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Dividing Opportunities: Tracking in High School Science

Introduction

Many states across the country already have or are in the process of increasing their high school graduation requirements. This is especially true in science. For example, Michigan has recently changed the number of required science courses from zero to three.

These changes are intended to, among other things, minimize the amount of variation in graduating students' science opportunities. Much of this variation is the result of the pervasive use of high school tracking – a practice that is almost exclusive to the United States.

This report examines the extent of tracking in 30 high schools that are part of PROM/SE. These schools represented over 14,000 students from 17 districts. Our results find that students in these districts typically follow one of numerous tracks and are thus offered different science opportunities. Consequently, when these students leave high school, the amount and type of science they have been exposed to vary widely.

What is Tracking?

Tracking is the practice of assigning different students to different groups of courses. For many years, tracking consisted of three distinct groups, which, ostensibly, matched students' future educational and vocational plans: the college preparation track, the general track, and the vocational track. Tracks spanned multiple academic subjects, so that a student in the general track for science was also in the general track for English, math, and social studies.

Today, school-wide tracks are rarely overt aspects of school policy. Rigid curricular programs that neatly divide students into three distinct groups have largely dissolved (Lucas, 1999; Oakes, 1985). This does not mean, however, that schools do not track students – most do. Rather, instead of overarching curricular programs that keep students in the same track across subjects, schools now differentiate students *within* subjects. This implies that within science, students take one of several groups of courses. Open any high school handbook and you will usually find a page – complete with arrows and circles – dedicated to displaying the particular courses in each group and the order in which these courses are to be taken. You will also surely find a more complex system than the simple, college, general, and vocational trichotomy.

In many ways, general labels such as vocational or college preparatory do not adequately describe the large variation in the number, type, or order of students' science courses. It may thus be more appropriate to define a student's science track as the particular sequence of courses he or she takes.

What Does Research on Tracking Tell Us?

Tracking is not a whimsical phenomenon. Most schools and districts in the United States track students because they believe it optimizes students' achievement. Advocates of tracking argue that this type of curricular differentiation facilitates teaching and learning, as it matches students' ability level to the most suitable curriculum. Tracking theory contends that some students would struggle immensely in high-level curricula while low-level curricula would confine others.

Most research on secondary school tracking, however, has found that differentiating the curriculum tends to adversely impact students in low-level courses compared to their high-tracked peers. Students in low-tracked courses are less likely to expect to go to college, less likely to actually attend college even after controlling for students' post-secondary expectations, and have lower self-images (Alexander & Eckland, 1975; Oakes, 1985; Rosenbaum, 1980; Vanfossen, Jones, & Spade, 1987). Tracking practices may vary across schools. In schools where tracking practices "lack structural flexibility" (Oakes, 1985) students may experience the entire high school curriculum in a low track. Perhaps most salient, though, is that many studies have found that tracking tends to exacerbate achievement inequalities between high- and low-tracked students (Gamoran, 1987; Gamoran & Mare, 1989; Hallinan & Kubitschek, 1999; Hoffer, 1992; Schneider, Swanson, & Riegle-Crumb, 1998; Stevenson, Schiller, & Schneider, 1994).

How Does Tracking Arise?

In order for multiple science tracks to subsist in a school, the school must offer multiple science courses. A school that offers four science courses – one corresponding for each grade level – and requires all students to take these courses offers only one possible sequence of courses, and thus one track. However, this is highly uncommon. Schools typically offer more than four science courses – often many more – and thus allow students to choose from numerous possible course sequences. These sequences can, and often do, vary by the number of courses taken, the order in which courses are taken, and the types of course taken.

What about the schools taking part in PROM/SE? What types of science courses do these schools offer? How many? How are students arranging these courses into distinct course sequences? Most importantly, what do the course sequences present in PROM/SE schools tell us about students' opportunities to learn? This report attempts to answer these questions.

How Many Different Science Courses do PROM/SE Schools Offer?

