the study. Third, I address questions that might be raised about this methodological approach.

This study's deciphering approach (see chapter 2) differs from a typical educational ethnography. As outlined in chapter 1, my central research question was: How are different kinds of students made and matched with different forms of science education? This question was subdivided into three parts that comprise my analytical framework. As illustrated in appendix F, I brought the same three questions to each site of analysis: a research journal called *General Science Quarterly* (*GSQ*), the policy documents of the Next Generation Science Standards (NGSS), and the fieldnotes and interview transcripts taken during my two years as an embedded researcher at Alderwood High School (AHS). These questions were: a) *What categorical distinctions are made?* b) *How are distinctions seen or known?* and c) *How are curricula ordered based on these distinctions?* These three questions focused my analysis at the level of the specific theories and techniques associated with categories, distinctions, and curricular differentiations invoked across sites of U.S. science education.

It may be useful to consider how my study draws on and also departs from a related study of classification systems in high school teachers' daily practice. Consider Horn's (2007) article titled "Fast kids, slow kids, lazy kids: Framing the mismatch problem in mathematics teachers' conversations." This article explores the categorical distinctions invoked by high school teachers in schools implementing equity-geared reforms. Both studies share a concern for the hierarchical organization of U.S. high schools and the perceived mismatch between marginalized populations and advanced science and math coursework. At the same time, the two studies adopt distinct theoretical and methodological approaches, ask different questions, and place different spatial and temporal boundaries around the phenomenon of interest. For instance, where Horn's study draws on ethnomethodological traditions of studying meaning-making in the workplace (e.g., Geertz, 1973), this study draws on genealogical traditions that trace historical conditions of possibility for seeing and sorting human difference as they circulate across domains and institutions (Foucault, 1977).

Building on insights from cultural-historical theories, Horn's study adopts a "community of practice" lens (Wenger, 1998) to ask: "How might teachers' communities of practice support their learning?" (p. 40). Using a multilevel, comparative case study design, this study offers a close analysis of how two mathematics departments drew on distinct conceptual resources to reinforce or contest the perceived Mismatch Problem in detracking reforms. One of the study's central concerns is identifying the discursive practices that teachers and teacher leaders can adopt to navigate equity dilemmas and to support colleagues in "developing their pedagogy in ways that will reach all students with richer, more challenging content" (p. 44).

My study builds on insights from science & technology studies and cultural studies, drawing on Hacking's (2007) notion of "making kinds of people" to ask: "Historically, how did it become possible to think about different 'kinds' of students as requiring different forms, or levels, of science education?" I adopt an "entangled history" (Sobe, 2013) study design that compares ordering strategies across three sites that vary in time (1920s versus 2010s) and domain (research, policy, practice). This study design provides insights into the specific practices of both research and pedagogy that converge to make the Mismatch Problem appear as a pedagogical dilemma in a particular time and place. The central concern is how equity and diversity are formulated as pedagogical problems across science education research and policy, as well as in teacher education and school reforms.

When I first transcribed the Physical Science meeting described in chapter 3, I considered analyzing the meeting transcript using Horn's (2007) framework. This would entail treating the event as an "episode of pedagogical reasoning," defined as "teacher-to-teacher talk in which teachers exhibit their understanding of an issue in their practice" (p. 46). Using this analytical framework would direct attention to the "discursive resources that went into the deliberation and construction of these decisions" (p. 48). This could offer a close analysis of the epistemic stances and problem frames adopted by members of the AHS science department, and discussion of how those stances and frames reveal distinct conceptions of students and of the subject matter (in this case, science) that are in negotiation over the course of the meeting.

In early attempts to analyze the Physical Science meeting, I drew on cultural-historical activity theories. I initially analyzed statements like "give those kids a chance to mature" as teachers drawing on the mediational means available in their historical, cultural and institutional contexts to make meaning and shape their utterances and actions (Werstch, 1991). Cultural-historical perspectives underline how artifacts, rules, and practices that are taken as natural may both enable and constrain people's activities in invisible ways (Pacheco and K. Gutiérrez, 2009; Rogoff, 2003). At first, I interpreted the teacher's utterance of "give those kids a chance to mature" as a deficit assumption that had become reified, or "built into the organization of curriculum, naturalizing and reinforcing the beliefs they represent" (Horn, 2007, p. 42). In fact, I soon noticed that similar assumptions of readiness appeared in the course descriptions of the AHS curriculum guide, as well as in school-wide discussions of data as calibrating expectations for focal groups in the School Improvement Plan: “If they come in with 43%, I can’t walk on water and get them to 60%” (Meeting fieldnotes, 2013; see chapter 3).