Using enrollment histories of over 14,000 seniors in 30 PROM/SE high schools across 17 districts, we calculated the number of distinct science courses offered. Unless there were obvious misspellings or abbreviations that suggested two courses were the same, no further classification was done. Each new course title was therefore treated as a different course. Two courses were not considered to be the same unless they had the *exact* same title. This means that two courses such as "Biology" and "Advanced Biology" were considered to be two different courses.

It is possible that "Biology" and "Advanced Biology" or "Physical Science" and "Physics" could represent the same curriculum, but this is an assumption that we are not willing to make. Previous research has shown that the covered content in two courses with a similar title can vary wildly (Cogan, Schmidt, & Wiley, 2001). We therefore find it more prudent to assume that, because schools choose to represent the general content they are teaching in a course (such as biology or physics) by different course titles, it is most likely that the content is different, at least to some extent.

The 17 PROM/SE school districts offered numerous distinctly titled science courses – 157 in all. These course titles varied enough to make simple classifications difficult[1]. On the one hand, PROM/SE districts offered several courses that most consider to be part of a standard science curriculum. For example, we found that most districts had course titles such as Biology I and II, Chemistry, Physics, Geology, Earth Science and Integrated Science, as well as typical advanced-level courses such as Astronomy, Advanced Biology, and various AP courses.

Yet, on the other hand, we found several courses that embody these standard titles, but differ slightly – ostensibly by their difficulty. These courses included General Science, Physical Science, and Basic Biology. Furthermore, many PROM/SE districts offered several less common science courses – courses other PROM/SE districts rarely offered. Examples of such standout courses were Botany, Ecology, Bioethics, Anatomy, Genetics, Vertebrate Zoology, Aquatic Science, Gardening I and II, as well as Advanced Gardening I and II, among others. These courses did not neatly fit into standard science categories and are part of the reason for the large number of distinct science courses found across the PROM/SE districts.

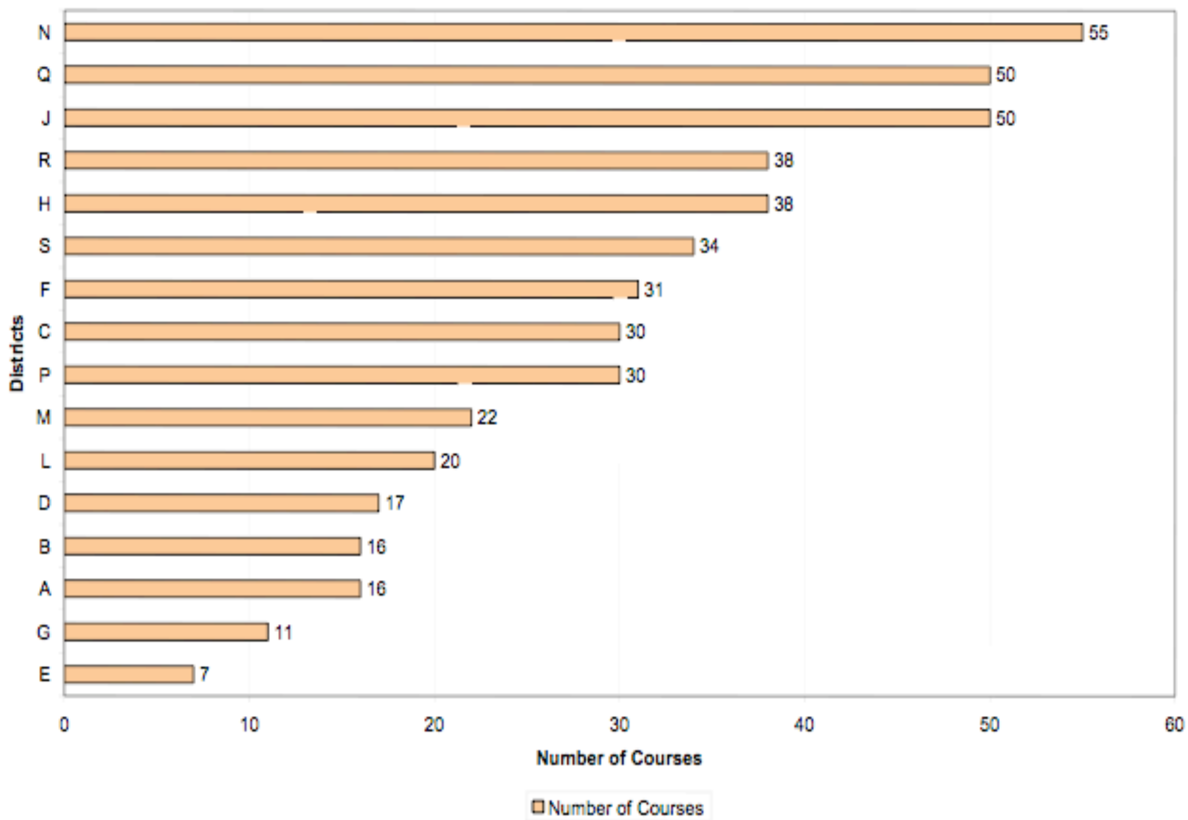
[1] We focus on the district rather than the school because the district sets curriculum policies. It is possible that high schools in the same district do not offer the exact same number or types of science courses. However, an explicit district policy would have to allow this. Consequently, we found the variation among schools in the same district to be quite small.

Do PROM/SE Districts Offer the Same Number of Science Courses?

Although we found numerous distinctly titled science courses, it does not necessarily follow that each PROM/SE district offered an equally expansive science curriculum. Schools strongly varied in the number of offered science courses. Figure 1 displays the number of science course titles offered by district.

At one end of the spectrum, some districts offered relatively few science courses; two districts offered fewer than 12 courses (an average of 3 distinct courses per grade level), with the minimum being 7 courses. But on the other end of the spectrum, several PROM/SE districts offered 50 or more distinct science courses, with the maximum being 55 courses. In fact, one PROM/SE district offered more biology-oriented courses – Basic Biology, BioScience, Biology I, Biology II, Advanced Human Biology, College Preparatory Biology, Environmental Biology, General Biology, General Biology A, and General Biology B (10 in all) – than another district’s total offered science courses (district E’s 7 courses). Even two geographically close districts (districts L and N) differed by 35 science course offerings.

Figure 1. Number of High School Science Courses by District



While looking only at the extreme ends of the spectrum may exaggerate the variation in course offerings, even a quick glance at Figure 1 shows that students' science learning opportunities in different districts are anything but similar.

Why Do Some PROM/SE Districts Offer So Many Course Titles?

Though Figure 1 provides evidence that most PROM/SE districts offer multiple science courses, and thus seemingly different learning opportunities to different students, not all districts do so in a way that suppresses students' opportunities. In some PROM/SE districts, the large number of science course titles is due mostly to the large number of *advanced* courses available. In other words, students in these PROM/SE districts have relatively few standard science course options (e.g., Biology, Chemistry, or Physics), but numerous advanced course options such as Advanced Biology, or AP Chemistry. Some districts' large course variation, therefore, is concentrated at science curriculum's upper-levels. This type of variation provides students multiple options to advance their interest in science beyond the standard science curriculum. These options are precluded in other districts offering only basic courses. From this perspective, then, some PROM/SE districts offer numerous science courses in order to enhance their students' learning opportunities.

In other PROM/SE districts, however, the large number of science course titles reflects a large number of available *lower level* courses. For example, these districts offer numerous courses that one would typically find in middle school such as Physical Science, Life Science, and Earth Science, or scaled-down versions of standard high school science courses such as Biology A or Basic Biology. These PROM/SE districts' large course variation is thus concentrated at science curriculum's lower-levels. However, this type of variation, unlike the districts that offer additional science courses in order to provide additional advanced-level opportunities, has the potential to limit students' learning opportunities. By offering multiple lower level courses, some PROM/SE districts provide students several opportunities to spend their high school years steeped in coursework many consider below the standard science curriculum, without the opportunities to learn rigorous science content.