I started wrestling with how to locate where these “meditational means” were coming from, drawing the analysis out to an ever-expanding remit of “context.” Was this a case of coded race talk (e.g., Pollock, 2004) stemming from local and national media portrayals of a dangerous demographic shift? Or was this a case of a teacher engaged in deficit thinking that traced back to hereditarian theories of IQ in the early 1900s (e.g., Oakes et al., 1997; Valencia, 1997)? During the same week as the Physical Science meeting, I came across Rudolph’s (2005b) article on the general science movement, which includes a 1916 advertisement for a course “adapted . . . to immature minds” (p. 63). I began to wonder how specific techniques for sorting and ranking students by maturity today related to those from a century prior. This parallel (see chapter 1) also suggested the possibility that racial disparities in science education today are not a passive reflection of societal prejudice (i.e., local and national context filtering in), but that the tools by which science teachers are trained may have their own histories in ranking human merit and reconfiguring social hierarchies.

Cultural-historical perspectives also stress that people appropriate and transform meditational means for their own purposes. This means identifying contradictions, multivoicedness, and a diversity of meditational means that are under dynamic negotiation (e.g., Engeström, 2009; Pacheco & Gutiérrez, 2009; Wertsch, 1991). My initial analysis of the Physical Science meeting had attempted to map some of these contradictions by inferring the various purposes lying behind or underneath teachers’ statements. I focused on one teacher’s efforts to reframe the problem from the different needs of “Phy-Sci kids” to the “Phy-Sci course” as a demoralizing, dead-end space. However, I began grappling with how to interpret the intentions behind teachers' utterances, since the same teacher suggested that students bypass Physics to take a lower level of General Chemistry. With these concerns in mind, I began to seek out theoretical and methodological approaches that did not assume a strict divide between text and context, or between human agency and nonhuman meditational means.

The central concern I wrestled with in analysis was the ethics and politics of responsibility. Particularly when one of the issues at stake in my investigation is racial disparities in science coursework, then the actors I choose to center risk becoming freighted with an ethical weight that is not theirs alone to bear. Here, I am following on the work of several critical ethnographies of schooling. In Pollock's (2004) ethnographic study of a high school, she shifts the unit of analysis away from students and teachers as members of racial groups and on to "race talk" itself to analyze when, where, and how racial categories were mobilized. K. Brown's (2006) study of the discursive construction of the at-risk child analyzes how a probabilistic way of thinking about students and their risk factors circulated across teacher education and school settings. Recently, Horn and colleagues (2015) draw on Latour's (2009) actor network theory to analyze data reports as actors in conversations about the disparate needs of subpopulations of students: "Endowing inanimate objects with agency may seem like a peculiar analytic move, but the data reports exert power in workgroup conversations as teachers contend with their narratives about teaching and learning" (p. 212). Finally, in a critical ethnography of the first year of Teach for America, Popkewitz (1998/2017) examines the system of reason that produced categories of students in need of rescue and remediation (e.g., the urban/rural) and the different kind of teaching they appeared to require (e.g., a bits and pieces curriculum).

Drawing on these studies, my aim was to shift the object of analysis onto the historically available practices for perceiving and classifying difference. First, it was important to adopt an analytical approach that did not require fixing spatial and temporal borders around the "objects" of analysis and the research "subjects" or "participants" (see chapter 1). The ethnographic aim of pursuing members' meanings tends to delimit a culture, community, or activity system, where what is given as historical is typically the history of that group or system. I wanted to examine how modes of classification and curricular differentiation were crossing boundaries of past and present, and of what is treated as the activity system versus the larger system, yet without assuming those temporal or spatial scales *a priori*.

Second, as my project began to center on an analysis of classification of human kinds, it was important that the study itself not engage in classifying teachers or departments as closer to or farther from a pre-established norm of science teaching, teacher learning, teacher agency, or equity. Stabilizing these norms would make it difficult to trace their historical shifts and differentiations. It was important to avoid restricting my analysis to teachers or teacher learning, as this tends to insulate research, policy, and teacher education from similar scrutiny. The problem, as I argue throughout the study, runs deeper and wider than a matter of teacher beliefs, practices, or decision-making, and how "decision-making" became an object of social science analysis is part of the phenomenon I'm interested in studying. My aim was to treat the statements of educational practitioners in a symmetrical fashion to the statements of educational researchers and policymakers, using their juxtaposition to highlight paradoxes of inclusion/exclusion that emerge within and across these domains (see chapter 9).

Another reason to decenter the individual teacher as my object of analysis emerged as the study design took shape. In juxtaposing the 1920s and the 2010s, I worried that centering the analysis on participating teachers would risk portraying them as in some way personally aligned with early 1900s scholars defending biological determinism, American exceptionalism, and colonial rule. Rather than cleave off these historical citations as “of their time,” I believe it is important to consider how such discourses entered early twentieth-century science education and how they relate to current reforms. The challenge became how to “experiment” methodologically in exploring historical resonances and durabilities, but without putting my participating teachers in harm’s way by attempting to represent “their meanings” or “their purposes.” Using pseudonyms did not seem sufficient to avert the misreading that the discourses of a discredited past are simply embodied in an individual teacher (e.g., “Mr. D” or “Mr. D’s ideology”). This is why I chose to cite statements from teachers by pseudonym initials and to refrain from presenting a typical description of research participants in demographic or autobiographical terms.

My study works from the premise that, like Rabinow’s (1996) interviews with molecular biologists, the science teachers I interviewed “did not have a stable point of view but were themselves engaged in questioning their allegiances, their dispositions” (p. 19). Rather than describing a timeless ethnographic present, this approach attempts to understand what is emergent by locating oneself in a place and talking to people who are engaged in developing new practices and understandings in response to shifting formulations of the problem (Rabinow, 2008). The premise is that these dynamic interactions—including the conversations that I engaged in or initiated—are historically and culturally continent. Rabinow (2008) offers a call to “inquire into what is taking place without deducing it beforehand,” where the “question of how older and newer elements are given form and worked together, either well or poorly, becomes a significant site of inquiry” (pp. 1-2). I wanted to investigate how elements that come together to make someone a professional science teacher (or educational researcher) today have linkages beyond a particular department, school, or academic field.

As an entangled history of the present (Foucault, 1977; Sobe, 2013), the study does not attempt to offer a totalizing account of either past or present. As analyst, I had to be selective and tactical in what to trace, where, how far back, and using which sources. Making history "effective" in Foucault's (1977) sense of the term required consideration of which junctures or ruptures would offer the greatest leverage to question the common sense that sustains practices of ordering, marginalization, and exclusion. For instance, I initially assembled any statements about mental, cognitive, or developmental differences under the heading of "Capacity" rather than "Readiness." Yet there is already a robust literature documenting teachers' conceptions of intelligence as fixed and hereditary (e.g., Oakes et al., 1997), and how intelligence emerged from a racialized history (e.g., Gould, 1996; Valencia, 1997). While I noticed an occasional reference to IQ at AHS or to differences in science ability or talent in current research and policy, such statements were few and far between compared with talk of capabilities or skills in relative, temporal terms. Statements about readiness also stood out to me at AHS, because unlike the few whispered comments about IQ, claims of (un)readiness for advanced science were made publicly across varied settings (e.g., teacher interviews, department meetings), and in relation to equity arguments (see chapters 1 and 3). In this sense, my presence in the data collection process gave me insight that certain classifications were treated as suitable for public, professional discourse, while others were expressed in hushed or hesitant tones. Because my aim was not to evaluate participants' conceptions of intelligence or race, I was more concerned with the theories and techniques that made differentiating readiness appear as an equity strategy responding to an objective, pre-existing condition. The importance of denaturalizing Readiness was confirmed by my reading of the NGSS, which repudiated stereotypes of science ability but took racial disparities in science achievement as indicating the need for a "two-pronged approach" to make instruction "accessible" to all students (see chapter 4).