What Does the Proliferation of Course Titles Mean for Tracking?

Of course, PROM/SE districts cannot be neatly classified as either concentrating most science course options at advanced levels or lower levels; most districts provide additional science courses at both ends of the curriculum spectrum. Yet, offering additional courses at either curricular level increases the number of different ways students can combine science courses. In other words, the large number of science courses available in most PROM/SE districts leads to a large number of possible tracks or sequences through the science curriculum.

More specifically, the large number of available science courses in most PROM/SE districts implies that students in each district can arrange the type, number, and order of their courses – and thus vary their exposure to science in numerous ways. Given the observed proliferation of high school science courses in PROM/SE districts, tracking can result from two somewhat distinct sources.

First, it occurs from the fact that there are many different available course types. In science, there are at least five course types: biology, chemistry, physics, geology, and astronomy. How many and which particular broad categories of courses a student takes defines a broad-based definition of a track. For example, many high school students take one biology course, followed by chemistry and physics courses. From this perspective of tracking, it makes no difference if the student took Advanced Biology or General Physics, only that they took a course under the biology or chemistry umbrella.

The second defining aspect of tracking derives from the fact that, within a school, there are often multiple versions of the same course category. For example, a school may, and as we have already seen often do, have more than one biology course. It may offer Basic Biology, College Preparatory Biology, Biology II, AP Biology, or others. The above results demonstrate that this phenomenon is common in PROM/SE districts, especially in biology where, across the 17 districts, there are 19 different course titles.

The combination of these two conceptualizations of tracking generates an even greater chance for inequalities in science opportunities. For example, two students in the same school may take substantively different courses (e.g. Biology, Physics, Chemistry, Geology) *and* take different versions of these courses (e.g. Basic Biology vs. College Preparatory Biology). In all, the large variability between districts in the number and types of courses offered portends prodigious differences among high school seniors' exposure to science.

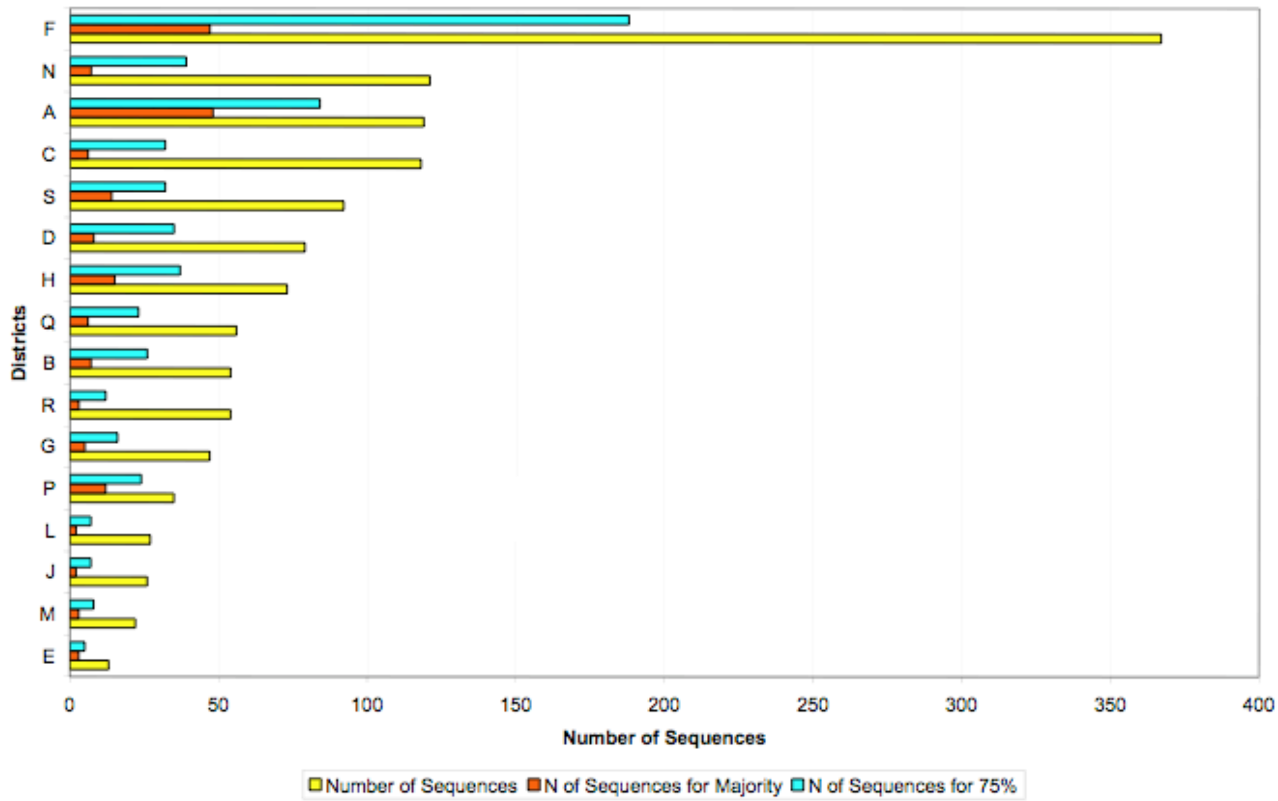
How Many Course Sequences Are Present in PROM/SE Schools?