One might ask whether my approach of treating statements from AHS symmetrically with those of policy and research is to disavow my presence at the school. In other words, how can I account for the ways in which my extended time and interactions at AHS inevitably shaped the statements I collected, and also my analysis of those statements? Certainly, my presence impacted what was said to me or around me, but there is no objective means to establish the degree or direction of this effect. Importantly, the analysis does not attempt to establish the frequency, representativeness, or specific situational factors that facilitate a particular statement, nor to identify the underlying motivation or intentions of the speaker. Instead, I am interested in the fact that it was possible to say X statement as a science educator in the United States between the years 2013 and 2015 (Hacking, 2002). From there, my analytical framework directs attention away from contextualizing the statement within what is assumed about research participant, and instead attends to the explicit categories invoked, the techniques that made a particular distinction visible, and the associations made between a category of students and a certain aim or method of science instruction.

In writing the study, my aim was to continually prevent the misreading of a particular statement as owing to a teacher's misinterpretation or misuse of theory or data. Once I selected a statement from an AHS teacher that I (as analyst) was arguing was entangled in an ordering strategy, I looked for comparable statements in research or policy. For instance, when I decided to focus the Needs chapter vignette on the Chemistry in the Community course, I analyzed not only the *Chemistry in the Community* textbook from the school, but also traced the research studies that went into designing and validating this curriculum (Sutman & Bruce, 1992) (see chapter 7). Another tactic I employed was to center the AHS analysis around dilemmas or paradoxes arising from within what is currently upheld as "research-based" practice in science education to highlight concerns at the intersection of knowledge, power, and ethics (Hacking, 2002).

One potential concern is that the study's approach neglects to sufficiently convey the voice of teachers or offer rich depictions of the pedagogical conceptions and commitments of each. A related concern is how the move to decenter the human subject may be read as disembodying their statements from their lived experience. Britzman (2000) discusses a key shift in writing poststructural ethnography, as "questions of subjectivity move beyond the stance of knowing how others make sense and toward a consideration of how reflexivity can be practiced when making sense of oneself is understood as occurring through the construction of the other" (p. 29). Britzman recounts that in her ethnography of student teaching, *Practice Makes Practice,* she originally attempted to represent a "humanistic ethnographic subject" (p. 34). In attempting to question the limits of that representational logic, she changed chapter titles from "The Story of Jamie Owl" (as if a stable, comprehensive, and coherent representation of Jamie's experience) to "Narratives of Student Teaching: Stories from Jamie Owl" (pp. 34-35). Similarly, my study is not a "Story of AHS" or "Story of Mr. D" (see chapter 1), but stories of ordering strategies from AHS that are interwoven with those from research and policy. Following Scott (1992), my concern is not portraying not lived experience itself, but the historical conditions and practices that make particular subjectivities and differential experiences possible. The study only traces a few of these entangled histories and does not attempt to depict a wide range of looping effects. Nevertheless, the urgency for me was in understanding how key theories and techniques that sustain tracking in U.S. high schools also appear in official reports (e.g., NGSS) and teacher evaluation rubrics (e.g., edTPA) that disavow deficit thinking.

Another potential concern is that by decentering the subject, the teachers (who nevertheless "show up" in the form of statements) could be read as passive in the face of broader discourses and policies. A challenge in writing the AHS chapters was how to discuss the ordering strategies at the high school without portraying them as fully determining. Whenever possible, I wove in the questions, concerns, and critiques that AHS teachers and other staff members raised related to elements I was gathering together under each ordering strategy. In chapter 3 on Readiness, for instance, I highlight how educators:

- critiqued Physical Science as a "dumping ground,"
- questioned how "students' needs" were being determined,
- demanded the elimination of Physical Science as a "dead-end" track,
- raised concerns about how college science courses "weed out" students,
- critiqued the rigid instruction offered in upper-level courses,
- articulated dilemmas of academic rigor versus responsive pedagogy,
- critiqued the reliability, validity, and pedagogical utility of standardized test data,
- questioned how science achievement metrics collapsed meaningful disciplinary differences,
- critiqued the school's repeated display of achievement gap data with no discussion of racism, raising concerns about a Pygmalion effect, and
- called out the rationale of "not ready yet" as not merely effecting a delay, but an exclusion through separate tracks.