In order to examine this issue further, we recorded each of the 14,000 students' course selections and the order in which they took these courses. Each unique combination of science courses constituted a distinct science course sequence.

In all, there were over 1000 such sequences. But like we saw with the total number of different courses offered, the number of sequences varies appreciably by district. Figure 2 shows the number of different course sequences present in each district. In some districts there were over 100 distinct course sequences while in others there were fewer than 30. Most districts, however, had closer to 50 sequences. Nevertheless, the variation in the number of course sequences is striking – even the least tracked district still had 13 distinct science course sequences.

It is misleading, however, to think that each sequence is equally populated. Some sequences contain more students than others. Therefore, Figure 2 also shows the minimum number of sequences needed to represent a majority of students' (i.e. more than 50 percent) and for three-fourths of students' course-taking behavior.

Figure 2. Number of Science Course Sequences by District



These percentages are particularly revealing: most students in each district belong to a relatively small number of sequences or tracks. Indeed, for 6 of the districts, a majority of students took 5 or fewer sequences. Similarly, in all but one district, fewer that one-third of the total course sequences were needed to account for a majority of students; in some districts, fewer than one-fifteenth of the sequences were needed. For example, in district R, where there were 54 distinct science sequences, most students were in only 3 sequences. Even to account for 75 percent of the students, "only" 12 sequences were needed.

In all, the number of sequences needed to account for the simple majority of students was less varied than the total number of sequences. With the exception of districts A and F, which required 48 and 47 sequences respectively, the remaining districts varied from 2 to 15. Although this variation is more reasonable, it is anything but insignificant. Moreover, the fact that 51 percent of students in each district are ensconced in substantially fewer sequences implies that the remaining 49 percent of students are sprinkled among numerous alternative sequences.

Perhaps the most salient example of this issue occurs in district F. Not only were there over 350 distinct science sequences, an incredibly large number to begin with, but 284 sequences were unique to one student. This implies that 284 students in district F patched together a unique sequence of science courses and, consequently to some extent, encountered different learning opportunities. Providing different learning opportunities to 284 students is alarming, but is even more striking when one considers that, in the entire district, there were only 719 students. Moreover, only 10 of the 367 sequences involved 10 or more students. As a result, 357 science course sequences in district F involved fewer than 10 students, a statistic that unmistakably clashes with the notion of equal content coverage for all, or even a majority of, students.

What Science Courses and Sequences Are PROM/SE Students Taking?

As mentioned earlier however, having multiple course sequences does not necessarily imply limiting students' learning opportunities. Some PROM/SE districts provided numerous advanced level courses in order to allow students to pursue their interests beyond the standard science curriculum. Therefore, we must complement the above description of total number of course sequences with a discussion of what types and levels of courses compose these sequences.
One way to examine students' sequence compositions is to look at students' initial courses. Figure 3 displays the percentage of students in each PROM/SE district whose first course is below, above, or equal to Biology I.[2] As suspected, the percentage of students in each starting level varies substantially by district. The percentage of 9th grade students enrolled in Biology I ranged from a low of about 2% in district E to a high of approximately 88% in district G. Most districts had about 45% of their students taking Biology I.

The percentage of students taking Biology I or higher varied even more substantially, from 2% to about 95%. Thought about another way, this implies that the percentage of students beginning in classes below Biology I ranged from 98% to 5%. Although for many of the PROM/SE districts fewer than 15% of students started their high school science

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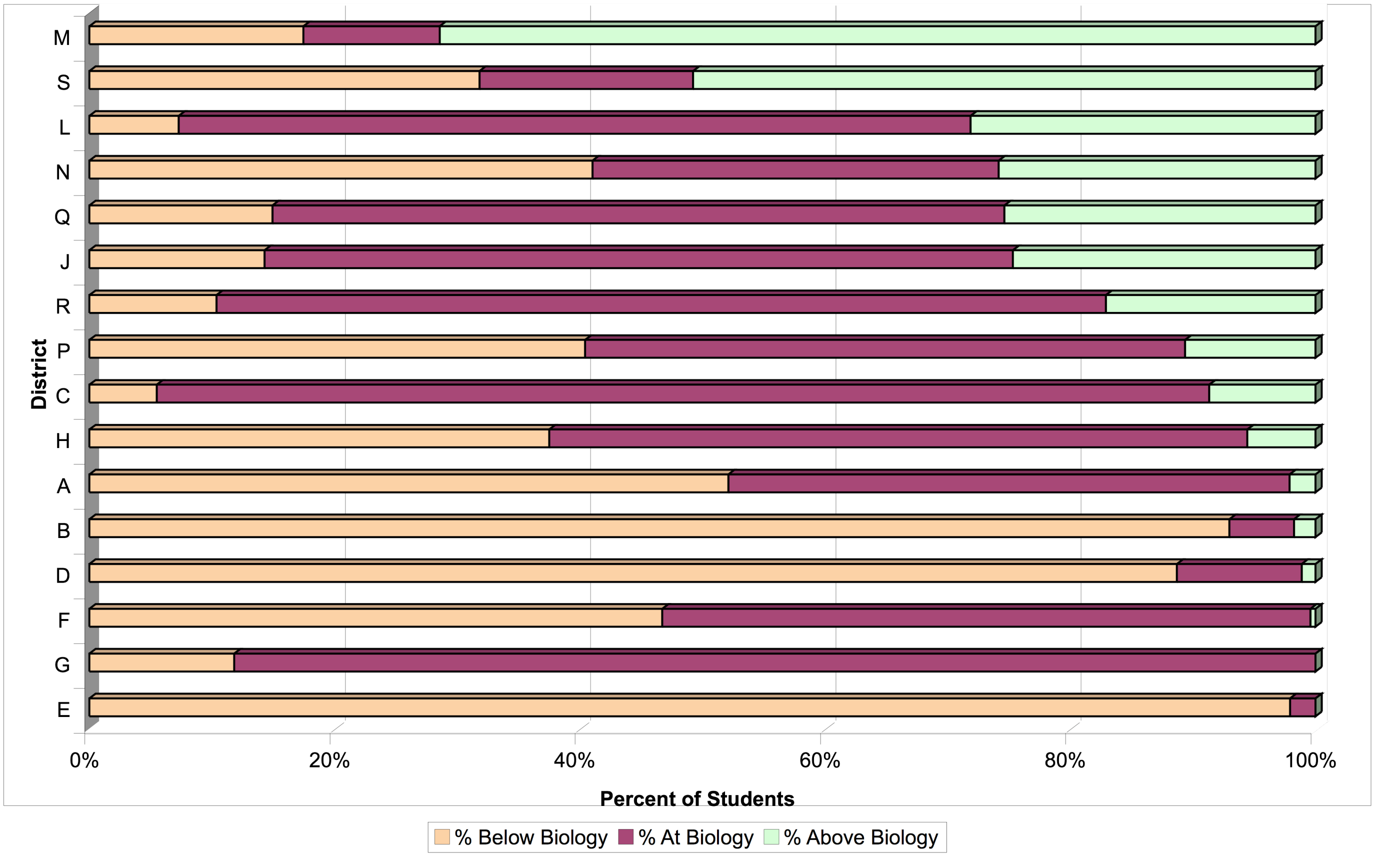
[2] Biology I is the reference course because biology is the most commonly offered course type and Biology I is the most commonly taken course title in 9th grade. Biology is typically the first course for students in most U.S. high schools, acting similarly to Algebra I in mathematics. Moreover, as will be seen later, beginning high school in a course below Biology I strongly influences future course choices.