If I think of the examples above as instabilities in the ordering strategy, then it is clear that the developmental scales and standardized test data associated with Readiness do not fully determine teachers' minds and actions. At the same time, these instabilities indicate the contours of a common sense that continues to be reiterated through mutually reinforcing practices of research and pedagogy, even as particular elements of its network face questioning and critique. Across the chapters, I sought to suggest this dynamism while also indicating historical durabilities in official policies and recommended practices, including equity-oriented discourses of malleable intelligence, developmentally appropriate instruction, and the power of yet.

While I found ways to interweave teachers' direct critiques of ordering strategies (see chapters 3, 5, and 7), teachers also offered other critical analyses related to equity and diversity that exceeded the limits of my analytical framework (see appendix F). In reading the statements collected from AHS meetings and interviews, I noticed that teachers and other staff members brought up a number of concerns about marginalization and exclusion that deviated from the typical formula of matching X category with Y type of instruction. Although analysis of these examples is beyond the scope of the study, I synopsize a few here to give a sense of the range of discourses available for thinking about social and educational injustice. Teachers expressed concerns related to white, affluent parents' advocacy for students to "stay with their friends" and how this reinforced the *de facto* segregation of elementary and secondary classrooms in the district (Interview EP, 2014; Interview TN, 2014). Teachers and staff members also raised concerns about the classification of students as English learners, critiquing how this category was alternatively elevated as a "model" for other minoritized groups, essentialized as Hispanic, invisibilized as outside the two focal groups in the School Improvement Plans, and marginalized as the primary responsibility of ESL teachers and bilingual resource specialists (Interviews SF, 2014, 2015; Interview MR, 2015). A third set of concerns related to the disenfranchisement and criminalization of students of color at AHS through new attendance policies, data-driven behavior management reforms, and racial microaggressions, especially in the wake of district- and city-wide protests after the shooting death of an unarmed Black 19-year-old by a police officer (Interview PB, 2015; Interview TN, 2015; Interview TO, 2015). One staff member organized presentations for colleagues on the racial and socioeconomic segregation of Glacier City, brought in articles on white fragility, and raised concerns that high school seniors reported never having had a teacher of color in their K-12 experience in GCSD (Interview AD, 2015). Finally, teachers raised concerns about sexism and racism in the scientific disciplines, sharing research with students about gender discrimination in physics, highlighting the experience of a family member who found himself as the only person of color at a large scientific conference, and bringing up a study shared on social media about how Black and Latinx scientists are frequently mistaken as custodial staff in their laboratories (Interview EP, 2014; Interview MS, 2015; Interview IY, 2015).

Although an incomplete list, this synopsis gives further indication of the plurality of discourses, questions, and critiques that were available to educators at AHS in 2013-2015. These were concerns that—as teachers pointed out—were rarely discussed in meetings, especially those using data-driven protocols to get at the “root cause” of disparities (Interview AD, 2015; Interview TN, 2015). Likewise, the NGSS case studies on “diverse subgroups” include a section called Context that solely consists of data on demographic shifts, science achievement gaps, and a synopsis of recent policy statements. A wide range of science education studies—e.g., those drawing on critical race, borderlands, feminist, postcolonial, and queer theories, among others—is not made visible in the NGSS as relevant to understanding issues of equity and diversity.

The methodological approach—deciphering the making of difference by juxtaposing statements from past and present—is to open up black-boxed classificatory techniques that operate across fields of educational research and teacher education, but also in first-block General Physics, AP Chemistry, or Honors Biology. The study does not attempt to describe the plurality of resistances and resignifications that undoubtedly take place within those classrooms or behind the scenes in writing science education policy or curricula. Instead, what the study's historicizing method contributes is a sharper understanding of taken-for-granted ordering strategies, so that they do not remain locked in place or perpetually reinscribed in new forms.