Figure 3. Starting Level Science Course by District



coursework with lower-level biology or below-biology courses, the majority of districts had more than 40% of students taking such courses. In some districts, then, more than 85% of students had opportunities to learn rigorous science content, whereas in other districts this privilege befell only a small percentage of students.

Besides possibly being offered limited learning opportunities, beginning high school in courses below Biology I also strongly impacts future science learning opportunities. Findings based on the Longitudinal Study of American Youth data indicate that students beginning high school in courses below Biology I (General Science, Earth Science, Physical Science, Life Science, Environmental Science/Ecology, Marine Science, and Biology: No Lab) were less likely to take Chemistry I and Physics I (Schneider et al., 1998). For example, only 16% of students who took General Science in 9^{th} grade took Chemistry I or higher, and none took Physics I, though 7% took the lower-level Physical Science. Similarly, 80% of students beginning in a No Lab Biology course took Physical Science (none took Physics I or higher), and only 8% took Chemistry I.

The meager percentages of students beginning high school in courses below Biology I who encounter important chemistry and physics learning opportunities are even more salient when compared to students who began in Biology I or higher. For example, about 85% of students beginning 9^{th} grade in Biology I took Chemistry I or higher, and about 50% took Physics I or higher, with an additional 14% taking Physical Science. Overall, the science course patterns seen in PROM/SE districts are similar to national patterns (Schneider et al., 1998). Though science is less hierarchically structured than mathematics, and thus the order one takes high school science courses is less defined, most students in PROM/SE districts take biology, then chemistry, and then physics. And though this particular sequence is common, some argue that it does not necessarily make scientific sense. Lederman (1998) suggests that it is more sensible to take physics first. Nevertheless, as can be seen in Figure 3, opportunities to take any physics course, let alone beginning in physics, varies strongly by district.

Implications for Students' Science Opportunities

This report has found several startling facts. Districts in PROM/SE offer an incredibly large number of distinct science course titles and there is substantial variation across districts. Many of these course titles are variations of broad curricular categories such as biology or chemistry. However, it may be unwise to assume that these variations are simply different names for the same course. Each course may present different curricular opportunities.

This large variation in the number and types of courses in PROM/SE districts portends wildly discrepant, possibly even chaotic, learning opportunities. Though there are not discrete, overt curricular tracks (e.g., the "college-prep" or "vocational" track), the large number of distinct science course sequences in many PROM/SE districts implies that many students are encountering different learning opportunities within the same district. Students may have in common that they attend high school in the same district, but as they graduate there is little commonality in the type of science to which they have been exposed. It is not that all high school students should take the same courses, but there should be a high degree of overlap across programs for most students. This would result in a relatively small number of science sequences – certainly not 100.

Instead we have seen that students in the same district enter high school in very different courses and leave with dissimilar learning opportunities.

Promoting Rigorous Outcomes in Mathematics and Science Education (PROM/SE) is a comprehensive research and development effort to improve mathematics and science teaching and learning in grades K-12, based on assessment of students and teachers, improvement of standards and frameworks, and capacity-building with teachers and administrators.

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